SÜSS MicroTec

SAFETY AND INSTALLATION



Mask/Bond Aligners

MA/BA Gen4

Manual Mask/Bond Aligner

Rev09 21-12

READ THIS MANUAL PRIOR TO PERFORMING ANY TASK!

SAFETY and INSTALLATION

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This manual is a user documentation of SUSS MicroTec Lithography GmbH (in the following "manufacturer") and allows safe and efficient use of the mask aligner MA/BA Gen4.

Prior to working on this product, the personnel must have thoroughly read and understood these instructions and, furthermore, know and observe officially recognized rules regarding occupational health and safety. The basic prerequisite for safe working is compliance with all the safety and handling instructions stated in this manual and the safety and installation manual of the tool.

Figures in this manual are for the fundamental understanding and can deviate from the actual design of the tool.

English is the original language of this manual.



Electronic and Pneumatic Plans

Electronic and pneumatic plans are provided on the machine PC:

► *Workpart D* ➔ *Documents*

A link to this folder is located on the desktop.

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Service

Our customer service is pleased to provide further technical information.

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1 WARNING and SAFETY PRECAUTIONS

Equipment Options:

NOTICE!
Optional equipment can influence the possible hazards in the machine!

Following options are available for the MA/BA Gen4:

- LH350 Lamp House with high pressure UV-lamps alternatively:
- UV-LED Light Source with LEDs
- UPS Uninterruptable Power Supply
- CIC Power Supply

1.1 General Safety Information



Before installation and operation of the equipment following safety information has to be read carefully!

NOTICE!

The chapter "Safety Precautions" contains information the operator must know and understand in order to avoid the risk of personal and equipment damage.

This section describes general safety precautions and procedures which must be observed and followed by all persons working with the equipment covered by this manual.

After a thorough review by qualified safety personnel, the user should generate specific safety procedures with regard to particular application and configuration of the equipment and local codes. Operators must be thoroughly familiar with these procedures which should also be posted in an accessible location so that all equipment operators are exposed to the information on a continuing basis.

In addition to the specific safety precautions detailed in this section, anyone working with or in close proximity to the equipment described in this manual should observe adequate precautions and safe operating practices generally applicable to the operation of semiconductor production and processing equipment.

1.2 Intended Use

NOTICE!
Other than the intended use of the machine will lead to a loss of warranty!

WARNING!

Risk for Personal Injury and Material Damage!

Equipment of this type may cause serious personal injury or material damage if it is not used or operated in the correct manner, or if unqualified personnel have access to it.
The same applies if the equipment has been installed incorrectly or has not been maintained sufficiently, or if consumables, accessories, spare parts or software is used that is not authorized by the supplier, or if components will be removed.

- ► Only operate the system in a technically perfect condition and in compliance with the operating instructions.
- ► Disruptions, especially those that may affect safety, must be promptly remedied by authorized personnel.

The system described in this manual has been manufactured according to the technical standards, safety regulations, SEMI-standards and EC directives.

If not installed properly or not used as directed, dangerous situations or damage might occur.

Changes or modifications to the machine without prior written permission by the supplier will void warranty and will void the user's authority to operate the equipment.

Any unauthorized changes or modifications to the system or use of incompatible accessories would void all warranties as well as SUSS liability. Consult SUSS MicroTec Lithography GmbH before implementation of any change or modification. Quote also system type and serial number when making inquiries.

After manual re-configuration of the mirror house position and the adapter of the alignment stage and subsequent re-start, the machine can be used as bond aligner (substrate-to-substrate aligner without UV-exposure).

Processes:

- Photo lithographic system for automated 1:1 direct projection of structures from a photo mask to photo-sensitive coated substrates.
- Manual or automatic alignment of structures on the substrate to the mask.

Substrates:

Following substrate sizes and shapes are able to be processed:

- Round substrates (wafer) from 2 in. to 200 mm
- Square substrates from 2 in. to 6 in.

Components/ Use:

- As light source a closed UV source is used together with adapted exposure optics.
  Only exposure lamps released by SUSS for the mask aligner and the corresponding lamp house must be used.
- Running the lamp in the machine is only permitted in combination with the SUSS lamp power supply. The adjustment procedure for lamp cooling for the corresponding lamp type provided by SUSS must be followed.
- Integrated components - like the lamp power supply - are designed strictly with the specific use in mind.
- Any other use of the machine than as a photo-lithographic or bond aligning system or of its components is not intended by design. Therefore any other use of the machine must be agreed with SUSS MicroTec Lithography GmbH in advance and must be specifically released by SUSS.
- The machine must only be operated as a whole. Removal of individual parts for separated operation or machine operation with removed components is not allowed.
- Enclosures and covers are necessary for save operation. Any use without enclosure or removed covers is not permitted.

Software:

- Software is an integral component of the system. Software which is not originally intended for use in this system and not tested and released for the system by SUSS MicroTec Lithography could pose a risk for functionality, process performance and material handling.
- Installation of additional software without prior written permission by SUSS contradicts the intended use of the machine.

Avoidance of Hazard:

- Only if intendedly used within a closed lamp house no specific hazard by the lamp will arise for the user.
- Sufficient ventilation of lamp house, lamp power supply and the whole machine has to be guaranteed to avoid overheating and subsequent damage and hazards.
- If in special cases the machine shall be used for applications with increased safety requirements this has to be considered during installation by additional safety precautions at installation site.

Maintenance/ Service:

- In case of installation, operation, changing of operational conditions, maintenance-, inspection- and service work all protective procedures described in the user manual have to be followed.
- You are advised to make use of the support and services offered by the competent SUSS MicroTec lithography service center with regard to planning, installation, commissioning and servicing.
- If working with chemicals follow all local regulations, laws, guidelines and safety data sheets (SDS).

Contact:

For planing, installation and service consult your local SUSS representation. For latest contact information go to www.suss.com.

1.3 Minimum User Requirements

Ensure that:

- the operator is equipped with his/her appropriate personal protective equipment.
- the user does not change or modify the system without the prior written permission of the manufacturer.
- the operator runs the system only with all installed covers and working interlocks.
- service and maintenance work will be carried out only by qualified and adequately trained personnel.
- trained service and maintenance personnel replaces defect system components immediately and only by original spare and wear parts.
- all personnel working with or near the equipment have received all safety information concerning the machine and that they are properly trained on the safety requirements of the machine.
- all persons working with the system are properly trained for the operation with the system.
- the user respects all safety information provided in this manual and in all additionally applicable safety and local preparation information which are delivered by SUSS MicroTec Lithography GmbH or to which SUSS has pointed out to.
- the user does not remove, modify, cover or change any content or the readability of all safety signs and labels which are located at or in the machine.
  No additional labels are allowed to be placed to the machine which could reduce the attention to the safety labels provided by SUSS MicroTec Lithography or which could reduce the effectivity of the labels.

1.4 Qualified Personnel

Qualified personnel are persons, who on account of the training and instruction they have received and their experience and knowledge of relevant standards, specifications, accident prevention regulations and operating conditions, have been authorized by those responsible for the safety of the system to carry out any necessary work and who are able to recognize possible dangers.

Qualified personnel have to avoid accidents during electric work and repair or during maintenance work. All personnel shall wear or use personnel protective equipment which is required for save work performance.

All system users are advised to become familiar with the contents of these safety instructions prior to operating the system. They also should have read and understood the operating instructions.

In addition, always comply with local health and safety regulations and company safety requirements regarding safe usage of equipment. Knowledge of the first aid and the local rescue facilities is also required.

OSHA (Occupational Safety & Health Administration) Definition:

"Qualified" means one who, by possession of a recognized degree, certificate, or professional standing, or who by extensive knowledge, training and experience, has successfully demonstrated his ability to solve or resolve problems relating to the subject matter, the work, or the project.

1.5 Signs and Safety Precautions

The terms DANGER, WARNING, CAUTION and NOTICE are used to indicate special dangerous situations or special information that have to be followed.

Safety Related Terms and Signs:

Following safety related terms and signs are used:



DANGER!

This safety related term consisting of symbol and signal word DANGER indicates an imminent hazardous situation which, if not avoided, could result in death or serious personal injury.



WARNING!

This safety related term consisting of symbol and signal word WARNING indicates a potential hazardous situation which, if not avoided could result in minor or moderate personal injury.



CAUTION!

This safety related term consisting of symbol and signal word CAUTION indicates a potential hazardous situation which, if not avoided could result in death or serious personal injury.



NOTICE!

This safety related term consisting of symbol and signal word NOTICE indicates a potential hazardous situation which, if not avoided could result in material or environmental damage
or
draws attention to special technical product information which may not be immediately obvious even to qualified personnel.

Warning Signs:

Following warning signs are used in this manual:

	General warning symbol (explanation is always necessary)
	Electric shock hazard
	Crush or pinch point hazard
	Intensive light and potential eye damage hazard
	Hot surface hazard
	Inhalation hazard
	Chemical hazard
	Fire hazard
	Displosion hazard
	Heavy load hazard

Prohibition and mandatory signs:

Following prohibition and mandatory signs are used in this manual:

	Strong magnet; non-ionizing radiation Persons with pacemakers or implanted defibrilators must keep back
	Wear eye protection
	Wear face protection
	Wear protective clothes
	Wear hand protection
	Lift with two persons
	Position of seismic anchor point
	Read manual

Indication Signs:

Indication signs point to the content of an adjacent text and do not function as safety signs.
Indication signs enable quick identification of text passages and accelerate the search for information.

Following indication signs are used in this manual:

Sign	Description
1. 2.	This sign represents one step of an action sequence.
▸	This sign represents a one-step instruction.
⇨	This sign points to the result of an instruction.
	Reference to another paragraph or another document.
Button ***[xy]***	Appearance of hardware keys
Function key ***[xy]***	Appearance of software keys
"Tab xy"	Appearance of GUI-elements

1.6 Training and Qualification

1.6.1 Standard Training Recommendation

We recommend performing of training for qualified persons before they are allowed to perform electrical work at the equipment.
We recommend a refresher training at regular basis (at least every 3 years)
The training shall take place in practice and/or in lesson format.
The training shall be documented.

The training of a qualified person shall include following topics:

- safety relevant labor practices including the right selection and use of personal protective equipment (PPE)
- skills and methods that are necessary to identify open conducting parts from other parts of the electrical equipment.
- skills and methods that are necessary to determine the nominal voltage of the open conducting parts and to determine the minimum distance and the corresponding voltage a qualified person will be exposed to.
- options to perform the job safely.
- options to de-energize the system and all electrical components safely (logout/tagout).

1.6.2 Additional Training Recommendation

Additional training options that are recommended for work at electrical equipment:

- NEC (EN60204-1)
- National Electrical Safety Code (ANSI C2)
- Correct use and careful handling of personal protection equipment
- Correct use of test and measurement equipment
- Work permit and approval procedures
- Correct clothing for electric arc protection
- First aid course at least every 3 years

1.6.3 Tasks and Related Training Requirements

Operation of a manual mask / bond aligner:

- Knowledge of how to handle process material safely.
- Knowledge of the microscope alignment process in the machine.
- Understanding the exposure process.
- Understanding the presentation of the process status in the user interface.

Start-up and shut-down of manual mask / bond aligner:

- Knowledge of how to start the machine and the UV lamp.
- Knowledge of how to select and start alignment and exposure programs.
- Knowledge of how to handle photo masks safely during loading and unloading
- Knowledge how to select and install the correct tooling (chuck, mask holder, upper substrate holder) for the intended task.
- Understanding the parameters to be programmed and the inherent risk of damage to material or equipment caused by improper combination of tooling and program.
- Understanding how to identify potential problems with the machine.

Performance of light measurement and adjustment:

- Knowledge of how to use the SUSS MicroTec light measurement probes.
- Practice of preparing measurement protocols.
- Understanding the potential hazard originating from UV-radiation.
- Knowledge of how to adjust lamp power at the power supply.
- Knowledge of how to adjust light uniformity using the lamp positions adjustment - and in complex situations also the lens positions.

Configure or program processes:

- Knowledge of how to use the mask / bond aligner for configuration and programming.
- Understanding the parameters to be programmed and the inherent risk of damage to material or equipment caused by a wrong process.

Perform safety checks:

- Understanding the hazards caused by UV radiation (especially invisible radiation), by mechanical movements and by electrically energized parts - also the understanding of how to avoid all these hazards.
- Understanding how all interlock and safety functions of the machine are working.
- Knowledge of how to check the safety on the machine and how to defeat and reinstall interlocks.
- Practice in filling of safety check reports.

Exchange of UV-lamp or UV-LED light source:

- Special training for exchanging the exposure lamp: i.e. handling of the lamp, performing electrical connections to the lamp, checking and adjusting lamp positions, checking of lamp cooling, ability to identify degraded mirrors.
- Special training for exchanging UV-LED light source units.

Service task of UV-LED light source:

The single UV-LED light source unit does not contain any user serviceable parts.



CAUTION!

Performance Hazard!
Never disassemble the UV-LED light source unit. Mechanical assembly is crucial for light shaping and light uniformity

Perform general trouble shooting and maintenance:

- Special training for maintenance access points
- Understanding machine states and processes
- Experience in using the service program (ServiceGUI)
- Knowledge in handling of cleaning agents - including flammable liquids - and grease
- Detailed knowledge of mechanical machine components

Perform service tasks:

- Special training for service by a SUSS MicroTec Lithography trainer.
- The optional UV-LED light source does not contain any user serviceable parts.

1.7 Recommended Safety Equipment

The operator of the facility has to take care that following safety equipment as a minimum requirement is available at installation site of the equipment:

Mandatory:

Fire protection equipment including fire extinguisher



Protective Clothes
Close-fitting working clothes with a low tear strength, with snug sleeves and no protruding parts. They predominantly serve to protect from getting in contact with chemicals and prevent from irradiation of bare skin by UV lamps.



Safety Gloves
Media- and heat-resistant safety gloves protect hands from aggressive media, mechanical, thermal and radiation dangers.



UV-Safety Goggles
Safety goggles protect eyes from flying parts, splashing media and hazardous radiation.

1.8 PPE according to NFPA 70E

Technical personal who is exposed to the danger of an electric arc flash is bound to wear his/her PPE (Personal Protective Equipment) according to NFPA70E.

NOTICE!
These requirements are only valid in the USA and only obligatory for exports into this country.

e.g. according to NFPA70E following PPE is necessary:

- for protection against electric arc flash approved long-sleeved clean room top.
- for protection against electric arc flash approved clean room trousers
- protective helmet
- for protection against electric arc flash approved face shield.
- leather or rubber gloves and shoes



NOTICE!

For the currently valid requirements read and observe the current NFPA70E-Standards.

1.9 Forseeable Misuse

Reasonably foreseeable misuse means:

- Use of the mask aligner for alignment and exposure of substrate sizes which are not specified within the sales contract.
- Operation of the machine with bypassed safety circuits.
- Use of media which are not specified within the sale contract, section ‚Safety References‘.
- Use of non-authorized external power sources.
- Use of software which is not authorized by SUSS MicroTec.
- Use of accessory parts which are not authorized by SUSS MicroTec.

CAUTION!

Danger of Serious Machine Damage !

Because of use of non authorized accessory parts or software!

► Only use accessory parts which are authorized by SUSS MicroTec Lithography GmbH to avoid damage of the equipment.

► Software is an integral part of the system. Software which is not originally designated for the use with this equipment and which is not tested and authorized for the system by SUSS MicroTec Lithography may bear the risk for functionality, process performance and material handling.

► Installation of additional software is only allowed with written permission of SUSS MicroTec.

1.10 Transport and Installation

CAUTION!

Ergonomic Hazard!

Risk of damage and injury of the spine by lifting of heavy objects.

► Always use corresponding tools for lifting of heavy loads.

► Always move with the required number of persons.

Load	Support
<18 kg	1 person
18-32 kg	2 persons
32-55 kg	3 persons
>55 kg	Fork lift
Mask/ bond aligner chassis	4 persons + additional tool
Base frame	4 persons + additional tool
CIC	2 persons
Alignment stage	2 persons

NOTICE!

Transport has to be performed by a qualified company.
All basic work concerning installation, assembly and repair have to be performed by qualified service personnel of SUSS MicroTec Lithography GmbH.
All maintenance has to be performed by qualifed personnel of SUSS MicroTec Lithography GmbH or trained inhouse personnel.

Observe:

- technical data and information according to the order specification concerning intended use (assembly, electrical connection, ambient and operating conditions).
- common installation and safety conditions.
- local, system-specific requirements
- correct use of tools and transport devices.
- commitment of installation responsible persons to provide suitable safety procedures according to the respective country regulations.

This user manual contains instructions which the user has to follow during the intended use of the machine.

Transport-, assembly-,operation- and maintenance instructions and other technical data (in instructions, in product documentation or at the product itself) which are not pointed out especially have to be observed as well, to avoid errors which could lead directly or indirectly to serious personnel or material damage.

1.11 Maintenance and Service

Specific maintenance and service tasks in connection with the safety instructions are defined in the maintenance and service manual.

NOTICE!

Maintenance and service work must only be performed by qualified and technically trained persons.

NOTICE!

Only use accessories, spare parts, software and consumables which are authorized by SUSS MicroTec to avoid personal injury or damage of the system.
Parts and software which are authorized by SUSS MicroTec are compatible with the machine. Non-authorized materials and software can cause serious machine damage or damage of process material.

If malfunction arrives because of parts or software which has not been approved by SUSS MicroTec, the plant operator has to accept full responsibility on the required service work.

NOTICE!

Ensure a minimum lighting level of 300 lux (30 fc (US-unit)) in all maintenance areas.

Check on a regular basis all media pipes and fittings for leakage and strong sit. Perform maintenance work according to the **Manual for Preventive Maintenance**.
Before re-installation check if all safety covers are correctly installed and that the safety interlocks work correctly.

WARNING!

Working without Service Skills!

Risk of Injury/ Risk of Machine Damage!

- ► Only service personnel is allowed to operate the system if the system is in service mode.
- ► Call for a service technician to terminate the service conditions if you only have operator rights.

1.12 Disposal of Waste



Make sure that contaminated material is disposed according to local and environmental laws and regulations.



Besides we recommend to contact a waste management expert.

Material Separation:

Dispose as special waste:

- Contaminated and used tubes
- All electric /electronic parts (boards)

Following components bring into a recycling process:

- Plastic parts
- Metals (stainless steel, aluminum)

Waste Product:

There are no standard EU regulations for disposal of chemicals or residues.
Chemical residues are special waste. Its disposal is regulated in corresponding laws and regulations. Each individual world wide state has its own laws and regulations.

We recommend to contact responsible authorities or accredited waste disposal departments for advice.

Packaging Materials:

Disposal according to official regulations.

- Contaminated packaging has to be disposed in a similar manner as the contaminant.
- Non-contaminated packaging can be treated or recycled as domestic waste (if not determined differently by official authorities).

1.13 Safety Hazards

This section describes specific safety hazards or potential hazards which may be associated with the use of this equipment, the possible consequences of human interaction with the hazard and the method(s) for avoiding the hazard.

Hazards described in this section are:

- Electrical hazards by potentially lethal voltages or electric current.
- Mechanical hazards by moving machinery parts.

- Mechanical hazards by exploding UV-lamp bulbs
- Thermal hazards by hot machine parts
- Thermal hazards by hot lamps
- Chemical hazards by specific materials or agents (e.g. contamination)
- Non-ionizing radiation hazards (UV, Halogen lamps, UV-LED light sources)
- Hazards after extraordinary events.

1.13.1 Electrical Hazards

Protection against electrical hazards is provided in general by enclosed, grounded cabinets for electrical parts using hazardous voltages. (e.g. lamp house, power supply for electronics and computer). All boxes and cabinets are equipped with warning labels for electrical hazards. If covers or connections are removed there is a risk of electric shock.



DANGER!

High Voltage!

Risk of Death by Electric Shock!

► Do not remove any cover as long electric voltage is present.

► Non-professional work inside the computers and the machine can cause electric shock.

► For maintenance work switch off the equipment.

► Follow the lockout/tagout procedures.



DANGER!

High Voltage!

Danger of Electric Shock!

► Ground the equipment!

► Never remove grounding cables from the equipment!



DANGER!

Dangerous Voltage inside the Machine!

Risk of Death by Electric Shock!

► When removing internal components (e.g. power supplies) from the equipment observe the warning labels (on the component or in the schematics).

► Make sure that the respective device has been discharged.

- In case of any fuse replacement use fuses only of the same type and with the same load as the replaced fuse.
- Never use auxiliary fuses.
- Never short circuit the fuse block.

If any electrical problem occurs, turn the machine off and notify a supervisor or maintenance staff immediately.

Safe Work during Maintenance of the Equipment:

- Maintenance, adjustment etc. on the electrical system must be performed by specifically qualified personnel only
- Only perform work at a fully de-energized („electrical cold“) equipment.
- Always observe the inhouse safety instructions and the lockout/tagout procedures.
- It should never be necessary for the operator to open the cover of an electrical portion of this machine.

UPS:

Take special care by working on the UPS, its wiring or other parts connected to the UPS:

- Disconnect and secure the UPS output wiring or
- Pull out the 10A fuse at the battery prior to work on the system.

Mask Library:

The MA200 Gen3 may be equipped with a mask library module:

- Protection against electrical hazards is provided in general by closed, grounded cabinets for the electrical devices using dangerous voltages.
- Such boxes are located mainly inside the base frame of the machine. Those are the power distribution box, power supplies for electronics, the computer and control units for motor driver.
- All boxes are marked with the electrical hazard label.

1.13.2 Mechanical Hazards

Improper operation of the machine may result in serious injury.

Moving Parts:

The equipment has moveable parts (wafer transport systems, prealigner, alignment stage etc.) These hazard areas are labeled with warning labels.

- Moveable parts could catch foreign material e.g. clothing, fingers, hair, cables etc.
- Fingers could be crushed.



WARNING!

Crushing Hazard!

Risk of injury for hands and fingers by machine parts in actions.

► Keep all doors (if present) closed and do not remove any cover.

► Do not grab into running machine.

► Switch off the equipment for maintenance work.

Pressurized Lamps:

If equipped with a lamp house that uses pressurized UV lamps, improper handling of an UV lamp may result in injury from fragments of an exploding pressurized lamp.



WARNING!

Risk of Explosion!

UV lamps are highly pressurized. They can explode if mistreated causing serious injuries by fragments.

► Touch only when wearing face shield and gloves.

► Avoid rude handling.

► If not in use store it in its original box.

- Details see *Chapter 1.14 “Safe Handling of UV-Lamps to Avoid Mechanical and Chemical Hazards” on page 30*

Compressed Gases:

The machine uses compressed gases (CDA, Nitrogen) for many functions. Compressed air has the potential of harming people if abused or in cause of a fierce leak.
Do not lacerate pneumatic tubes or disconnect a pressurized tube! Always make sure that the gas supplies are switched off prior to work at the pneumatic system.

1.13.3 Thermal Hazards

Lamp House for Pressurized UV Lamps:

Thermal hazards will result from contact with heated parts of the equipment and may arise by premature opening of the lamp house door. During normal operation the upper exhaust duct of the lamp house on the back of the machine can attain the temperature of about 70°C. The UV lamp bulb and sockets are extremely hot when ON. After switching OFF the lamp needs cool down time and the interior of the lamp house needs continual cooling.



WARNING!

Risk of Burns!

The lamp and its surrounding are extremely hot - even after switched off the lamp.

► Do not touch the components.

► Wait until the surface has cooled down below 40°C.
Before opening the door to the lamp house allow the UV-lamp and the interior of the lamp house to cool down:

- at least 10 minutes for LH350 and LH1500
- at least 20 minutes for the LH5000.

► Always wear heat resistant gloves.

1.13.4 Heavy Loads Hazards

Many system components are heavier than one person can safely lift without assistance e.g.:

- Machine chassis
- Base frame
- Alignment stage
- Lamp house
- UV-LED light source



CAUTION!

Ergonomic Hazard!

Risk of damage and injury of the spine by lifting of heavy objects.

► Always use corresponding tools for lifting of heavy loads.

► Always move with the required number of persons.

An overview over tools and the required number of persons for carrying heavy machine components you find in chapter *"Transport and Installation"*.

1.13.5 Noise Emission Hazards

The sound level measured in operator and maintenance areas is well below 70dB(A). No hazard is caused by noise.

1.13.6 Radiation Hazards by Non-Ionizing Radiation

UV Light

UV light is invisible for the human eye and can cause severe eye damages and skin burn.

Depending on the used wave length range the UV light is only accompanied by a low amount of visible light.

WARNING!

Risk of Eye Damage and Skin Burns!

Invisible high energy UV light may damage eyes or skin.

- ► Do not work on the machine if covers are removed.
- ► When performing light uniformity checks always wear UV protective glasses and cover your skin.
- ► Increased awareness is required when using short-wave UV 250 or UV 300 light (if applicable) or when using 365 nm wavelength only.
- ► Increased awareness is required when the optional UV-LED light source is used with 365 nm wave-length exclusively, because this radiation is com-pletely invisible to the human eye.

Protective equipment:
- UV-Safety Goggles
- Safety Gloves

For Details see: *Chapter 1.7 “Recommended Safety Equipment” on page 17*

If the UV-LED Lamp House is installed, three wavelengths (365 nm, 405 nm, 436 nm) intensities can be adjusted independently. While 405 nm and 435 nm are still visible as deep blue, the 365 nm radiation is invis-ible.

If this wavelength is selected and activated solely, very intense UV-light is emitted, which may be undetectable by the human eye. This can cause a potential dangerous situation which must be countered by ade-quate instructions to the operators.

UV-LED Front lens holder:

If a UV-LED light source is used, the front lens holder is equipped with a fluorescent cube

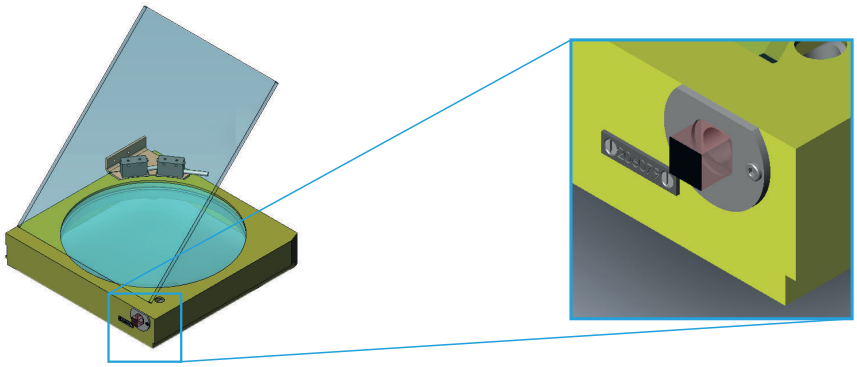


Fig. 1 - 1: UV-Detector in Front Lens Holder

Reason for that is the almost invisible radiation in the UV range. Espe-cially if the wavelength 365 nm is used exclusively the human eye is not able to detect any light.

To be able to check whether radiation is present in the exposure area a cube built from red fluorescing material is inserted into the front of the front lens holder.

1.13.7 Chemical Hazards

Chemicals Used or Produced by the Machine

Mercury (Hg)

The UV lamp contains a small amount of toxic mercury (Hg) Hg enclosed in an intact lamp bulb will not affect humans or the environment.

If a UV lamp breaks or bursts, counter measures to contain the mercury content are to be taken immediately.

- Mercury content UV lamp up to 1000 W: < 1,0 g
- Mercury content UV lamp 5000 W: ca. 3 g

Broken cold lamp:

If broken the cold lamp spills liquid mercury which must be caught:

- collect visible droplets by suction with a syringe or vacuum device.
- following clean up - including invisible remaining - shall be done using a mercury absorbing agent like sulfur powder or a specialized Hg-catcher like Mercurysorb by Carl Roth.

Explosion of a hot lamp:

- The mercury content will mostly being blown away as vapor very quickly.



WARNING!

Risk of Poisoning! Mercury is Very Toxic!

Incorporated mercury can result in chronic heavy disease!

► Avoid inhalation of mercury vapors!

► Immediately remove spilled mercury with recommended procedures and agents.

Procedure in case of lamp explosion:

1. Immediately switch of power for the lamp and the machine.
2. DO NOT switch off the exhaust system for the lamp. Suction is the most effective way to remove mercury vapors.
3. DO NOT open the lamp housing.
4. Immediately evacuate the immediate area of the machine.
5. Ventilate the room.
6. Wait at least 30 minutes before returning to the machine.

7. Remove glass fragments, bulb sockets and potential mercury residue, deposited inside the lamp house. Wear appropriate personal equipment such as Latex gloves and goggles.

8. Decontaminate the empty lamp house as described above for liquid mercury spillage.

9. Check exhaust lines and filters (if present) for Hg-contaminations. If necessary replace such parts

10. Wipe optics very gently using lint free paper, which is slightly dampened by a residue free liquid.

11. Treat all debris as well a the materials used in the cleanup as hazardous waste and dispose off accordingly.

NOTICE!
Follow local rules and laws for Hg waste.

Disposal of used lamps:

- Hg lamps are hazardous waste.
- They must be disposed according to local rules and laws.
- If possible, used lamps should be returned to the original supplier for recycling.
- Shipping by air only when declared as dangerous goods (UN2809) together with an IATA shipper‘s declaration and specially packed.

Ozone (O_3)

The UV lamps used in the mask aligner produce ozone especially directly after switch-on. A correctly adjusted exhaust for the lamp house provides for quick evacuation of the ozone. The measured values for the ozone concentration with correct exhaust is well below the limits accepted by OSHA.

- Operate the lamp only with correctly working exhaust.
- Use exhaust even for short operation of the lamp.

NOTICE!
To avoid exposure to ozone adjust the exhaust flow for the lamp house to the correct settings.
Never use the lamp without exhaust.

Use of Toxic or Secret Process Materials (Substrates, Resists)

When using toxic or company confidential materials (e.g. GaAs), the system's user has to make sure that his personnel is supplied with the necessary safety instructions and Safety Data Sheets to run the system in a safe way.

NOTICE!

It is the user's responsibility to mark all containers and cassettes containing toxic materials with appropriate labels and warning signs.

Working with Cleaning Agents

Cleaning agents like isopropyl alcohol (IPA) are flammable solvents and must be used in accordance with Federal, State and local requirements. Proper precautions must be taken in the storage, use and disposal of this cleaning agent, which should be treated as hazardous materials.

- Only use in well-ventilated areas.
- Do not us in the vicinity ignition sources such as flames and sparks.



WARNING!

Highly Flammable Media!

Risk of burning because of highly flammable media!

► Keep away from ignition sources/hot surfaces.

► Wear personal protective equipment.

► Observe and comply with the corresponding safety data sheet.



WARNING!

Irritating Media!

Health hazard caused by contacting or inhaling of irritating media!

► Avoid eye and skin contact.

► Do not inhale.

► Wear personal protective equipment.

► Observe and comply with the corresponding safety data sheet.

Protective equipment:
- UV-Safety Goggles
- Safety Gloves
- Protective Clothes

NOTICE!

All information concerning safety must be read and understood by the personnel who work with or in vicinity of the equipment before operation of the equipment.

NOTICE!

Components of the mask aligner - especially optical parts - only clean with IPA and DI water.

Working with other Chemicals

- Only chemicals approved by SUSS may be used.
- When using other chemicals always wear recommended personal protective equipment (safety goggles, gloves, face shields etc.) in accordance with the chemicals you are handling.
- Consider and observe the corresponding Safety Data Sheets.

1.13.8 Increased Hazards after Extraordinary Events

Following an extraordinary event - heavy malfunction of equipment, overheating, seismic event, etc. - the equipment may be damaged without evidence.

- Do not run the machine without prior careful checks by service technicians.
- Follow the instructions in maintenance and service manual.
- If a chiller is used, check if liquid has been spilled.

1.14 Safe Handling of UV-Lamps to Avoid Mechanical and Chemical Hazards

UV-lamps have a high internal pressure.
Hot lamps must not exposed to high temperature fluctuations.
Lamps must not exposed to mechanical pressure.

- Only open the lamp house if the lamp has been cooled down.
- Never touch lamp at its glass bulb. Only touch it at its ends.



WARNING!

Risk of Explosion!

UV lamps are highly pressurized. They can explode if mistreated causing serious injuries by fragments.

► Touch only when wearing face shield and gloves.

► Avoid rude handling.

► If not in use store it in its original box.



Protective Clothes

Close-fitting working clothes with a low tear strength, with snug sleeves and no protruding parts. They predominantly serve to protect from getting in contact with chemicals and prevent from irradiation of bare skin by UV lamps.



Safety Gloves
Media- and heat-resistant safety gloves protect hands from aggressive media, mechanical, thermal and radiation dangers.



UV-Safety Goggles
Safety goggles protect eyes from flying parts, splashing media and hazardous radiation.

NOTICE!
Each lamp destruction results also in emission of mercury.
Details concerning emission of mercury are described in section „Chemical Hazards“.

Rules for save handling of the lamp:

- Only transport and store the lamp in the original supplier‘s box.
- Only operate the lamp with a SUSS power supply which is optimized for the lamps.
- Only use lamps which are authorized from SUSS for the corresponding power supply.
- Respect the maximum life time of the lamp. It is specified in the lamp data sheet.
- Only open the lamp house after cool-down of the lamp.
- Set the cooling data carefully according to the manual.
- After lamp exchange check all electrical contacts and renew if necessary.
- Ensure that the cooling nozzle is adjusted correctly to the lamp socket.
- Check the lamp socket for discoloring. It is a sign for insufficient cooling. Check cooling if necessary.
- Avoid any mechanical stress to the bulb.
- Touch the lamp only at its ends (sockets), Never touch the bulb.
- Respect the orientation and polarity of the lamp during installation:
- If changing the lamp type select the new lamp type in the menu of the lamp power supply BEFORE installation of the lamp.
- Read and respect the manual of the lamp power supply.

1.15 Safety Hazards during Operation, Maintenance and Service

Dangerous situations may arise if certain precautions and procedures are not strictly followed.

A description of the special interlocks and their functionality which are integrated in the SUSS system you find in chapter *"Safety Circuits of the Equipment"*.

Type of Alarm Display	Description
Warnings	The warnings indicate dangers which may arise during installation, maintenance or operation of the equipment. Warning labels are positioned as close as possible to the potential hazard area or its safety cover inclusive the outer covers.
Alarm Messages GUI	Temporary dangerous situations during specific equipment conditions are able to be displayed in the user GUI.
Acoustic Alarm	Current dangerous conditions which require quick action are generated as acoustic alarm.
Signal Lamp (if the system is equipped with)	The signal lamp serves as display for the equipment condition for the personnel working with the equipment. The signal lamp is attached to the base frame. Detailed information concerning function of the signal lamp (if applicable) you find in the corresponding chapter of the equipment documentation.

1.15.1 Warnings and Warning Labels

All safety hazards of the equipment which are known by SUSS MicroTec Lithography GmbH at the time of effecting this manual are indicated with warning labels at the equipment in close vicinity of the hazard.
These warnings indicate dangers which may arise during installation, maintenance or operation of the equipment.

These warnings contain:

- one or more symbols or pictograms
- a clear keyword to identify the accident level.
- a description of the hazard and its possible consequence.
- a hint concerning the prevention of the hazard

NOTICE!

Do not remove or damage any warning label.
Use only cleaning agent IPA, because aggressive solvents may destroy the labels.
Immediately substitute any unreadable warning label (can be ordered from SUSS MicroTec)
Warning labels serve for the safety of the user!

1.15.2 Additional Safety Warnings

Lamp Power Supply CIC:

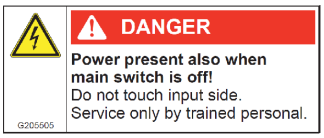
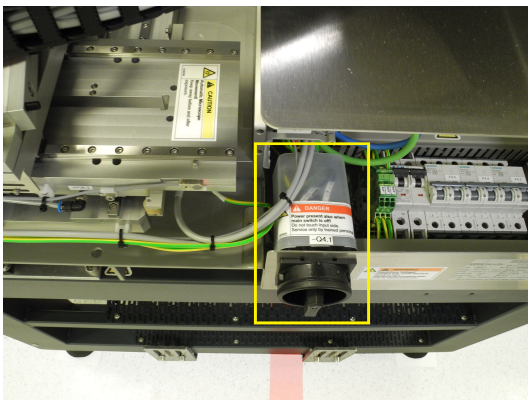
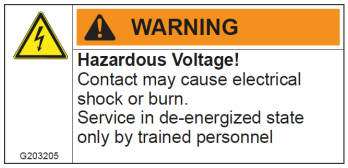
- Acoustic alarm
- Indicator lamps
- Display

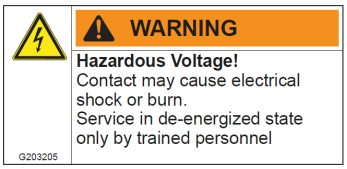
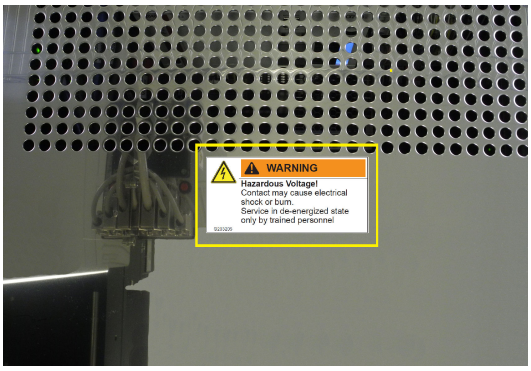
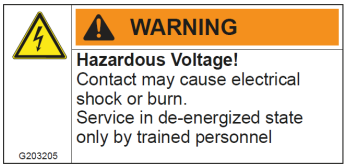
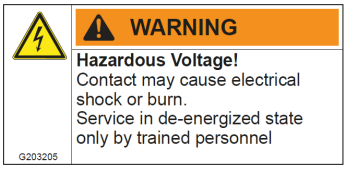
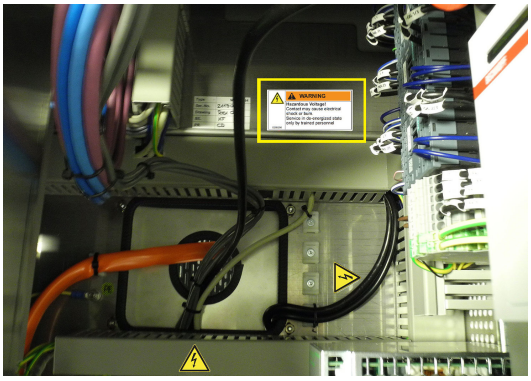
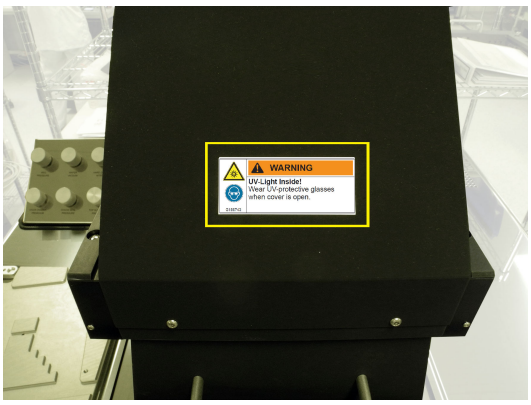
The CIC shows its status with an 8-digit display and some indicator lamps.
If cooling fails the alarm of both display modes and an additional acoustic alarm will be used in combination.
Detailed description you find in the user manual of the CIC.

1.15.3 Possible Hazards in the Mask Aligner

Following overview drawings show the positions of possible hazards in the machine:

Legend concerning the positions of hazards and mandatory signs:

A		
B		
C		

C	WARNING Hazardous Voltage! Contact may cause electrical shock or burn. Service in de-energized state only by trained personnel G203205	WARNING Hazardous Voltage! Contact may cause electrical shock or burn. Service in de-energized state only by trained personnel
C	WARNING Hazardous Voltage! Contact may cause electrical shock or burn. Service in de-energized state only by trained personnel G203205	WARNING Hazardous Voltage! Contact may cause electrical shock or burn. Service in de-energized state only by trained personnel NOTICE
C	WARNING Hazardous Voltage! Contact may cause electrical shock or burn. Service in de-energized state only by trained personnel G203205	WARNING
D	WARNING UV-Light Inside! Wear UV-protective glasses when cover is open. G186743	WARNING UV-Light Inside! Wear UV-protective glasses when cover is open.

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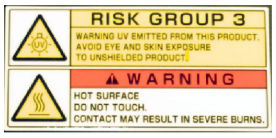
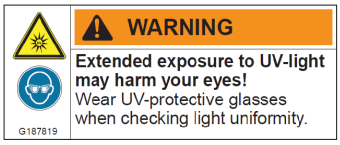
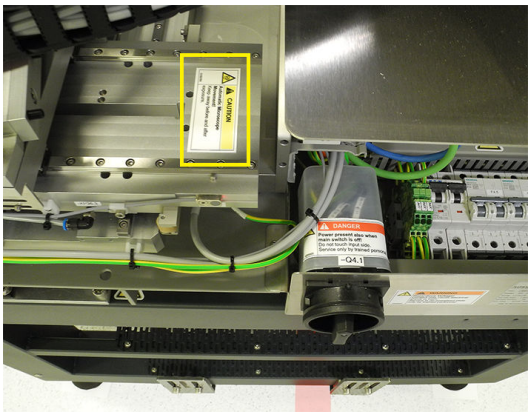
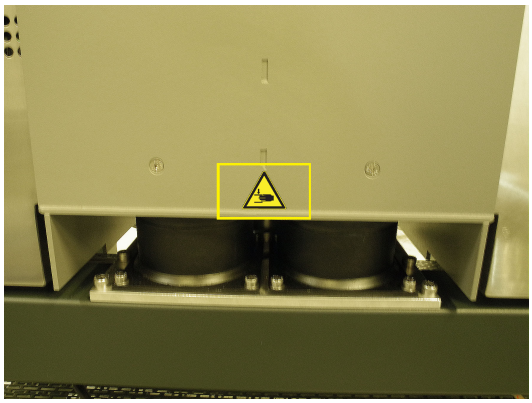
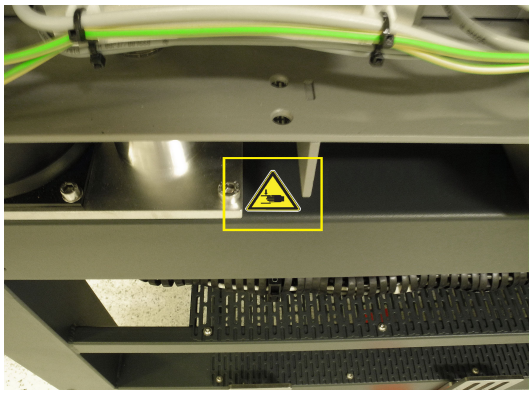
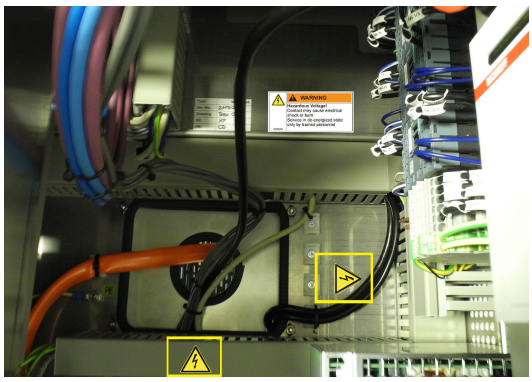
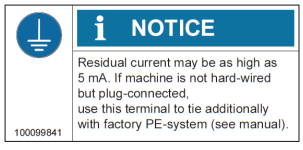
E		
F		
G		 Left/right microsocpe movement

H		
H		
I		
K		

Following overview drawings show the positions of possible hazards in the machine:

Legend concerning the positions of hazards:

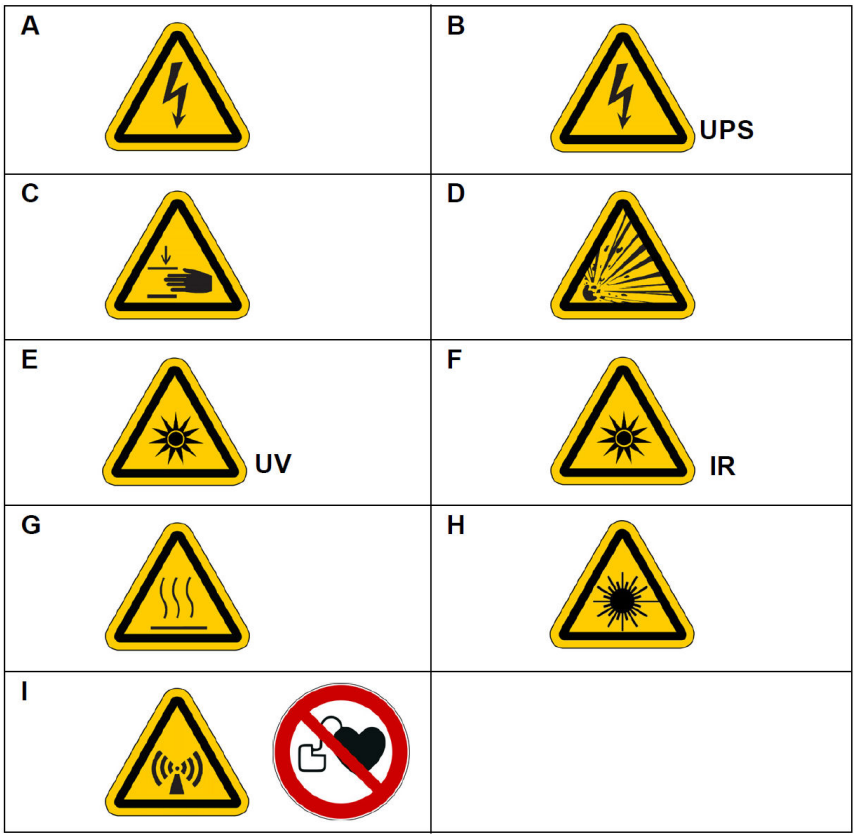


Fig. 1 - 2: Legend of Hazards

Front View

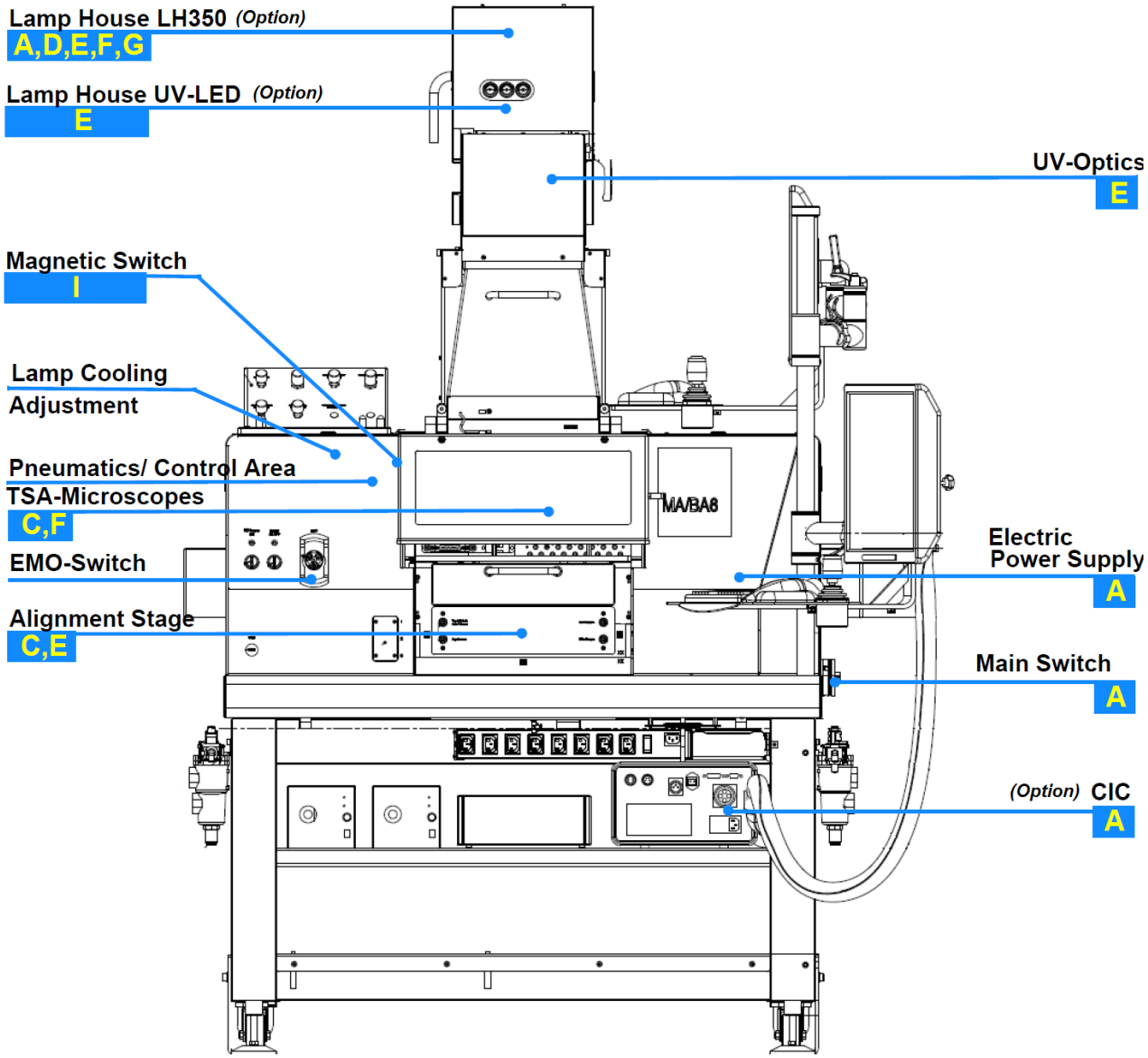


Fig. 1 - 3: MA/BA Gen4 Front View

Side View

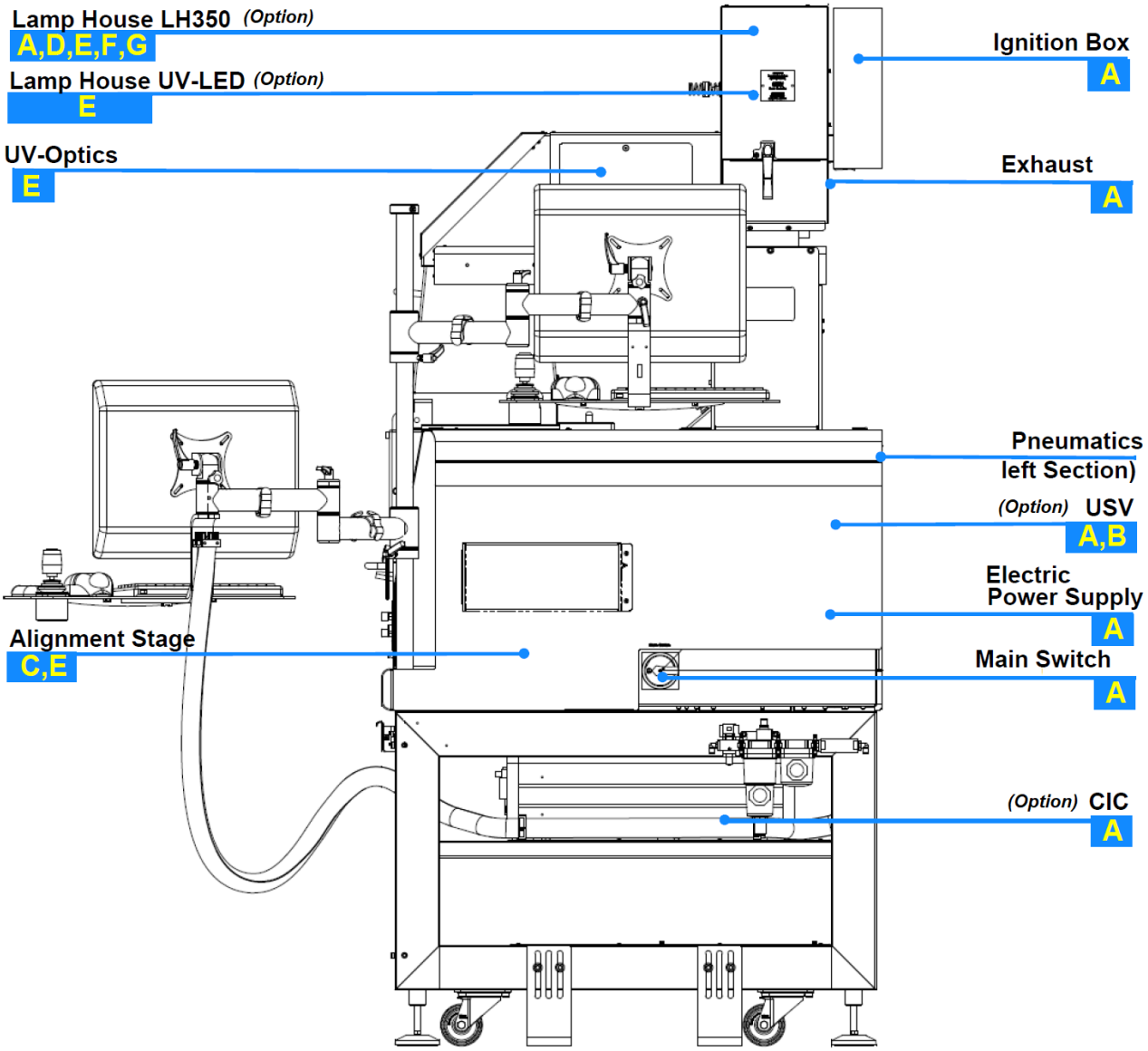


Fig. 1 - 4: MA/BA Gen4 Side View

1.16 Lockout/Tagout Procedure

Lockout/Tagout are planned safety procedures for shut-off the energy supply from industrial machines and equipment during maintenance and service work.
These procedures protect the workers from hazards coming from running machines or electric current.

Requirements:

- The lockout device/procedure should be in accordance with SEMI S2 and legal requirements (and for the USA with OSHA CFR (Code of Federal Regulations) Title 29, Part1910 sections 147 and 331-335)).
- The customer has to provide the possibility to centrally switch off the gas and media supply (vacuum, CDA, nitrogen etc) for service and maintenance work.

Lockout/Tagout for:

- safe work during maintenance, cleaning, repair
- prevention of personal injury
- prevention of material damage
- protection against own mistakes and mistakes from others.
- every visible and clear sign for locking of a machine

Lock and Tags:



Fig. 1 - 5: Example for Locks and Tags

WARNING!

Electric, Pneumatic and Thermal Hazards!

Risk of Personnel and Material Damage!

► Never try to operate switches, valves or separators for energy supply if they are locked or tagged accordingly.

1.16.1 Electrical Work - Voltage Types According to SEMI S2

TYPE 1: Equipment is fully de-energized (electrical „cold“)

TYPE 2: Equipment is energized. Energized circuits are covered or insulated. Electrical work is performed at a remote position to preclude accidental shock.

TYPE 3: Equipment is energized. Energized circuits are exposed and accidental contact is possible.
Potential exposures are less than 30 V RMS. 42.4 V peak, 60 V DC or 240 VA in dry location.

TYPE 4: Equipment is energized. Energized circuits are exposed and accidental contact is possible.
Potential exposure is greater than 30 V RMS, 42.4 V peak, 60 V DC, 240 VA or radio frequency (rf) able to result in hazardous voltages or energies.

Apply for maintenance: All work has to be done with completely de-energized („electrically cold“) equipment.
Condition Type 1 according to SEMI S2 has to be established.

The following procedure has to be implemented in order to safely perform relevant maintenance or service tasks of Type 1 and to ensure that the equipment is isolated from each possibly dangerous energy.

All equipment shall be isolated from all energy sources as described in the following sections and locked out or tagged out to protect against accidental or inadvertent operation when such operation could cause injury to personnel.
Make no attempt to operate any switch, valve, or other energy isolating device when it is locked or tagged out.

1.16.2 Responsibility

- Appropriate employees e.g. technicians, operation manager shall be instructed in the safety significance of the lockout/tagout procedure.
- Each new employee whose work operations is or may be in the area shall be instructed in the purpose and use of the lockout/tagout procedure.
- It is the manager’s responsibility to ensure that all appropriate employees are trained.
- The technicians are responsible for the correct realization for the lockout/tagout procedure before starting the maintenance work.

1.16.3 Preparation

► Locate and identify all isolating devices, (switch(es), valves or other isolating devices) relevant to the machine.

► Notify all affected employees that a lockout/tagout procedure is going to be utilized and the reason therefore.

The authorized employee shall know the type and magnitude of energy that the equipment utilizes and shall understand the hazards thereof.

1.16.4 Electrical Energy Isolation

Shut Down Procedure

Shut it down by the normal shut down procedure:

1. Switch off electrical power using the main switch on the machine
2. Unplug the supply cord at the facility outlet.
3. Ground (short circuit) the machine frame.
4. Check voltage free state: After ensuring that no personal are exposed, the voltage - free state (deadness) has to be checked.

NOTICE!
If the equipment is installed in the USA:
The circuit breaker in the supply area must not be installed more than 20 Feet (6 m) away from the operator station.

NOTICE!
Service work at electrical systems is only allowed to be performed by qualified personnel.
Covers of the electrical systems must not be opened by the operator.

In case of electrical problems:

► Switch off machine
► inform supervisor or technician.

Stored electrical energy:

Components that may have a residual voltage after switching off (which is able to be at risk for the operator) must be actively discharged (e.g. motor controls and high-capacitance capacitors) to transfer them into save condition:

- De-energize the capacitors and
- Short and ground circuit all highly-capacitive elements.
- Observe the components' discharge times.

Stored non-electrical energy:

Stored non-electrical energy in components which could activate electrical circuits have to be blocked, discharged or de-activated to exclude any accidental activation of electrical circuits.

Examples for stored non-electrical energies are pneumatically controlled components which could set electrical valves.

Protection against unintentional switch-on:

1. All switches which are switched off have to be protected against unintentional switch-on, if possible with mechanical locks.
   If locks are not available, choose an alternative approved method to prevent unintentional switch-on. Additionally install a tag.

2. Identify pressure switches (if applicable) with warning labels or with similar methods to protect against unintentional built-up of pressure.
   For this:

   - check the pressure-free condition of the equipment with suitable measuring devices.

Grounding and short-circuit:

1. Ground and short circuit all components to be handled. The grounding/ short circuiting devices must be connected to the grounding equipment first and then the components are to be grounded.

2. Attach the grounding/ short circuiting devices so that they are visible at the machine (if possible).
   If not, they have to be attached as near as possible to the machine.

3. Take appropriate measures (jumper, grounding) prior to beginning work, if wires are to be cut or interrupted.

4. Check that the grounding/ short circuiting devices, cables, connectors fit and that they are suitable for the short circuit stress at the installation position.

5. Ensure that all grounding and short circuit measures remain effective during work.
   If grounding and short circuit shall be removed for measurement or testing, take appropriate measures for security.

6. Cover/ barrier powered adjacent components:
If components adjacent to the work location cannot be switched off, they must have appropriate covers or barriers. Notice and comply with the regulations according to „working adjacent to powered components“. In general - working in close proximity of powered components (> 30 V RMS or 42,2 V peak) is only allowed, if any access to powered components is limited by the appropriate covers or barriers.

Check zero-potential:

After ensuring that no personnel is in danger, the zero-potential state has to be checked at all connections in the vicinity of the machine.

- The checking devices have to be conform to inhouse regulations.
- Check transportable checking devices and voltmeters directly before and after use.

1.16.5 Pneumatic Energy Isolation

Switch-off of pressure supply for CDA and nitrogen for maintenance work:

1. Disconnect the supply for CDA and nitrogen. Use the main shut-off for this purpose.
2. Protect all shut-off options for CDA and nitrogen against unintentional switch-on, optionally with mechanical locks.
3. Mark all pressure valves with tags, labels or other proven methods to prevent accidental re-pressurization of the media supply.
4. If lockable valves are available at installation site, switch them off, lock and tag-out.
5. Disconnect the supply tubing from the valves outlet to permit dissipation of any stored pneumatic energy.
6. Check the depressurized state of the system by checking the main gauges.

NOTICE!

The user shall provide the possibility at supply end to close the media supply (vacuum, CDA, nitrogen) during maintenance and service work.

1.16.6 Thermal Energy Isolation

- Ensure that no danger comes from thermal energy stored inside the machine - especially in the lamp house.
- Wait until any part of the equipment that has been heated during the process had sufficient time to cool down to 40°C or lower.
- During the cool down time, keep cooling and exhaust running.



WARNING!

Hot Surfaces!

Danger of Burning!

► Do not touch hot components.

► Wait until the surface has cooled down below 40°C.

1.16.7 Lockout/Tagout Check List

Lockout:

- Shutting off any source of dangerous energy.
- Release of any possible residual energy.
- Secure the shut-off points with a lock.

Tagout:

- Marking with tags *"Locked"* - *"Do not use!"* and other important information.

Use following check list for lockout/tagout procedures for circuits or the equipment:

	Work Step	Done
1	Identify all sources of electrical energy for the equipment or circuits in questions. (e.g. power plug)	☐
2	Disable backup energy sources such as generators and batteries. (e.g. uninterruptible power supply (UPS))	☐
3	Identify all shut-offs for each energy source. (e.g. main switch)	☐
4	Notify all personnel that equipment and circuitry must be shut off, locked out and tagged out.	☐
5	Shut off energy sources and main switch.	☐
6	Lock switchgear in the OFF position. (Each worker should apply his or her individual lock).	☐
7	Apply a tag and prevent it from removing.	☐
8	Test equipment and circuitry to make sure they are de-energized. This must be done by a qualified person.*	☐
9	Delete stored energy by bleeding, blocking, grounding etc.	☐
10	Apply a tag to alert other workers that an energy source or piece of equipment has been locked out.	☐
11	Make sure everyone is safe and accounted for before equipment and circuits are unlocked and turned back on. Note that only a qualified person may determine when it is safe to re-energize circuits.	☐

* OSHA defines a „qualified person“ as someone who has received mandated training on the hazards and on the construction and operation of equipment involved in a task.

1.16.8 Restoring Machine to Normal Operation

Following items have to be observed before restoring machine to normal operation:

Perform tests and do visual checks:

A qualified person has to perform tests and visual checks to ensure that all interlocks are active and set to normal operation so that the equipment can set safely to normal operation.

Warn personnel:

Warn personnel that could be exposed to danger before switch-on of the machine.

Remove locks and tags:

Remove all locks and tags from the equipment. Only the person who did the locks/tags must remove them.

Exception: If a staff member is not available (change of shift, vacation) the locks/tags are allowed to be removed by a different operator. The supervisor of the original operator has to watch the procedure and make sure that all locks and tags will be returned to the originally responsible operator.

1.17 Safety Circuits of the Equipment

The mask aligner is equipped with several safety circuits for switch-off or warning in case of emergency.

The design of customer specific equipment is determined by the individual process requirements and the customer requirements.

Safety Circuit	Short Description	Mode of Operation
EMO	Switch-off of the machine except the computer.	If the EMO button (S5.2) is pressed the emergency- off module (K5.1 & K6.1) will switch off via relay (Q5.1 & Q5.2) the current to the machine and (Q6.1 & Q6.2) to the power supply of the UV-light source. The computer will remain energized for data saving reasons with UPS.
Flow Control Lamp Cooling	If the pressure of the CDA supply falls below the defined limit the lamp power supply (CIC) will be switched off after a defined delay. An optional flowmeter in the exhaust will also cause a shutdown.	If the pressure of the CDA supply controlled by the flowmeter (BP33.1) falls below a given limit, a delay (K.2 - K6.3) will become active. If at the end of the delay the measured pressure is still below the limit, the power for the UV-light source will be switched off via emergency-off module (K6.1) and the relays (Q6.1 & Q6.2).
Lamp House-Door Switch	If the locked door is opened the UV-light source will be switched off by triggering with the door switch.	If the lamp house door is opened, the switch (S7.1) will be opened. The power of the UV-light source will be switched off via emergency-off module (K6.1) and the relays (Q6.1 & Q6.3)

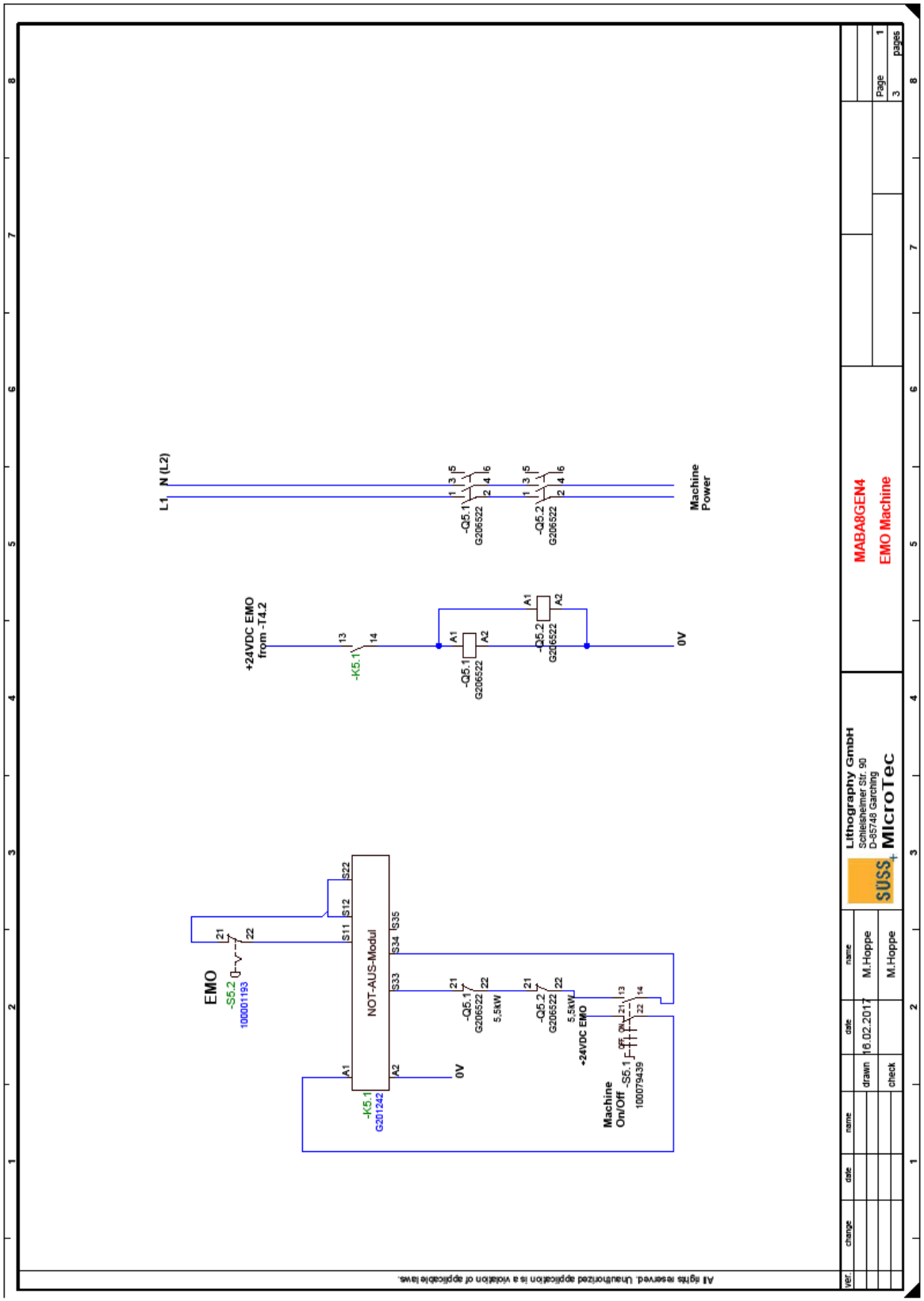
Safety Circuit	Short Description	Mode of Operation
Front UV-Protection	If the cover at the front of the optics tube is opened the shutter will remain in closed position/ the UVlight source will be switched off.	If the safety sensor (S7.3) is released the shutter opener (KP33.2) will be locked or the signal for shutter opening will be interrupted.
UV-Protection/ Optics	If the cover for access to the optics is opened the shutter will remain in closed position/ the UV-light source will be switched off.	If the safety sensor (-S7.2 or -S7.3) is released, the shutter opener (KP33.2) will interrupt (-K7.1) the signal for “valve shutter opener”.
UV-Protection/ UV-LED Light source	If the lamp house is moved back-wards away from its required posi-tion, the UV-light source will be switched off or cannot be switched on.	If the safety sensor (-S7.2 or -S7.3) is released, the LED-controller (-A42.1) will interrupt (-K7.1) the signal for “LED controller on”.

If the machine is used exclusively as a bond aligner, most of the safety circuits are omitted. Only the EMO is active.

The design of customer specific equipment is determined by the indi-vidual process requirements and the customer requirements.

Safety Circuit	Short Description	Mode of Operation
EMO	Switch-off of the machine except the computer.	If the EMO button (S5.2) is pressed the emer-gency- off module (K5.1 & K6.1) will switch off via relay (Q5.1 & Q5.2) the current to the machine and (Q6.1 & Q6.2) to the power supply of the UV-light source. The computer will remain energized for data saving reasons with UPS.

1.17.1 EMO


L1
N (L2)
-Q5.1
G206522
-Q5.2
G206522
Machine
Power
+24VDC EMO
from -T4.2
-K5.1
0V
EMO
-S5.2
100001193
NOT-AUS-Modul
-K5.1
G201242
5,5kW
+24VDC EMO
Machine
On/Off
-S5.1
100079439
MABA8GEN4
EMO Machine
Lithography GmbH
Schleißheimer Str. 90
D-85748 Garching
MicroTec
M.Hoppe
16.02.2017
Page 1
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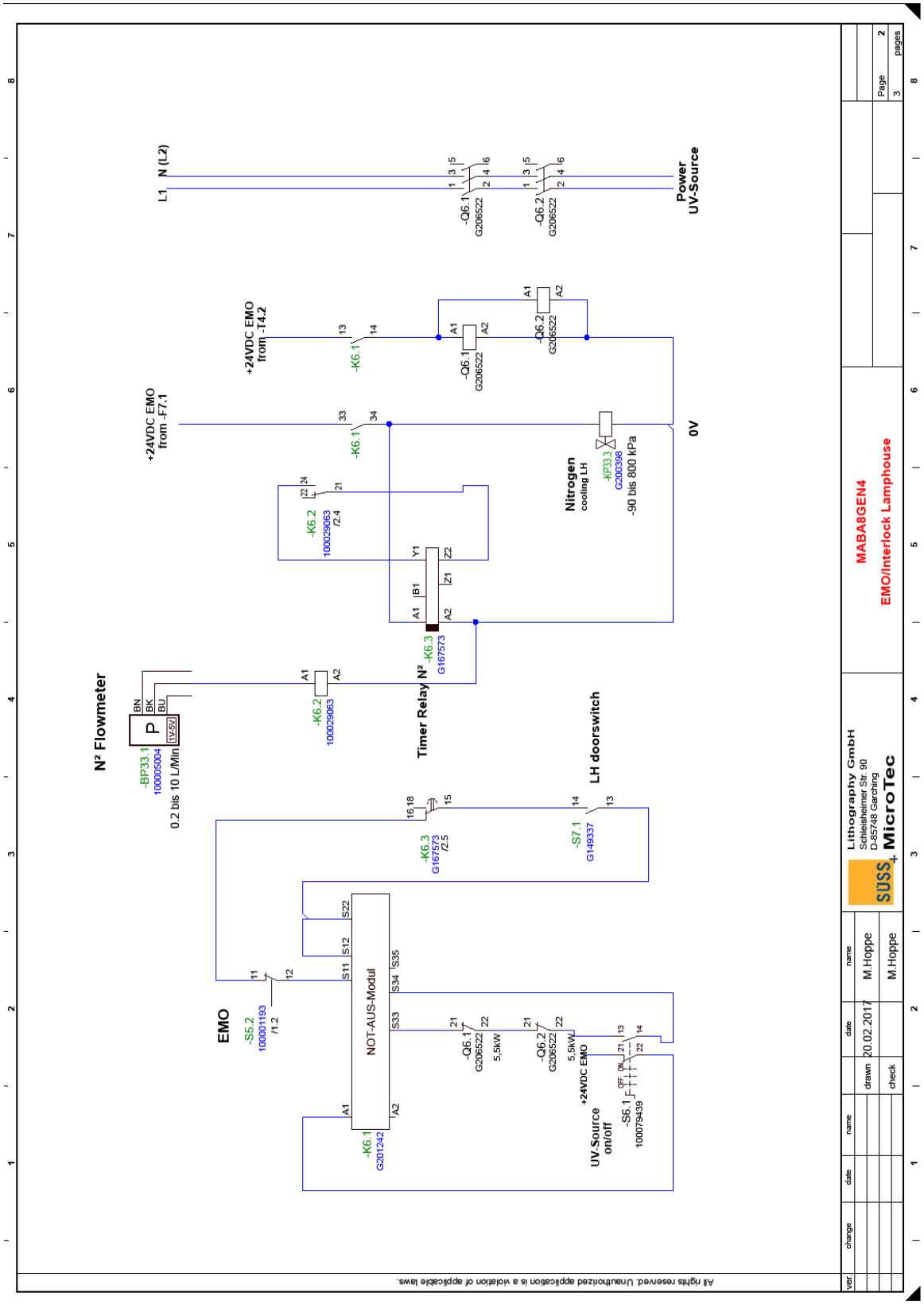
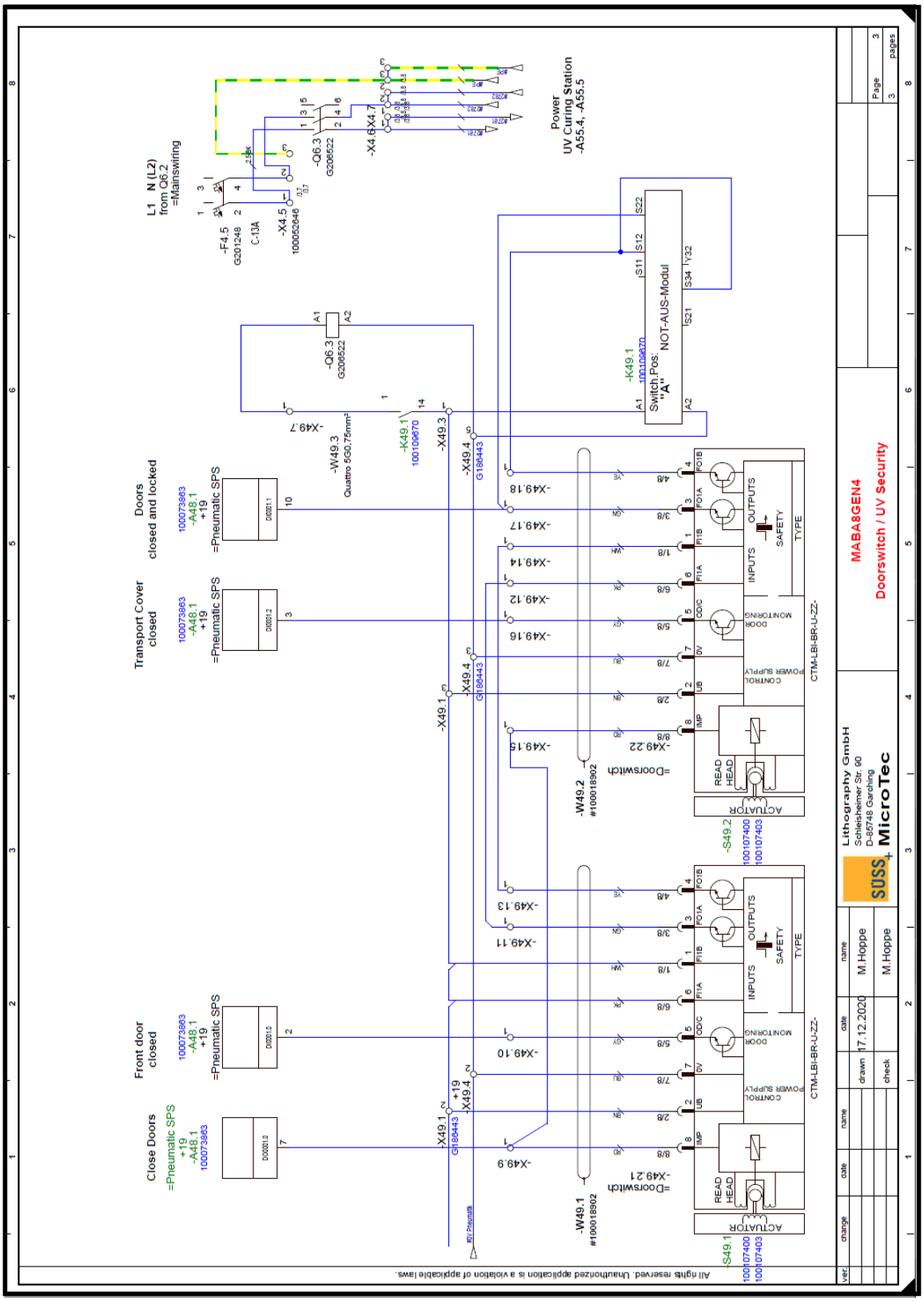
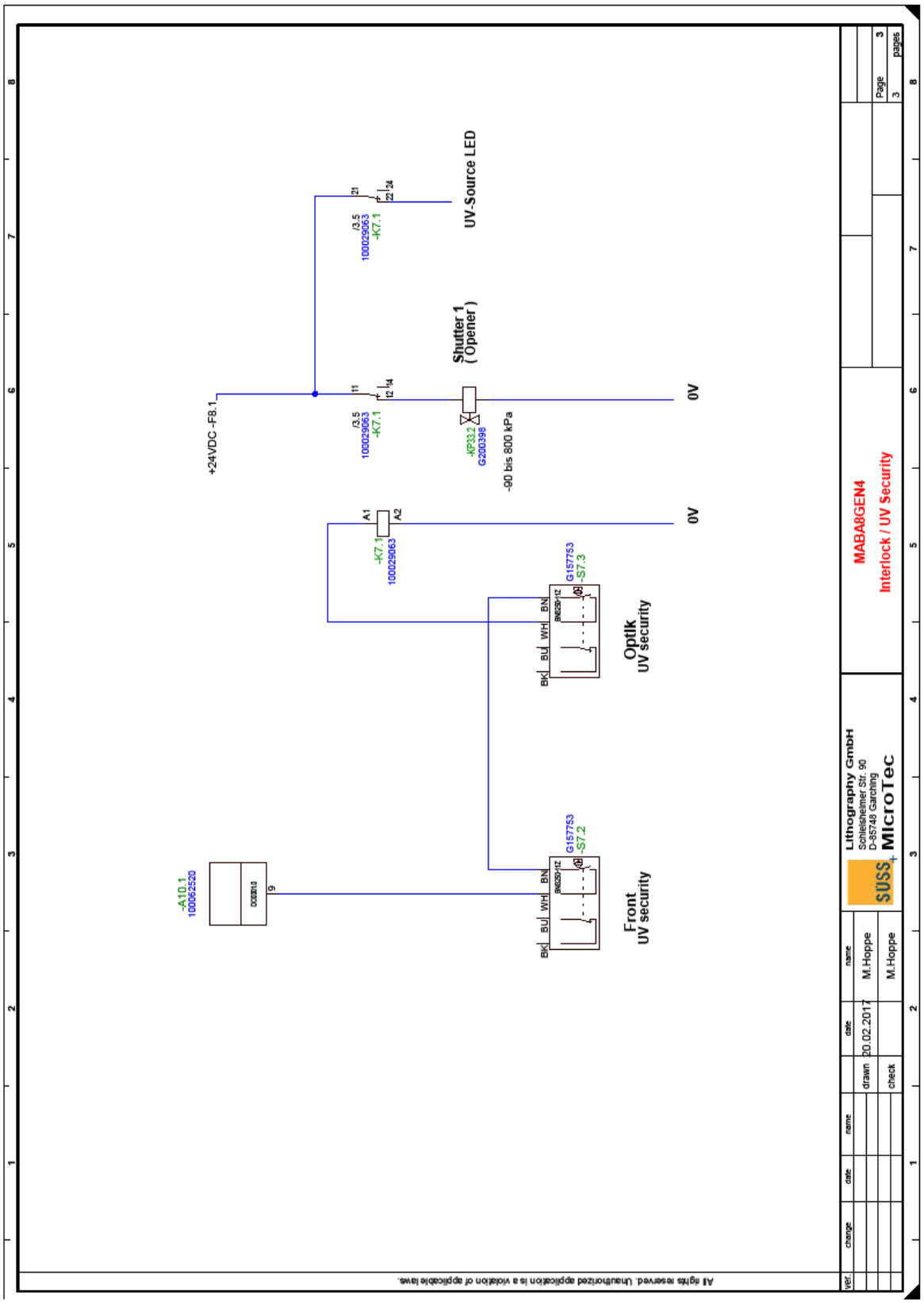
1.17.2 EMO Lamp House Door



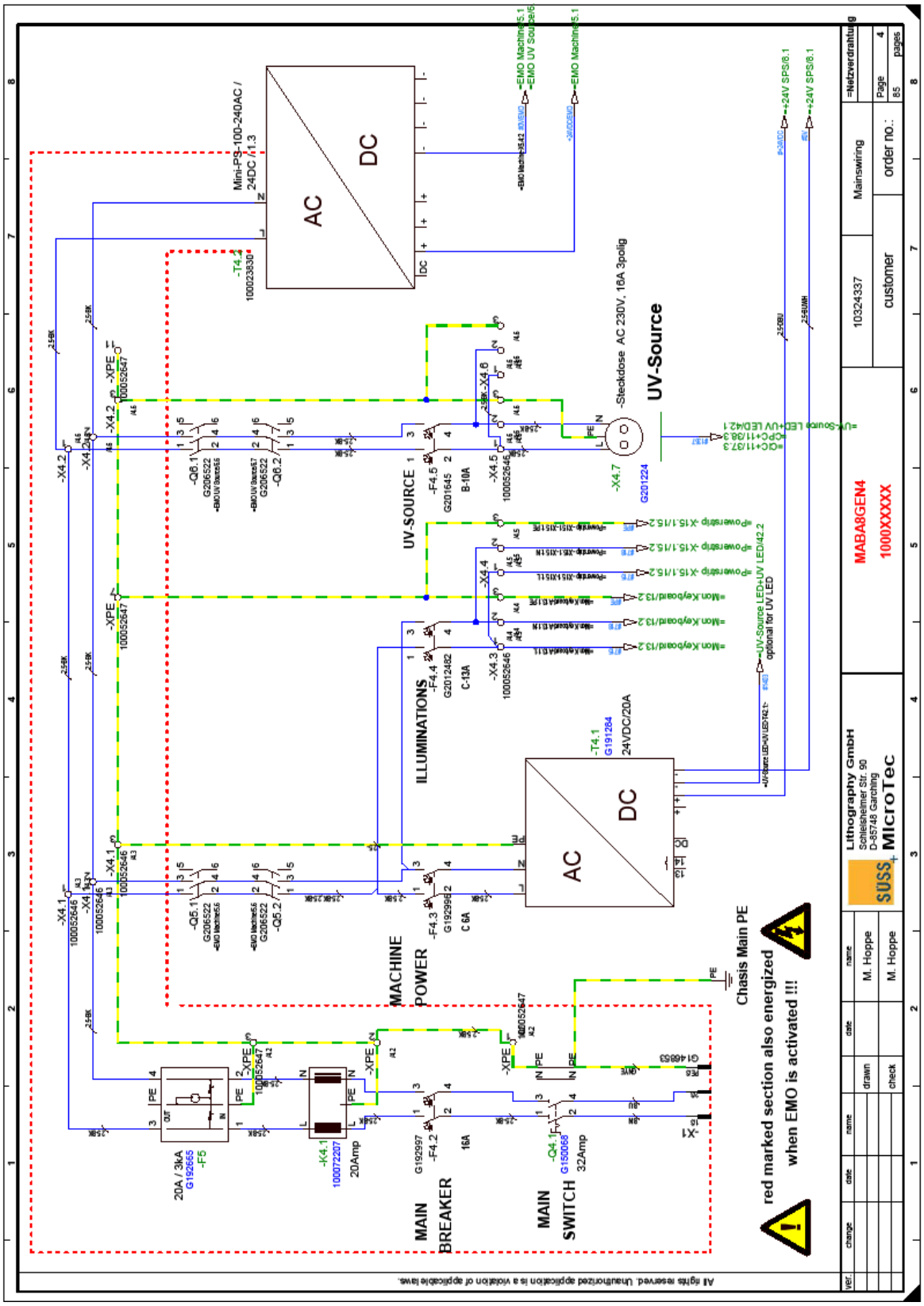
1.17.3 EMO Door Switches



1.17.4 UV-Protection/Optics



1.17.5 Main Circuits



2 INSTALLATION

NOTICE!
The information in this chapter is equipment specific and only valid for this system.

This chapter contains information about:

- Transport, receiving and unpacking of the equipment
- Requirements for the installation site
- Preparation for installation and installation
- Utilities
- Configuration/ layout of the equipment
- Earth quake guarding

Storage of the equipment over a longer time period requires a clean and dry storage area, temperature: 20 - 22° C, humidity: 45 - 55%

2.1 Receipt, Transport, Unpacking

Equipment from SUSS MicroTec Lithography GmbH run strong inhouse tests and are carefully packed to avoid transport damage.

2.1.1 Receipt of Goods

The transport of the equipment from SUSS MicroTec to the user‘s facilities is usually performed by express agents with restricted liability. The risk of loss or damage is borne by the party defined within the sales contract.

NOTICE!
It is the responsibility of the receiving party to inspect the packaging for integrity.
Insurance claims will become void, if visible damage and signs of maltreatment are not registered and reported!
“”

Check for Completeness and Damage:

After receipt of the equipment the shipment has to be checked as follows:

1. Compare the number of delivered palettes/boxes with the number on the shipping note.

2. Check the packaging for visible damage or signs of improper handling.

3. Check also that shock-watch indicator (small glass tube) and tilt-watch indicators (colored powder) are present at each box, sealed with SUSS stamp or with paper label, and none of the indicators is triggered.

Procedure in Case of Transport Damage:

In case of integrity risk with a received component, proceed as follows:

1. Do not accept or do only accept conditionally delivery.
2. Make a note of damage statement (short description) on the delivery document and let the freight carrier signs your statement, make sure that driver's name and handoff-time is recorded.
3. Do not prematurely open the damaged box, but take pictures.
4. Notify the freight supplying company and your SUSS representative promptly about the damage and arrange with both for adequate follow- up action.
5. When considerable damage is possible, then an independent loss adjuster should be present when opening the crates.

2.1.2 Dimensions and Weight of Transportation Packaging

The mask aligner is packed in a stable wooden transportation box.

Dimensions:

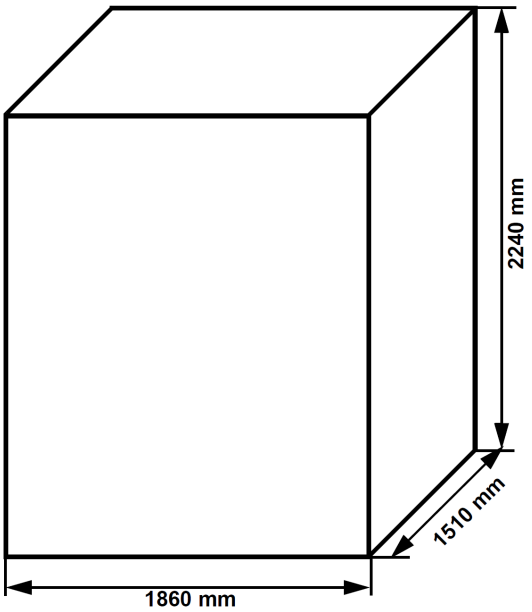


Fig. 2 - 1: Dimensions of the Transport Box

Weight: 300 kg

2.1.3 Transportation



The equipment user is responsible for the transportation of the packed system to the installation site.

Safety for transportation:



CAUTION!

No Movement off the Shipping Pallet!

Economic Risk of Damage and Injury!

► The customer may unpack the system in preparation for the installation. However, under no circumstances may it be removed from the shipping pallet without a qualified logistics company or a SUSS representative being present.

Transportation of boxes with machine parts:

- Before each transportation of the shipping pallet with the system, check that all locking devices to avoid damage of the system during transport are installed.
- Use a fork lift or crane to move the system on the shipping pallet. Adjust the forks wide and long.
- Make sure that the weight and the dimensions of the machine do not exceed the capacity of the fork lift
- Respect all labels and signs on the crates e.g.:
  - CG-marking („Center of Gravity“ if it is out of center of the machine)
  - Crossed-out fork lift symbol) (= do not lift from this side)
- Do not lift loads higher than necessary and do never stay under a lifted load.

Transportation of the system inside the factory:



CAUTION!

No Movement of the Installed System by the Customer!

Economic Risk of Damage and Injury!

► Any movement of the system is only allowed to be performed by SUSS service, SUSS representative or a qualified logistics company.

2.1.4 Unpacking

Unpacking and installation of the equipment must be performed by a SUSS MicroTec service technician.

Concerning warranty claims the packaging has to be removed by a service technician.

NOTICE!
Never remove a transport lock before the machine has reached its final position.

2.1.5 Storage of the Packed Machine

For long-term storage controlled environmental conditions have to be maintained.

Do not open the package. Once the package has been opened and a storage is planed, the machine has to be re-packed with additional drying agent.

Storage Instructions:

- Guaranteed temperature range: +20° C to +22° C
- Humidity: 45 - 55%

NOTICE!
Before taking out of service contact a specialist of SUSS MicroTec.

2.1.6 Disposal of Packaging Material

Packaging material has to be disposed or recycled according to local environmental laws.
Contaminated packaging material has to be treated like the contaminating substance itself.
If not officially regulated non-contaminated packaging can be treated as normal household waste or can be recycled.

NOTICE!
Some specially produced boxes should be stored over the whole lifetime of the machine (e.g. boxes for microscope, optics, lamp).

2.2 Selection Criteria for Installation Site

2.2.1 Criteria for Environmental Requirements

Following operation conditions are necessary for optimum process results:

Clean room class:	1000 and better free of dust and aggressive fumes (acids, base or solvent)
Vibration category:	VC-C, i.e.: speed of floor displacement < 12,5 µm/s in any direction.
Room temperature:	20° C- 22° C (68° F - 72° F)
Relative humidity:	45% - 55%
Allowed geographical height:	up to 1.000 m above sea level (higher regions require permission and special adjustments by SUSS MicroTec Service)

For reliable operation of the equipment:

- Verify that the machine is leveled carefully (leveling of the vibration insulated base frame.)
- Verify that no vibrations from building or other equipment is transmitted to the machine.

2.2.2 Additional Criteria for Installation Site

Service and maintenance area:	• In front of and next to the equipment enough space has to be provided to get access for service and maintenance work.
Vicinity to other equipment:	• Do not install the machine next to electric heavy-duty equipment as well as elevators, transformers and power current cables.
Electricity, fire and safety:	• The installation site has to meet all federal country- and local requirements concerning fire protection, electricity and safety.
Floor:	• The floor has to be clean room compatible, horizontal and even. The load-bearing capacity has be laid out for the weight of the equipment including periphery and operator.
Noise:	• Reduce the ambient noise level in the interest of safety and health of operator and user to a minimum.

2.3 Installation Preparation

Before installation of the machine all connections like electric power, CDA, vacuum, nitrogen (N2) and exhaust have to be provided.

NOTICE!

All connections for the machine have to be provided by the customer and have to be present at the site before installation.
The requirements concerning environment, dimensioning and weight have to be met.

WARNING!

Danger of Personnel Injuries and Machine Damage due to Incorrect Installation!

Incorrect installation bears the risk of death for the operator or can damage the equipment.

- ► All media connections have to be installed by an experienced technician.
- ► Electric power supply is only allowed to be installed by an electrically qualified person.

2.3.1 Shut-Off Valves for all Media Connections

Provide shut-off valves for each media supply inclusive vacuum.

The valves are used to:

- avoid media consumption with switched-off machine.
- enable a complete energy isolation at a locked machine.

NOTICE!

All shut-off valves shall be lockable and shall provide the possibility to attach labels (for Lockout/Tagout).

Additionally recommended are depressurizing fittings at the output side of the valves and separable couplings.

2.3.2 Electrical Safety Precautions



DANGER!

High Voltage!

Danger of Life by Electric Shock!

► Before connecting the equipment to the voltage supply switch off the main switch and the circuit breakers at the right side of the machine.

Install circuit breaker:

- **If the equipment needs a transformer the main switch of the transformer can be used as circuit breaker, if the main switch fulfills the conditions described above.**
- **If the equipment is installed in the USA, the circuit breaker has to be positioned next to the equipment.**

Check the supplied voltage:

- **Voltage and frequency listed on the name plate have to match with the supplied voltage.**

2.4 Utilities and Consumption

2.4.1 Use of Utilities

Vacuum: to fix the wafer/ substrate on the chuck
to fix the mask on the mask holder

Compressed air: for supply of the pneumatic systems

for cooling of exposure lamp and lamp house (only UV lamp).

Nitrogen (N_2): for contact processes and optional for cooling the exposure lamp

Electric connections and accessories: All electric and electronic connections at the equipment are marked.



NOTICE!

Make sure that the equipment and its components are grounded according to rules and regulations.

2.4.2 Pneumatic Connections and Consumption

Vacuum: < -80 kPa
Outer tube diameter: 6 mm

	maximum length: 2 m
Clean dry air (CDA):	0,5 to 0,8 MPa according to purity level ISO 8573-1:2010, **[5:6:4]** outer tube diameter: 6 mm
CDA consumption:	ca. 1 m³/h (LH350)
Nitrogen (N_2):	0,2 to 0,5 MPa outer tube diameter: 6 mm
Exhaust air*:	outer tube diameter: 6 mm
CDA Exhaust*:	outer diameter of the duct: 110 mm only necessary when a 500 W lamp is used.

* not applicable if equipped with UV-LED light source



CAUTION!

Risk for Contamination of Optical Components!

Nitrogen and CDA have to be dry and free of particles.
Contamination of optical components (lamp, mirrors, lenses) can affect the performance and the function of the equipment.

► Remove water, oil and dust particles from the supply system of nitrogen and air pressure.

2.4.3 Electrical Connection

Voltage/ frequency:	200-240 V, L1/N/PE, or L1/L2/PE, 50/60 Hz
AIC of main interrupt and breakers:	15 kA IEC
SCCR (Short Circuit Current Rating) of overall equipment:	5 kA
Apparent power:	ca. 1,7 kVA max, inc. CIC1200 and 350 W lamp ca. 1,0 kVA max, Bond Aligner without lamp
Power cable:	KABEL OELFLEX 491P BK 3G2.5 RU AWM CSA cable length = 3 m

Power plug:	G146853 EUROPEAN SCHUKO PLUG 16A/250V CEE7/7

Consumption

As bond aligner without lamp house:	0,3 kW
With 350 W lamp (CPC350):	0,7 kW
With 500 W lamp (CIC1200):	1,0 kW
With UV-LED light source:	Idle: 0.35 kW Full load (3 lines, 100%): 0,85 kW

2.4.4 Weight of the Machine

All listed weights include tooling and standard accessories kit: Special options could increase weight.

MA/BA:	360 kg inc. base frame
BA:	310 kg inc. base frame
Crate or box (empty):	300 kg

2.5 Layout of the Machine

2.5.1 Top View with Required Service Area

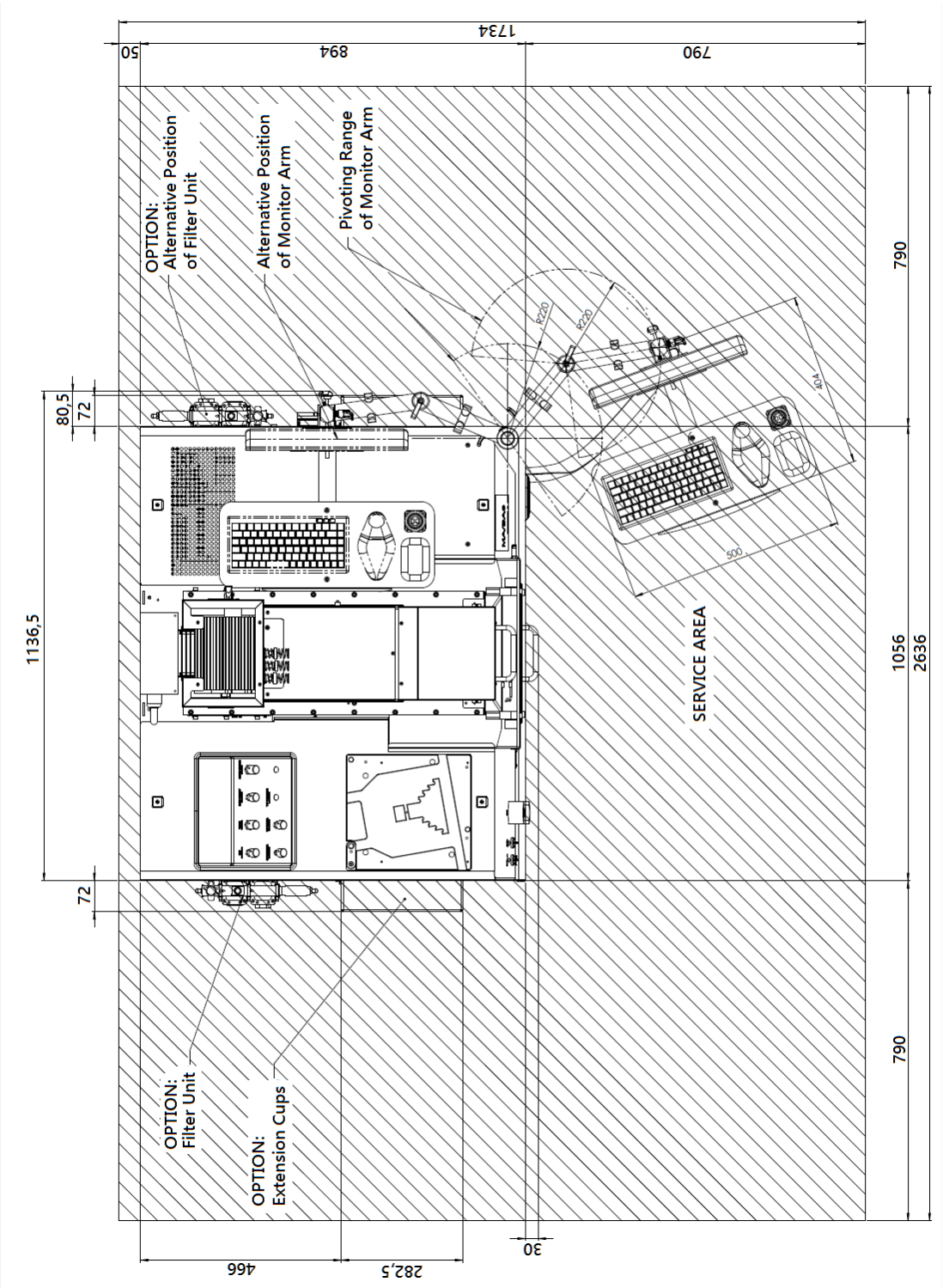


Fig. 2 - 2: MABAGen4-Top View (All dimensions in [mm])

2.5.2 Front View

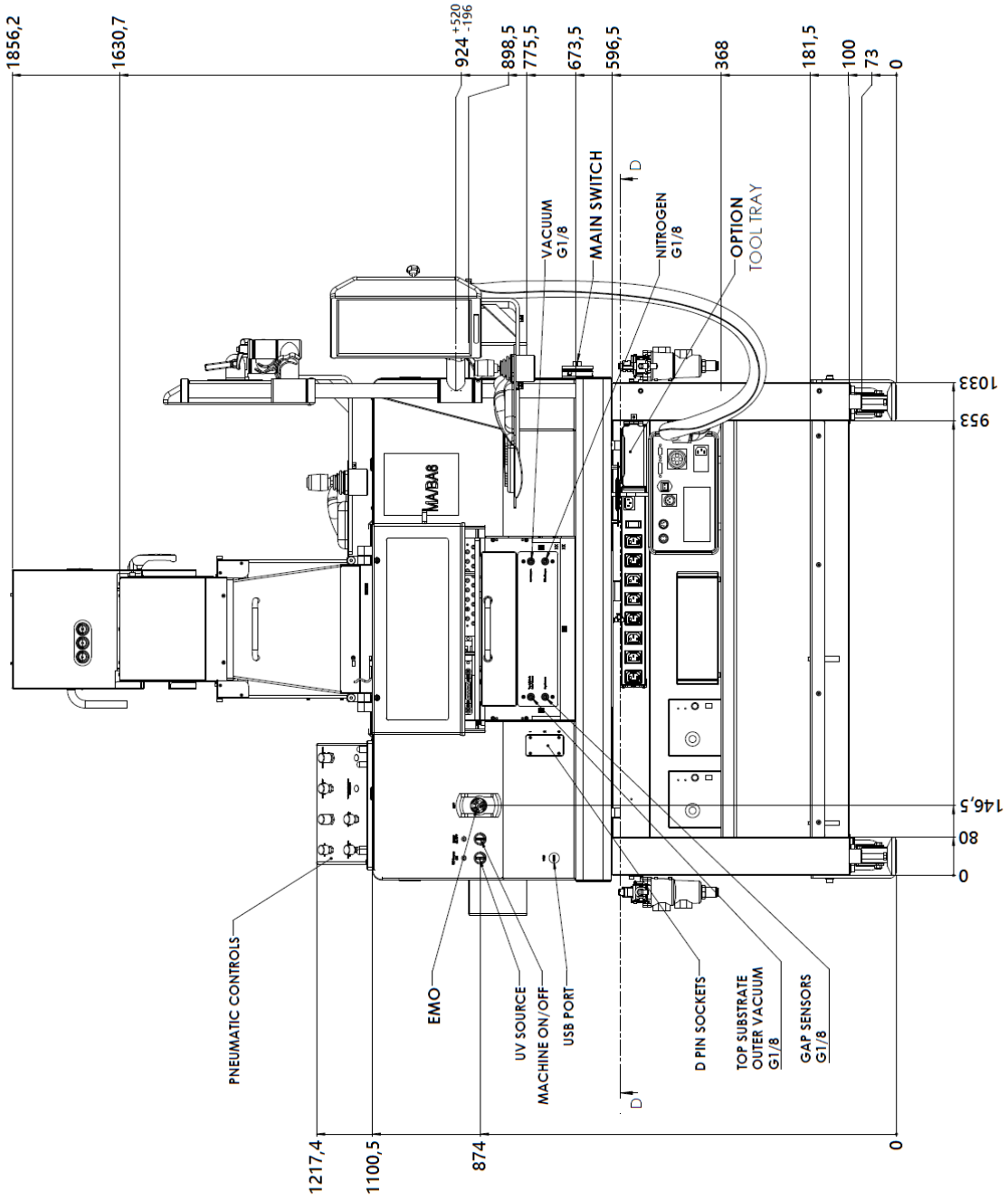


Fig. 2 - 3: MABAGen4-Front View (all dimensions in [mm])

2.5.3 Side View

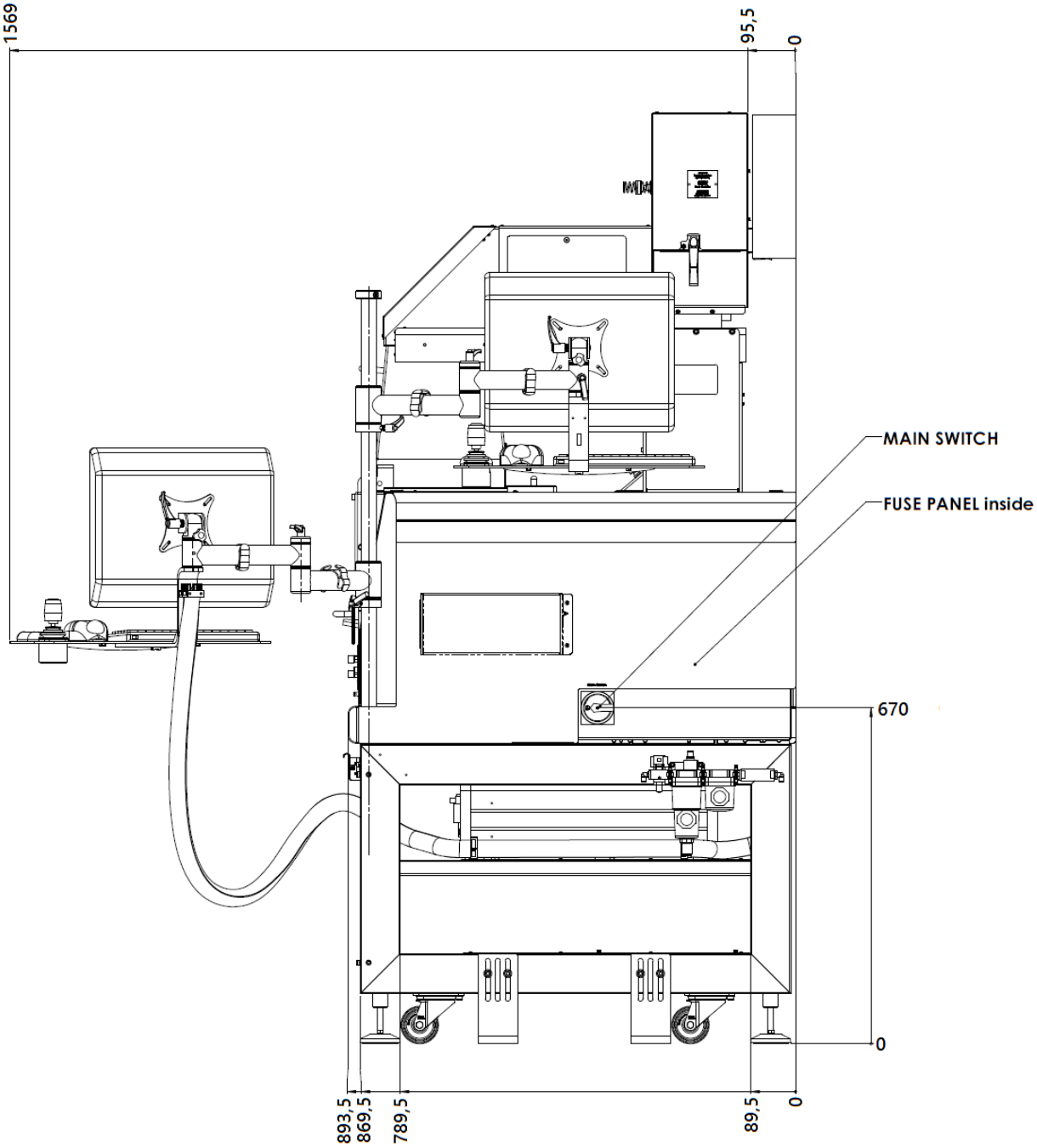
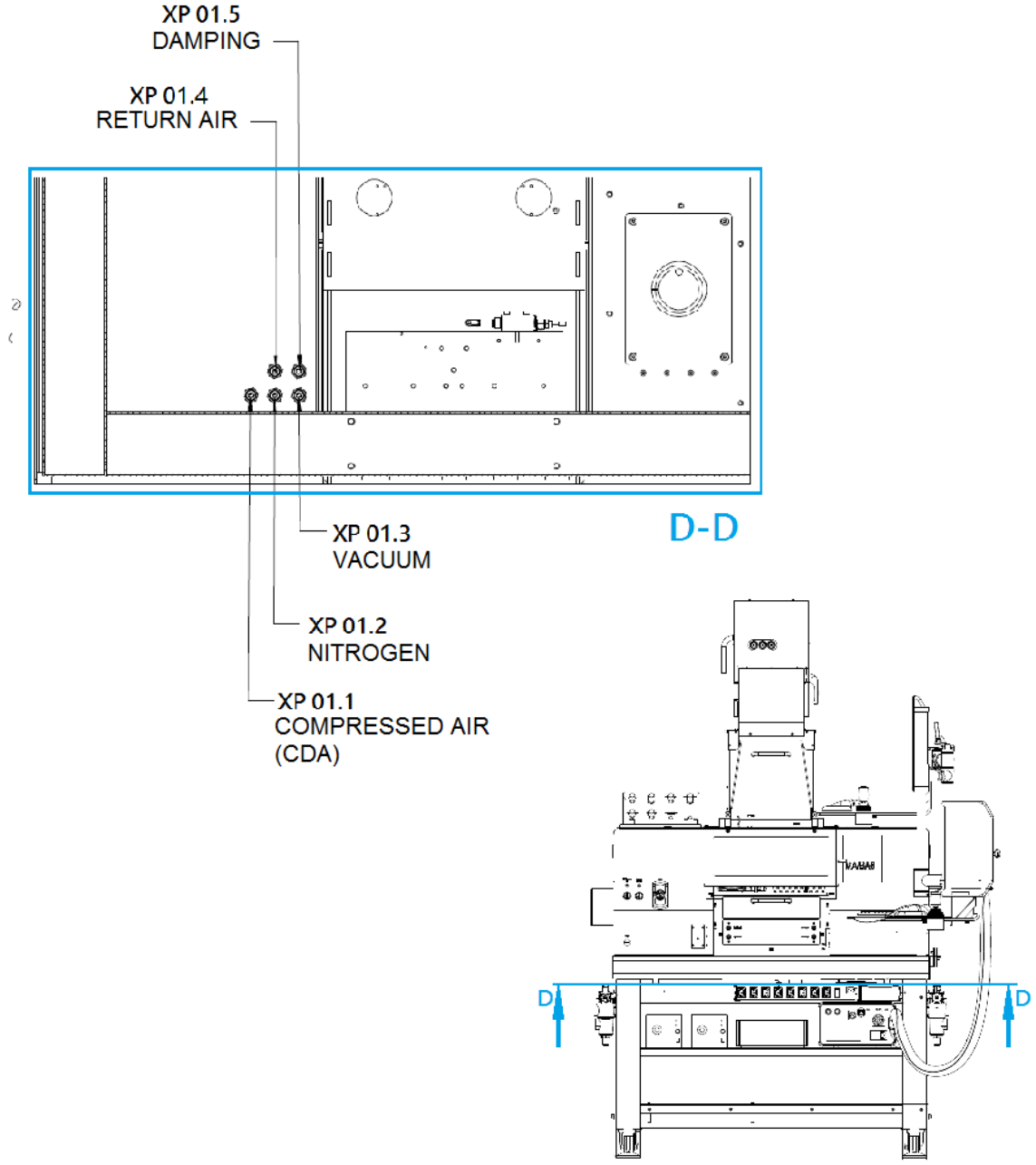
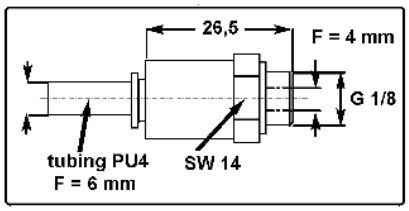


Fig. 2 - 4: MABAGen4-Side View (all dimensions in [mm])

2.5.4 Pneumatic Connections





The machine is equipped with connectors for pneumatic hoses with outer diameter 6 mm or optionally with connectors with outer diameter 1/4 inch.
Hose couplings for connection to the supply media are not included in shipment.

Fig. 2 - 5: MABAGen4-Pneumatic Connections

2.6 Earthquake Protection (Option)

Optionally the mask aligner can be equipped with an earthquake protection.

- With the earthquake protection the machine is mounted to the floor to prevent it from slipping or tilting in case of an earthquake.
- The earthquake protection shall save the equipment as well as the operator.



The position of each anchor point is marked at the machine with the adjacent mandatory sign.

NOTICE!

Prior to starting the process make sure that the mask aligner is fixed to the floor with the earthquake protection.
Use only earthquake protection authorized by SUSS MicroTec Lithography GmbH.

NOTICE!

The earthquake protection has to withstand the expected seismic forces (horizontal and vertical forces).

2.6.1 Floor Anchoring of the Equipment

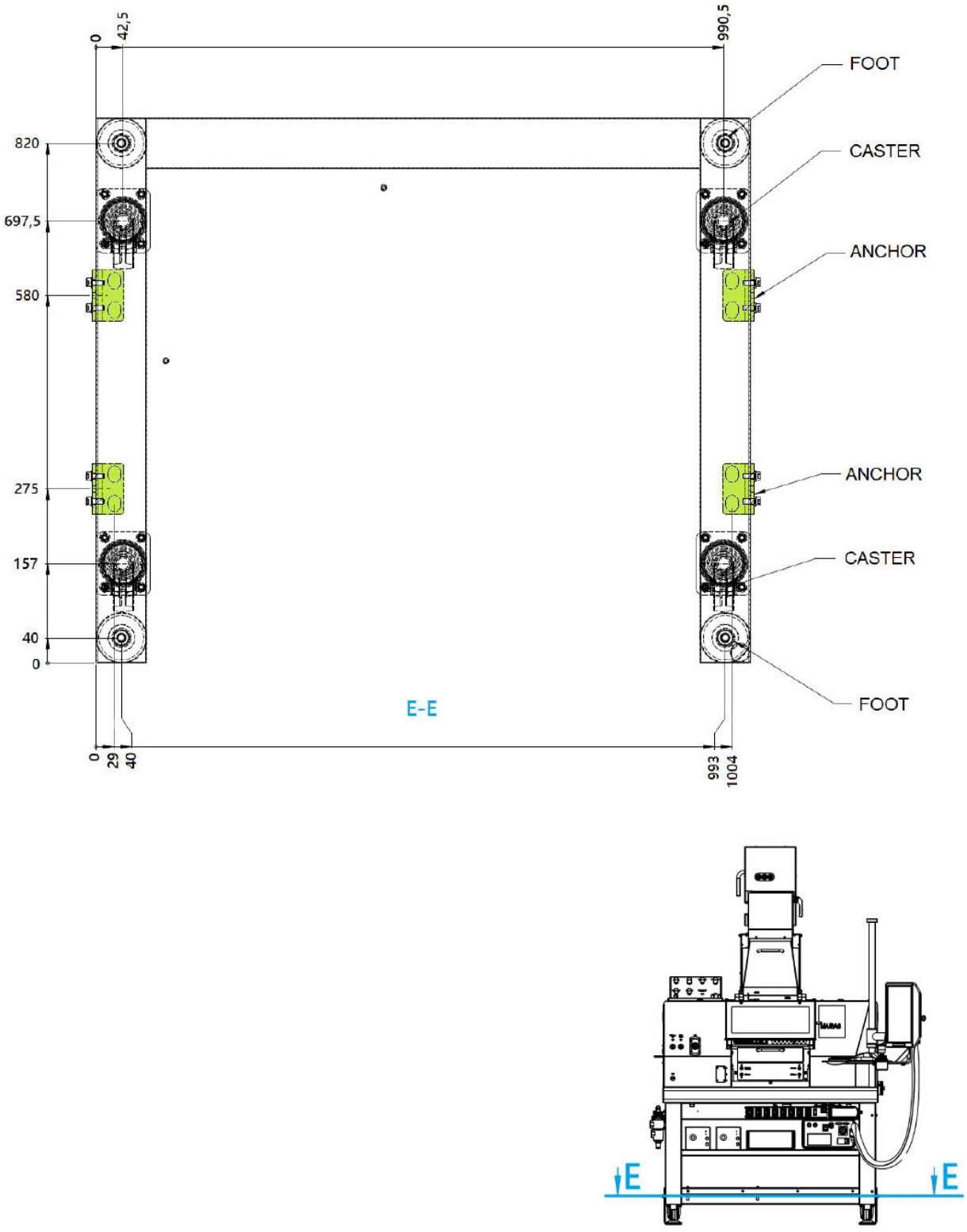


Fig. 2 - 6: MABAGen4-Floor Anchoring

2.6.2 Anchor Brackets

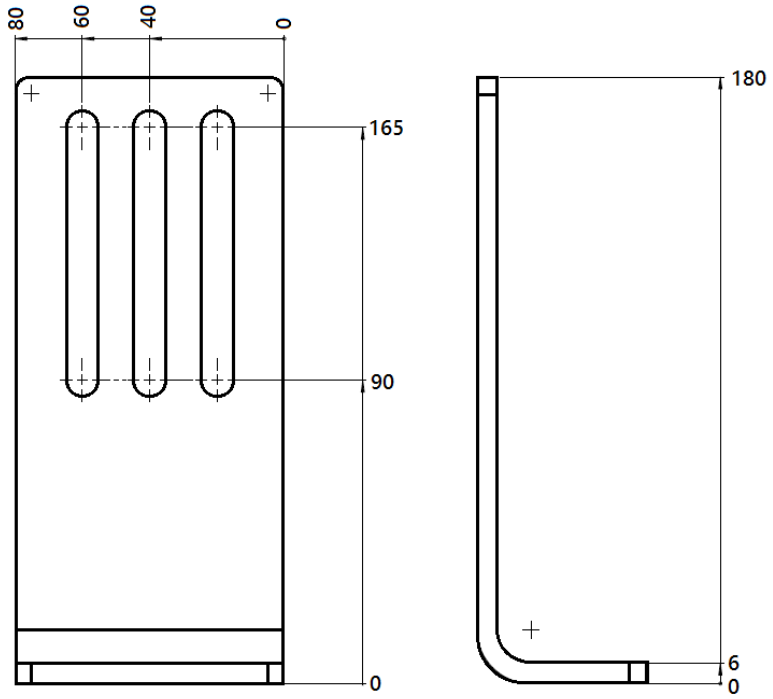


Fig. 2 - 7: MABAGen4-Anchor Bracket [all dimensions in [mm])

The brackets for earthquake protection come as a set of 4 pieces. They have to be ordered separately.

100076312 QUAKE GUARD

2.7 Lamp Cooling (not applicable with UV-LED Light Source)

2.7.1 Cooling of Exposure Lamps 350 W Hg and 500 W Hg-Xe

	Unit	Value for	Value for	Hints
Lamp		350 W lamp	550 W DUV lamp	
Diverse Specifications				
Lamp power	W	250 - 430	400 - 600	
Lamp adapter	Part number	G111071	G202485	G202485 contains air vent
Particularly important	Polarity		Anode UP!	
Adjustment of Throttles				

	Unit	Value for	Value for	Hints
Lamp socket cooling [1) 4)]	l/h	180	280	Adjustment only by service
Shutter [1) 4)]	l/h	260	260	Adjustment only by service
Heat sink [1)]	l/h	1000	1000	Adjustment only by service
Adjustment of Exhaust				
Exhaust tube of the lamp house		closed	open	
• Flexible duct, diameter	mm	no exhaust	100	
• Flow rate in outlet[3)]	m^3/h		7.4	
• Average air velocity in outlet[3)]	m/s		0.25	
• Air temperature in outlet - at nominal power[3)]	°C		<60	see note [2)]

[1)] CDA: Clean Dry Air

[2)] Exhausted air temperature measured at (input) clean room temperature 20°C - 22°C

[3)] to be measured in open air flow before flexible duct in solid outlet tube

[4)] optional Nitrogen

The listed data apply to the following exposure lamps:

G146049 LAMP HBO 350W/S OSRAM

G148979 LAMP HG-XE 500W

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- United Kingdom
- France
- Switzerland
- Netherlands

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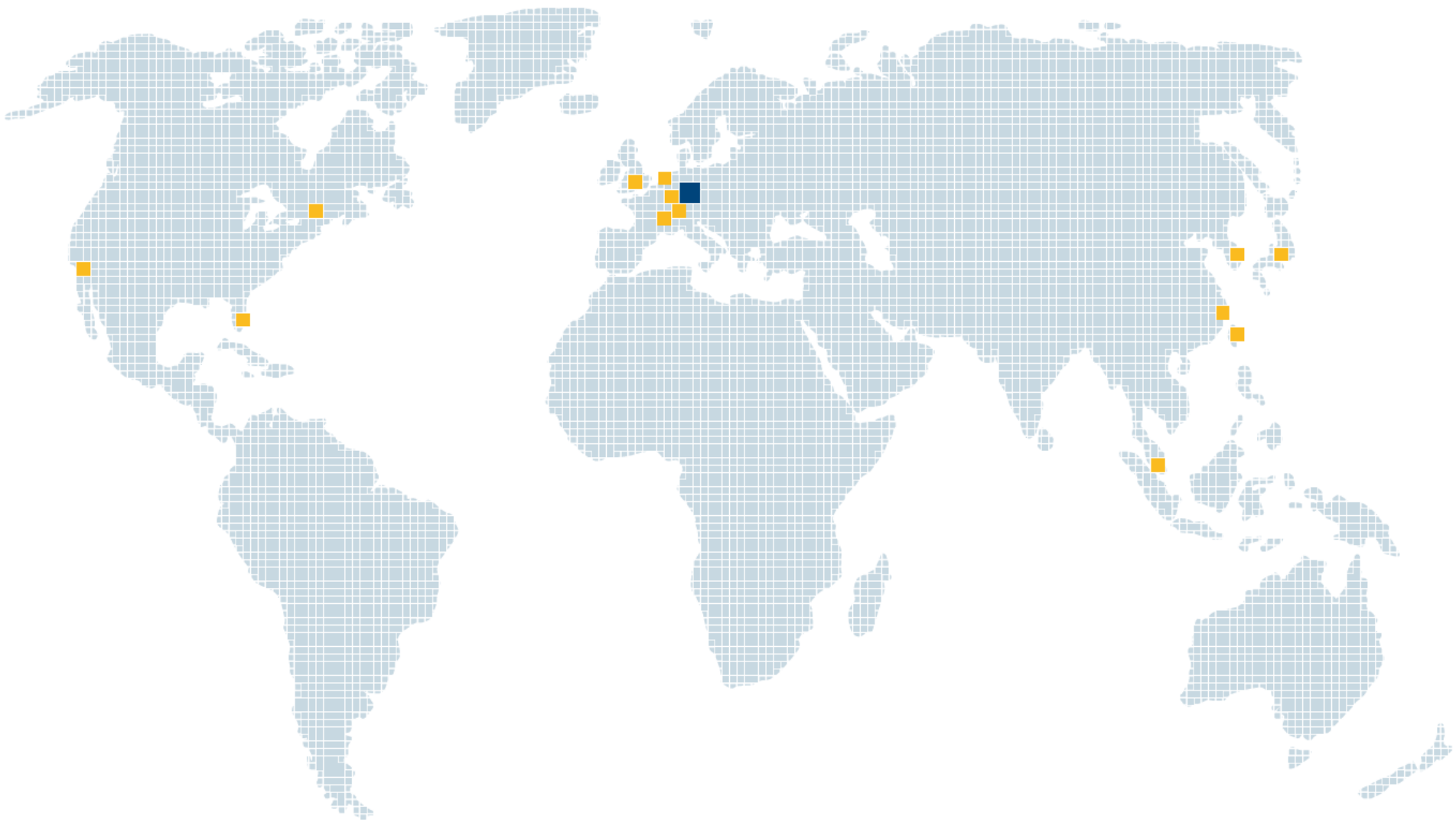
- Japan
- Korea
- China
- Singapore
- Taiwan



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OPERATION MANUAL



Mask/Bond Aligners

MA/BA Gen4

Manual Mask/Bond Aligner

Rev12 21-05

READ THIS MANUAL PRIOR TO PERFORMING ANY TASK!

OPERATION MANUAL

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This manual is a user documentation of SUSS MicroTec Lithography GmbH (in the following "manufacturer") and allows safe and efficient use of the mask aligner MA/BA Gen4.

Prior to working on this product, the personnel must have thoroughly read and understood these instructions and, furthermore, know and observe officially recognized rules regarding occupational health and safety. The basic prerequisite for safe working is compliance with all the safety and handling instructions stated in this manual and the safety and installation manual of the tool.

Figures in this manual are for the fundamental understanding and can deviate from the actual design of the tool.

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1 SUBASSEMBLIES and COMPONENTS

1.1 Overview

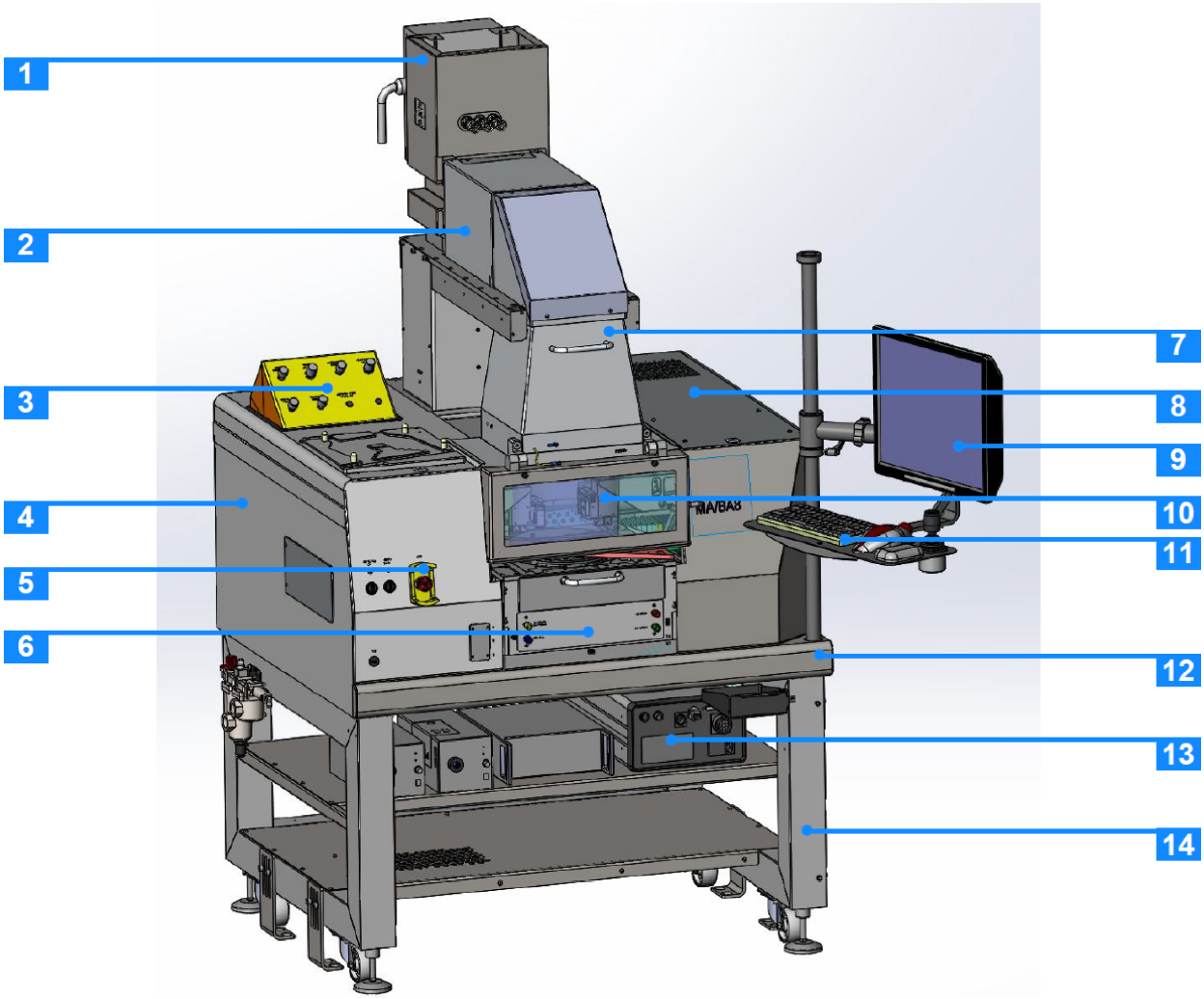


Fig. 1 - 1: Overview Subassemblies

1	Lamp House	8	Electronics/inside
2	Optics Tube	9	Monitor
3	Pneumatic Control	10	Microscopes
4	Pneumatics/inside	11	Operator Panel
5	Emergency Off	12	Mask Aligner Base Plate
6	Alignment Station	13	Lamp Power Supply CIC1200 (Option)
7	Front Lens Tube	14	Base Frame

1.2 Optical System



DANGER!

High Voltage! Risk of death by electric shock!

High voltages and currents are present in the ignition box and the lamp house.

- ► Incorrect handling at the lamp system could result in serious damage to the machine and in personnel suffering injuries.
- ► Only qualified and personnel specifically trained for the equipment are allowed to maintain the lamp house/ optics.



WARNING!

Risk of Eye Damage!

Invisible, high energy UV light may damage eyes or skin.

- ► Never use the machine without covers.
- ► When performing light uniformity adjustments always wear UV-protective glasses and cover your skin.
- ► Be especially careful with almost invisible UV radiation of UV300 and UV250.



WARNING!

Risk of Burns!

The lamp and its surrounding are extremely hot - even after switched off the lamp.

- ► Do not touch the components.
- ► Wait until the surface has been cooled down below 40°C.
- ► Always wear heat resistant gloves.



WARNING!

Risk of Explosion!

UV lamps are highly pressurized. They can explode if mistreated causing serious injuries by fragments.

- ► Touch only when wearing face shield and gloves.
- ► Avoid rude handling.
- ► If not in use store it in its original box.

The optical system of the mask aligner consists of several high-quality components which create in combination an optimum light uniformity in the exposure area.

Filtering of the light with individually selectable filters and optics combinations provide selective exposure with different wavelength ranges.

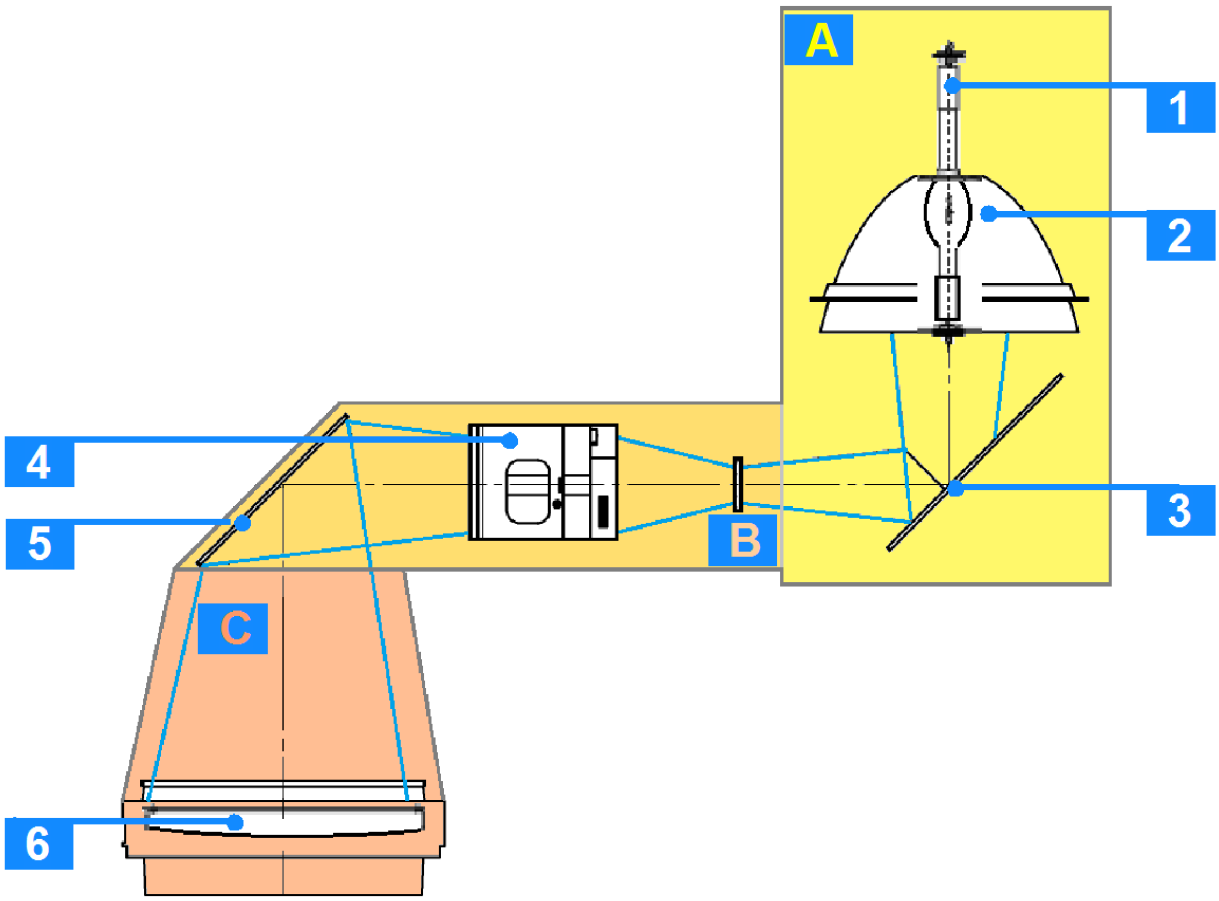


Fig. 1 - 2: Optical System

A	Lamp House
B	Optics Tube
C	Front Lens Tube
1	Exposure Lamp
2	Ellipsoid Mirror
3	Cold Light Mirror
4	Diffraction Reducing Optics
5	Tilted Mirror
6	Front Lens

1.2.1 Lamp House LH350

- A 350 W high pressure mercury lamp or a 500 W mercury-xenon lamp can be used as exposure lamp.
- For ignition of the lamp a high-voltage pulse is necessary. This is produced by an ignition box. Ignition is controlled by a lamp power supply.
    - If used with a 350 W lamp, the ignition box + power supply are mounted at the rear side of the lamp house.
    - If used with a 500 W lamp, the ignition box is mounted at the rear side of the lamp house and the lamp power supply is placed in the base frame.
- The mounting of the lamp is adjustable in X, Y and Z-direction. With this the lamp can be precisely positioned to optimize the light intensity and uniformity in the exposure area.
    - Using the SUSS MO-Optics (standard) the required high uniformity is reached with the optics. The lamp adjustment is only necessary to optimize the intensity (Z-adjustment).
- The lamp is placed within an ellipsoid mirror which focuses the light.
- The UV part of the focused light is reflected by a cold light mirror towards the optics tube. Depending on the used cold light mirror, different wavelength ranges can be used:
    - UV400
    - UV300
    - UV250 (only with 500 W HgXe)
- The long-wave part of the light ends up at a heat sink.
- In front of the optics tube a shutter system is placed that guarantees a uniform distribution of the light energy over the whole exposure area.

1.2.2 Lamp House UV-LED

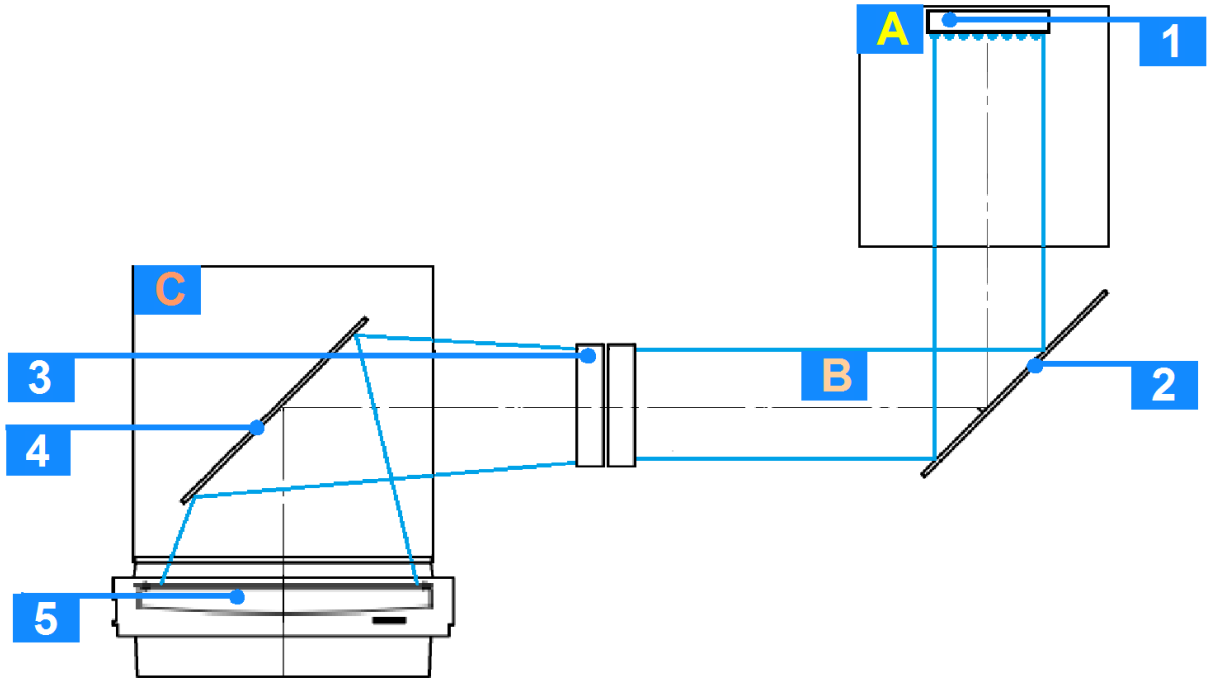


Fig. 1 - 3: Lamp House UV-LED

A	**Lamp House**	**2**	**Cold Light Mirror**
B	**Optics Tube**	**3**	**MO-Optics**
C	**Front Lens Tube**	**4**	**Tilted Mirror**
1	**Light Source (LED Arrays)**	**5**	**Front Lens**

- The lamp house uses a state-of-the-art UV-LED light source including the latest technologies. The LED arrays provide a several wave-lengths spectrum.
- The used UV-LEDs deliver a similar spectral range as common Hg-lamps. They provide comparable intensity and uniformity for the main Hg spectral lines 365 nm (i-line), 405 nm (h-line) and 436nm (g-line).
- The different wavelengths can be selected specifically and also adapted individually to a desired intensity. A combination to achieve a broadband illumination is also possible.
- The exposure spectrum can be tailored by software and stored for each process in the standard recipe file.

1.3 Optics Tube

- The optics components in the tube prepare the light to create an optimum diffraction reducing light quality in the exposure area.
- Individually selectable filters provide adaptation of the light for corresponding wavelength ranges and for reduction of intensity.
- At the end of the optics tube the light is deflected by a 45°-mirror towards to the front lens.

1.3.1 MO-Optics

- The mask aligner is equipped by default with the SUSS MO-Optics providing high uniformity and diffraction reduction in the exposure area.

1.4 Front Lens Tube

- The front lens is mounted in a tube which can be pushed to the rear if needed. That provides increased free moving space over the alignment stage.
- The front lens is the final component providing collimation and uniformity of light in the exposure area. That guarantees little diffraction effects and steep wall in the photo resist.
- The lens is adapted for the selected wavelength range. For the UV400 Optics the front lens is made from crown glass.

UV-LED Front Lens Holder

If a UV-LED light source is used, the front lens holder is equipped with a fluorescent cube.

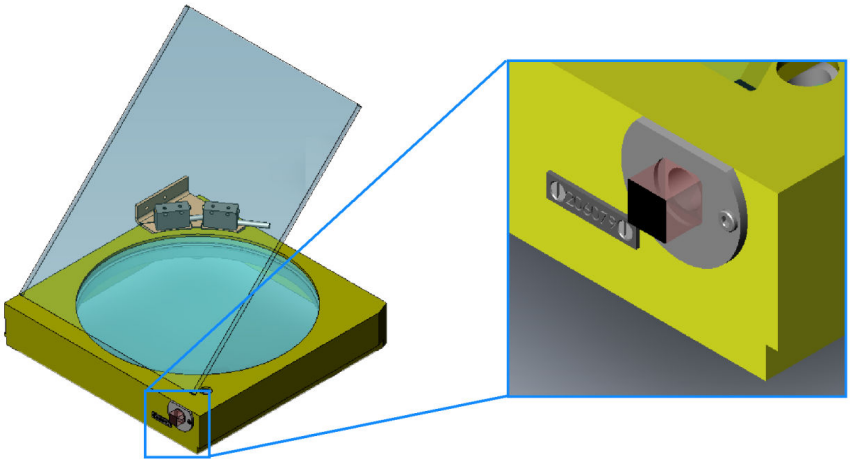


Fig. 1 - 4: UV-Detector in Front Lens Holder

Reason for that is the almost invisible radiation in the UV range. Especially if the wavelength 365 nm is used exclusively the human eye is not able to detect any light.

To be able to check whether radiation is present in the exposure area a cube built from red fluorescing material is inserted into the front of the front lens holder.

1.5 Pneumatics Controls

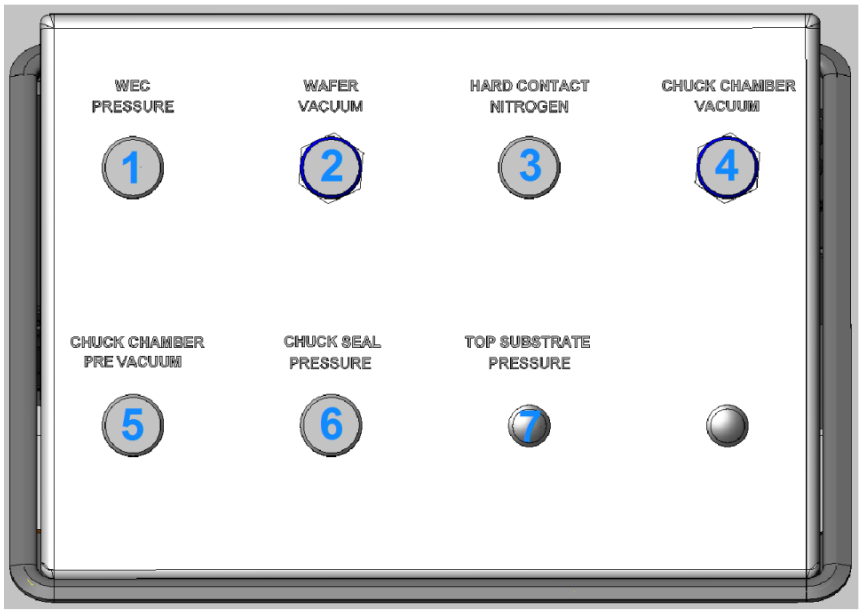


Fig. 1 - 5: Pneumatics Controls

1	**WEC Pressure**
2	**Wafer Vacuum**
3	**Hard Contact Nitrogen**
4	**Chuck Chamber Vacuum**
5	**Chuck Chamber Pre Vacuum**
6	**Chuck Seal Pressure**
7	**Top Substrate Pressure**

- The pneumatics controls are integrated in an operator panel at the left side of the mask aligner.
- All pressures, which may have to be adjusted during the process can be regulated at that panel.
- Display of the pressure values is realized in the user or service GUI at the screen.

WEC Pressure

- To perform a wedge error compensation (WEC) the wafer has to be pressed against the mask with a specified force. The WEC pressure has to be adapted to the size and the weight of the used chuck and wafer.
- The pressure for the WEC-head can be adjusted individually to corresponding process requirements (range: 0 - 100 mbar)

Wafer Vacuum

- During process most of the time the substrate is fixed at the chuck by vacuum.
- For sensitive materials (e.g. membrane) the vacuum can be reduced to avoid damage.

Hard Contact Nitrogen

- In contact mode „Hard Contact“ the lower substrate is pressed against the upper substrate (mask) with a nitrogen pressure.
- This pressure is individually adjustable with this control.

Chuck Chamber Vacuum

- In contact mode „Vacuum Contact“ a chamber is created using a vacuum seal. This chamber is evacuated to achieve best possible contact between mask and substrate.
- The strength of the chamber vacuum can be adjusted individually using this control.

Chuck Chamber Prevacuum

- An additional throttle enables reducing the vacuum to be able to built up the vacuum chamber slowly.

Chuck Seal Pressure

- A rubber vacuum seal is necessary which has to be inflated to seal against the mask creating a chamber between mask and substrate.
- The necessary pressure can be adjusted with this control. It should be as little as possible:
  - A wafer with a standard thickness according SEMI-specification requires a pressure of p = 50 up to 200 mbar.
  - Thicker wafers may require a higher pressure.

Top Substrate Pressure

- During a bond process a pin may be used to apply pressure onto the stamp. The stamp may be bowed slightly to touch the lower substrate in the center first.
- The pressure of the pin pushing against the substrate can be adjusted with this control.

1.6 Pneumatics



CAUTION!

Risk of Mechanical Breakdown!

Wrong settings can damage the machine!

► Do not perform any modification of the pneumatic setting if you do not have detailed knowledge about its impact on the machine.

► Only trained personnel is allowed to adjust the pneumatics.

- The pneumatics is located at the left rear in the machine. It is accessible after removing the outer covers.
- It contains all necessary pneumatic components to control the mask aligner.
- Two valves for the exposure shutter and the cooling supply of the lamp house are located directly at the lamp house.

1.7 Emergency Off Switch (EMO)

NOTICE!

Only use the emergency off switch to prevent injuries from individuals



Fig. 1 - 6: Emergency Off Switch (EMO)

- The emergency off switch (EMO) is the only red button at the machine, with a yellow plate behind it. It is located at the left front of the machine.
- The EMO - if released - switches off dangerous current from the machine. Electric current of all components as well as lamp power supply and exposure lamp are switched off. All movements are stopped immediately. The PC optionally is equipped with an UPS and will be switched off with a 2 minutes delay.
- If the machine has been switched off by EMO, the switch has to be deactivated before re-starting the machine.

1.8 Alignment Station

The alignment station is the heart of the mask aligner.

- It consists of an adapter frame (holder) for the mask (in mask aligner) or an upper substrate (in bond aligner), the chuck with Z-axis and wedge-error-compensation head (WEC-head) and the transport slide for the chuck and the lower substrate.
- The alignment subassembly with chuck WEC-head and Z-axis can be moved precisely in X, Y and Θ.
- The alignment is performed motor-driven via joystick.

Adapter Frame

- The adapter frame is used to carry the upper substrate holder.
- Depending on the application the upper substrate holder may vary in size and thickness. Therefore also the adapter frame has to be selected to fit with the application.
- It is part of the tooling.

Transport Slide

- The transport slide serves for loading the chuck and the substrate into the alignment station or to unload them from the station.
- Loading and unloading are performed manually.

Z-Axis

- The substrate on the chuck can be moved precisely with the Z-axis to programmed distances to the mask (alignment-, exposure distance, contact)

Wedge Error Compensation Head (WEC)

- The wedge error compensation head is used to create parallelism between mask (or upper substrate) and substrate on the chuck.
- As soon as the condition is reached, the position is fixed with brakes.

1.9 Top Substrate Holder

- Depending on the application of the MA/BA GenX the „top substrate holder“ is used as:
  - Mask holder (in mask aligner)
  - Holder for the upper substrate (stamp holder for the process SMILE Nano/ Micro Imprint)
- The mask holder holds the mask by fixing it with vacuum. Optionally an additional clamping is provided to prevent the mask from dropping.
- The mask holder is pushed into the frame for the upper substrate holder in the alignment station and is pneumatically clamped.

Bottom Loading Mask Holder

- Bottom loading mask holders for several processes and substrate sizes are available.
- The mask is fixed at the lower side of the mask holder both mechanically and by vacuum. For loading and unloading the mask the mask holder has to be removed from the alignment station.
- The bottom loading mask holder is especially suitable for applications that require high contact pressure.
- For WEC process with „spacers“ and the contact process „Proximity“ the mask holder must be equipped with moveable spacers.

1.10 Chuck

- The chuck is used as supporting surface for the substrate during the process.
- Depending on the selected contact program the chuck is individually adapted to the program (e.g. with vacuum seal for vacuum contact).
- The chuck is available for different substrate sizes and may be adapted individually to customer requirements.

1.11 Microscopes

- For alignment of mask to substrate several microscope models and light sources are available.
- Depending on the application one or more microscope assemblies are used in the machine.

1.11.1 Topside Microscopes

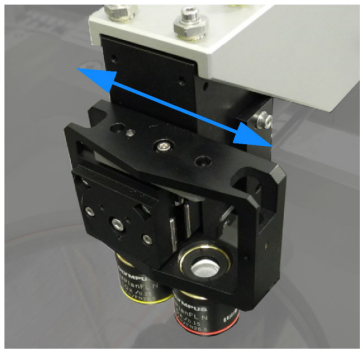


Fig. 1 - 7: Objective Changer

- Microscopes for topside alignment (TSA)

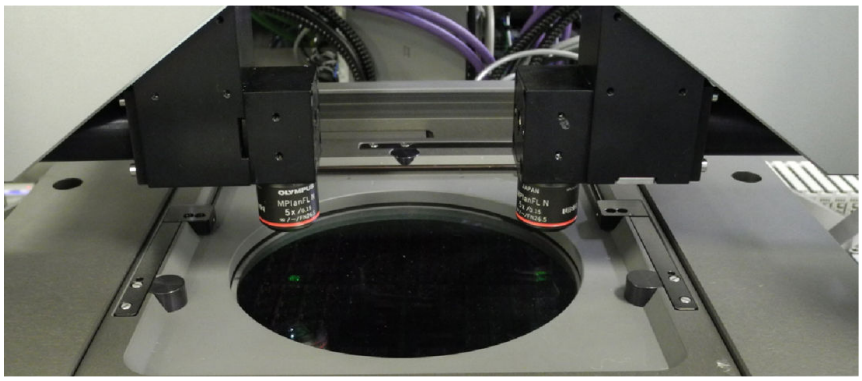


Fig. 1 - 8: TSA-Microscopes

- The microscopes are equipped with one objective by default.
- Optionally an objective slide with 2 objectives is available (see left image)
    - The selection of the objective is performed manually by pushing the objective holder back and forth.

- Before starting exposure the top side microscopes are automatically moved up and outwards.
- To get free access to the alignment stage or for changing the adapter frame the microscopes can be tilted manually backwards

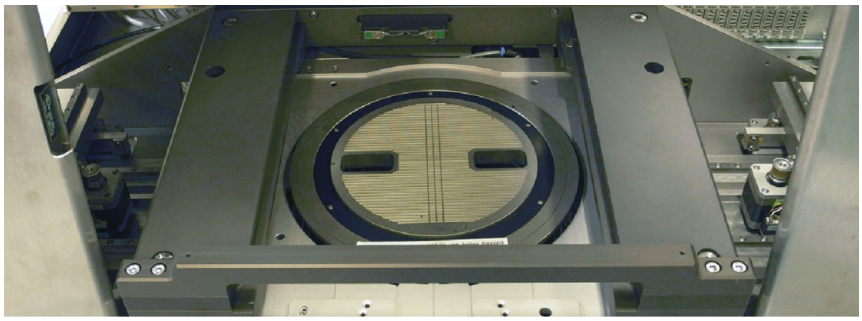


Fig. 1 - 9: Microscopes, tilted

1.11.2 Bottom Side Microscopes

- Microscopes for alignment from below.

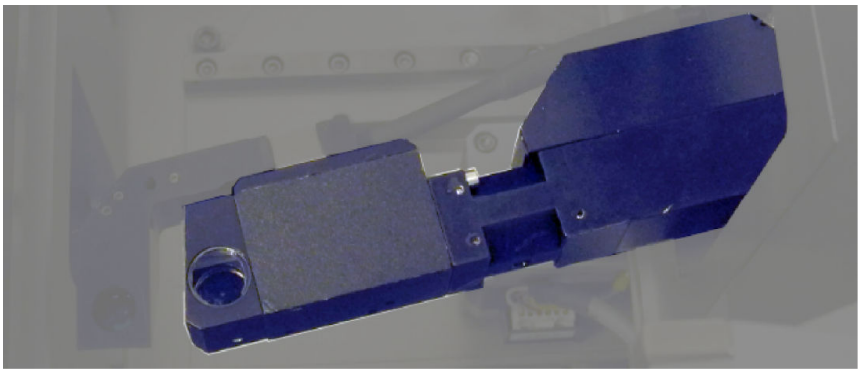


Fig. 1 - 10: BSA-Microscope

- The microscopes can be used in single operation or combined with top side microscopes.
- If used in combination the topside and bottom side microscopes are factory adjusted to each other.

BSA Slide Option

When using not only BSA alignment but also TSA alignment the range of movement for TSA is restricted because of collision avoidance for the BSA microscopes in the stage.

To overcome this restriction you can use the option "BSA-Slide". (The option has to be ordered separately.)

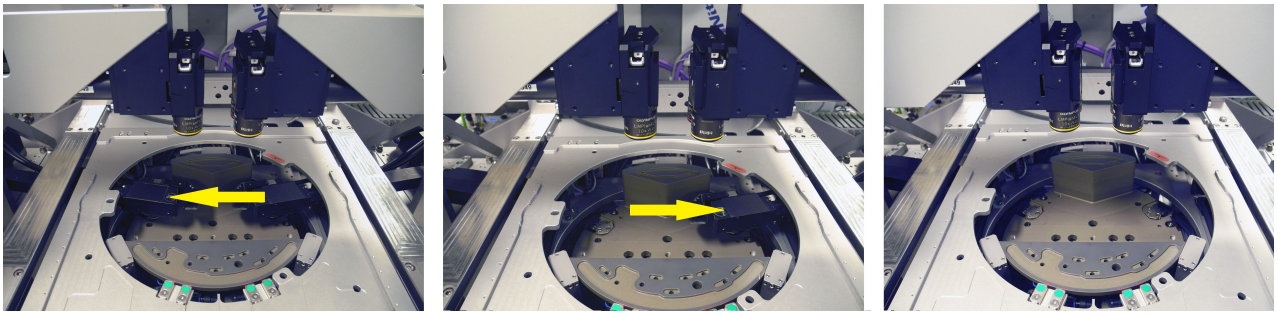


Fig. 1 - 11: Option BSA Slide -Movement of BSA-Microscopes

- Both BSA microscopes can be moved manually out of the stage.
- This outer position is detected by sensors.
- Once detected, the range of movement for the TSA microscopes is enlarged to their standard range.

1.11.3 Microscope Illumination

- By default the microscopes are equipped with light intense transmitted LED-illumination units.
- If necessary the units can be additionally equipped with filters for different applications.

1.12 Electronics



DANGER!

High Voltage!

Risk of Death by Electric Shock!

► Do not remove any cover as long electric voltage is present. Contact with electric voltage can lead to permanent injuries or death.

► Non-professional work inside the computers and the machine can cause electric shock.

It consists of 2 components:

- the PLC which also serves as PC, with inputs and outputs as well as AC and DC current supply, contractors, EMO circuit and fuses.
- the electronics at the alignment stage with axis control as well as in- and output assemblies.

Computer

- The computer of the MA/BA Gen4 serves also as PLC.
- Operation is done with keyboard and trackball/mouse at the operation panel.
- The mask aligner can be connected to the in-house network via ethernet connector at the PC.

1.13 Monitor

- The monitor is adapted to a column, height adjustable and swivel mounted.
- Alternatively 2 types of monitors are available:
  - Monitor 17 inch (standard monitor) aspect ratio: 1280/1024 pixels
  - Monitor 22 inch with touch function (option) aspect ration 1680/1050 pixels
- The monitor displays the graphical operation and service interface.
- All process and machine parameters may be adjusted via this interface.
- The microscope images are displayed at the monitor via cameras. Alignment is performed exclusively using these images.

1.14 Operation Panel



Fig. 1 - 12: Operation Panel

1	**Keyboard**
2	**Operation Panel**
3	**Manipulator/ Joystick**
4	**Mouse**
5	**Hand Rest**

- The operation panel is mounted at the monitor and also height adjustable and swivel-mounted. This enables operation of the equipment alternatively while sitting or standing.
- The complete operation is performed using the 3 components keyboard, mouse and joystick.
- An operation panel for left-handed operation can be ordered on request.

Joystick

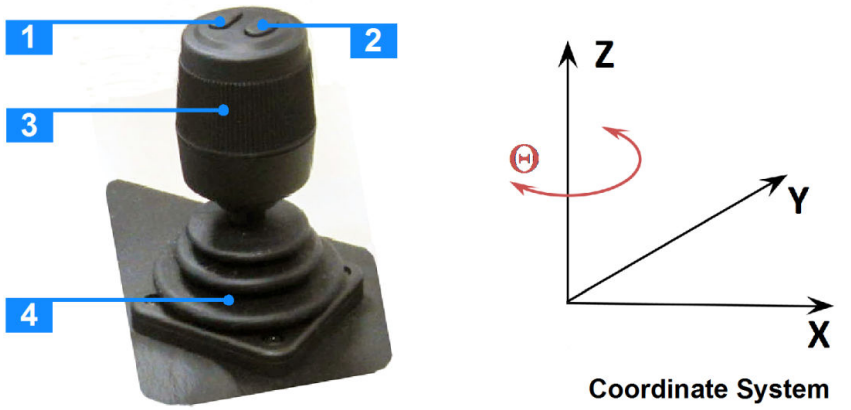


Fig. 1 - 13: Joystick

1	**Shift Key Microscope/Stage**
2	**Shift Key Speed**
3	**Knurled Ring for Theta Movement/ Microscope Focus**
4	**X-Y Movement**

- The manipulator at the operation panel controls the directions X,Y and Θ of wafer or microscope movement (see adjacent coordinate system)

Shift Key Microscope - Stage

- It switches between microscope and stage movement. (Both mic - left mic - right mic - stage)

Shift Key Speed

- It switches between different speeds for the alignment movement.

Knurled Ring for Theta Movement/ Focussing

- Theta movement of the alignment stage is performed by turning the knurled ring of the manipulator.
  - Turning clockwise moves the substrate clockwise and vice versa.
- Focussing of the microscopes is also done while turning the knurled ring of the manipulator.
  - Turning clockwise moves the microscope downwards and vice versa.

X-Y Movement

- Deflecting the manipulator left or right results in a corresponding movement of the wafer or the microscope in ± X-direction.
- Deflecting the manipulator backwards or forwards results in a corresponding movement of the wafer or the microscope in ± Y-direction.
- The dead band (= degree of deflection until the axis effectively starts moving) is adjustable.
- The characteristic of the deflection is parabolic.

1.15 Mask Aligner Base Plate

- All components of the MA/BA Gen4 are mounted on the chassis.
- The alignment stage and the microscope manipulators are additionally mounted on their own base plates.

1.16 Base Frame

- The base plate with the components is mounted on a stable base frame.
- 4 casters enable comfortable moving of the mask aligner. Short transport distances can be performed using these casters.
- For save operation the base frame will be put on rigid feet.
- Additionally an earth quake tie down is possible using safety brackets.



A detailed description you find in the Safety/Installation Manual.

1.17 Lamp Power Supply

- The CIC1200 Power Supply is stored on the rack of the base frame.
- The CPC is directly mounted at the lamp house.
- The lamp power supply provides current for the exposure lamp and controls it.

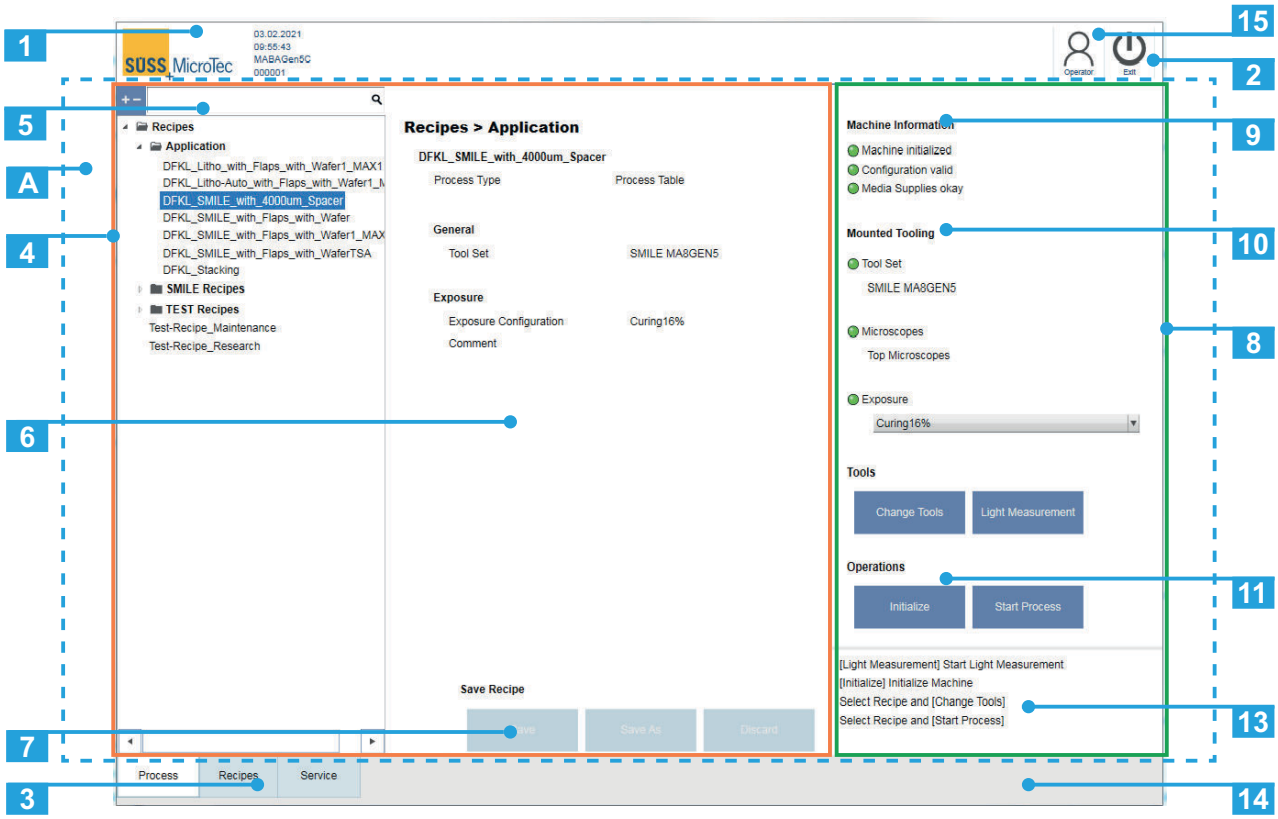


A detailed description you find in the manual of the lamp power supply (CIC1200 or CPC).

2 GRAPHICAL USER INTERFACE - GUI

2.1 GUI-Layout

Overview Start Screen



A	View Area (dotted line)	8	Process Navigation/Dialog Frame (green)
1	Title Line	9	Machine Information
2	Power Key for Software	10	Tooling/Exposure Information
3	Lower Frame with Tabs	11	Function Keys/Tools/Operation
4	Main Frame (orange)	13	Operator Guidance
5	Recipe Folders with Search Function	14	Function Key/Navigation
6	Recipe Parameter Info	15	User Login
7	Function Keys/Recipe Saving		

View Area (4+8)

- The view area is divided into two parts. Depending on the selected view and the process progress different data/elements are displayed.

Title Line

The title line contains:

- SUSS Logo
- important process parameters of the currently used recipe

- drop-down menu for selection of the user and his rights
- date and time
- power key for the software

The title line is always visible regardless of the process step.
Process parameters are only visible during running process.

Power Key for Software

- With this key the software can be terminated.

(To restart the software double click the icon on the desktop.)

Lower Frame

The lower frame contains:

- Tabs for switching to different views in the GUI:
  - **Process:**
    Process view; standard view during a running process
  - **Recipe:**
    Recipe view; view to see all recipes and their corresponding parameters
  - **Service:**
    Service view; view with all service functions, in- and outputs, hardware components etc.

The lower frame is always visible regardless of the process step.

Main Frame

- After software start in process view all available recipes and the function keys for recipe saving are displayed.
- During running process the video images of the microscopes are displayed.

Recipe Folders with Search Function

- All available recipes are listed on left side of the main frame.
- The recipes can be organized in folders.
- A search function on top of the list provides alphabetical search for individual recipes.
- Creation of the folders and organization is only possible in recipe view.

Recipe Parameter Info

- As soon as a recipe has been selected the right part of the main frame will display the most important recipe parameters.
- The folder path and the name of the selected recipe are displayed on top of the list.

Function Keys/ Recipe Saving

- The function keys for recipe saving become active, as soon as parameters are changed during the running process.
- At this point temporarily saved parameters can be stored to the recipe, a recipe can be saved with a new name or changes can be discarded.

Navigation/ Dialog Frame

- During running process the process view shows different function keys.
- Tabs provide different views within the process navigation.
- Clicking the corresponding tab the view in the process navigation can be changed.

↳ *Chapter 2.4 “Process View: Navigation/ Dialog Frame” on page 36*

Machine Information

- 3 LEDs indicate the important machine states:
  - Machine is Initialized
  - Configuration Valid
  - Media Supply

Mounted Tooling

- LEDs indicate the validity of the mounted tooling
- The correct calibration set can be selected with a drop down menu (only visible if the exposure mode is „Constant Dose“).

Function Keys/Tools/ Operation

- At this point different function keys are active, dependently from the process step:
  - Loading/unloading the mask and the mask holder - [Change Tools]
  - Light measurement - [Light Measurement]
  - Initializing - [Initialize]
  - Start process with selected recipe - [Start Process]

They are only active if the process allows it.
If not active, they are shown grayed out or are hidden.

User Guidance

- In the lower area of the process navigation user instructions are displayed guiding the user through the process.
- A key in the text of the user instruction is identified with brackets (e.g. [Next]).

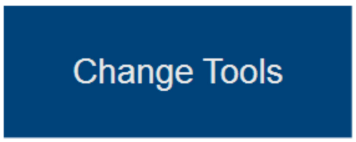
Function Keys

- Function keys are the main operation elements.
- They are only active if the process allows the operation.
- If not active they are shown grayed out or are hidden.
- Navigation Keys:
  - **BACK:**
    one step back in process sequence
  - **NEXT:**
    next step in process sequence
  - Both keys are only active (otherwise shown grayed out), if the step is allowed during process sequence.

2.2 Function Keys on the Start Screen

2.2.1 Tools

Change Tools



Function Key

- Function key to get access to the dialog frame „Change Tools“
- Clicking the key opens the dialogue for mask changing in the process navigation view.
- A drop down menu for selection of the „Mounted Tool Set“ is available.
- The components of the tool set of the selected recipe are listed.

Light Measurement



Function Key

- Function key for the process of light measurement.
- With this key the exposure shutter can be opened for an undetermined time to perform light measurement in the chuck area with an external manual measurement device (e.g. SUSS UV-Optometer)
- Clicking the key opens a dialogue for light measurement in the process navigation view.

Chapter 15.3.1 “Intensity and Uniformity Check” on page 231

2.2.2 Operations

Initialize



Function Key

- After power-on of the machine and start of the software initialization can be started with this function key.
  - Tools are detected (adapter frame, upper substrate holder).
  - All sub-assemblies drive to their home positions.
  - Clamping of the transport slide is released.

Initialization is only possible if the transport slide is inserted and clamped. If this is not the case the operator guidance requests to do it.

Start Process



Function Key

- After Initialization and recipe selection this function key becomes active.
- The machine process with the selected recipe (and the corresponding parameters) is started with this key.
    - The user guidance shows the next step to be performed.

A process start is only possible, if the recipe is accurate, adapter frame, mask holder and mask are loaded correctly and the TSA-microscopes are in working position.

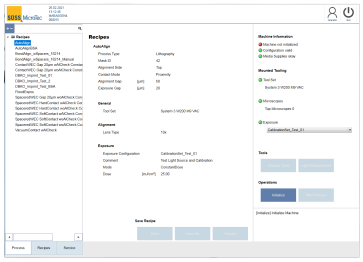
2.3 Process View: View Area

2.3.1 Views during Process Progress

The view of the view area depends on:

- the selected tab (Process, Recipe, Service)
- the selected recipe
- the current process step

After Software Start

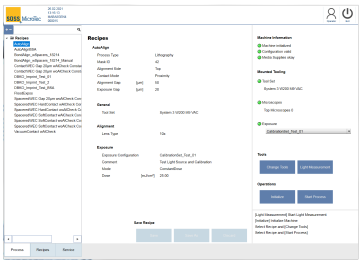


- After software start the main frame shows a list of all available recipes.
- The last used recipe is background colored in blue and a choice of important parameters of the recipe are displayed.
- The function key *[Initialize]* is active and initialization can be started by clicking it.

NOTICE!

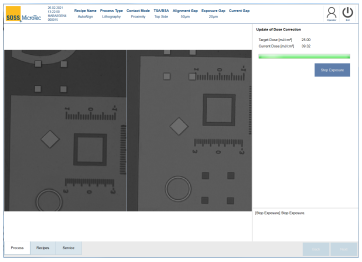
If „Mounted Tool Set“ and „Recipe Tool Set“ are not identical, an error will be displayed on the start screen.

After Initialization



- As soon as initialization is terminated, the user guidance requests selecting a recipe.
- Click a recipe in the list --> the recipe will be background colored in blue.
- A choice of important parameters of the selected recipe are displayed in the main window.
- The function key *[Initialize]* is active and initialization can be started/ repeated by clicking it.
- The function key *[Light Measurement]* is active. Light measurement can be performed at this point.
- The function key *[Change Tools]* is active. Clicking this key switches the navigation frame to the „Change Tools“ view.
    - Mask and mask holder can be loaded/unloaded.
    - The „Mounted Tool Set“ can be selected.
    - Information about the valid „Recipe Tool Set“ is displayed.
- The key *[Start Process]* becomes active.
- The process can be started with the key *[Start Process]*.
- As soon as the process has been started, the main window shows the video images of the microscopes.

Update Dose Correction*

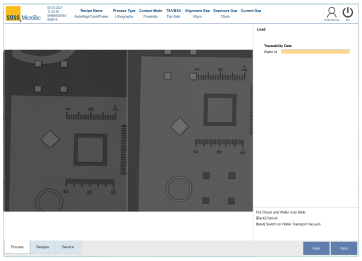


- If the recipe parameter „Exposure Mode“ is set to „Constant Dose“ an update of the dose correction will be performed after process start if:
    - the machine software has been re-booted.
    - the optics has been converted.
    - the validity of the dose measurement has been expired.

*Constant Dose is only used if the machine is equipped with a high pressure mercury lamp.
It is not valid for UV-LED light sources.

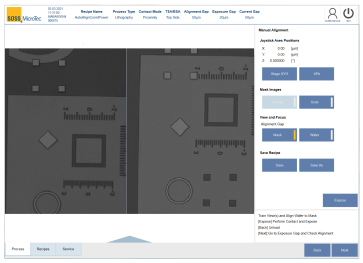
After Process Start

Traceability Data (Wafer ID)



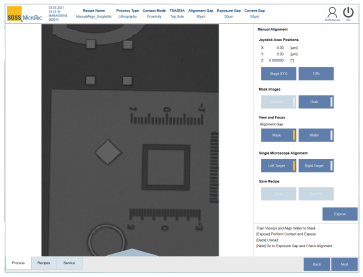
- Before loading the substrate it is possible to input a wafer ID.
- The input is optional.
  If not desired leave the input field free and proceed with *[Next]*.

Manual Alignment with 2 Microscopes



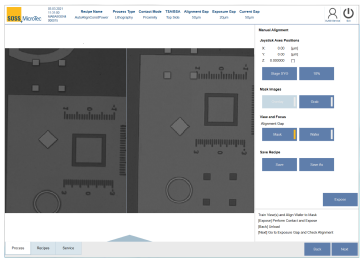
- After wedge error compensation and arrival at the alignment gap the process view shows in the main frame the video images of the microscopes
- The navigation frame shows all operational elements and displays that are necessary and valid.
- The operator guidance displays instructions for the user.

Manual Alignment with 1 Microscope



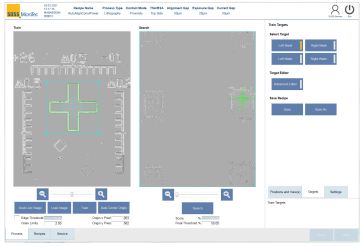
- If the checkbox „Alignment Single Microscope“ is selected in the recipe, the main frame in the process view shows the video image only of the left microscope.

Automatic Alignment Positions and Views



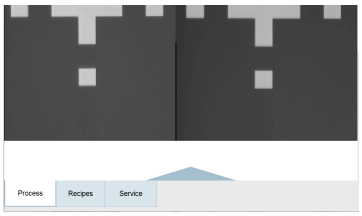
- If the recipe parameter „Alignment Mode“ is set to „Auto“ after wedge error compensation and arrival at the alignment gap the process view shows in the main frame the video images of the microscopes
- The navigation/dialog frame shows the view „Positions and Views“ with all operational elements and displays that are necessary and valid.
- The operator guidance displays instructions for the user.
- In this navigation/dialog frame the information and function keys are identical to the manual alignment frame with 2 microscopes.

Automatic Alignment Targets



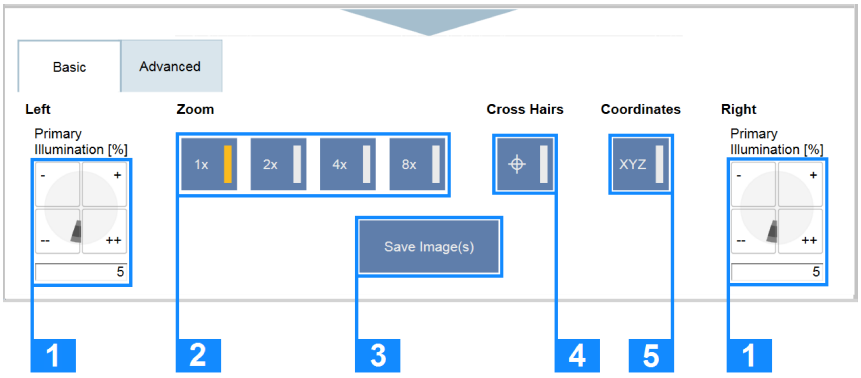
- If the recipe parameter „Alignment Mode“ is set to „Auto“, an additional view is accessible with the tab „Targets“.
- The navigation/dialog frame shows the view „Train Targets“ with the function keys for selection of all possible target views.
- Depending on the selected target view in the main frame the corresponding train and search image is displayed.

2.3.2 Function Area for Image Quality and Magnification



- Clicking the triangle above the tabs or clicking the main frame of the process view will open the function area for adjustment of:
  - Image quality and
  - Zoom

Tab "Basic"



1	**Brightness control for microscope illumin. left and right**
2	**Zoom setting**
3	**Key for saving the current camera images to a DCIM folder**
4	**Key for displaying a cross hair over each image**
5	**Key for displaying the current microscope coordinates**

Brightness Control



- The setting elements in the user GUI provide brightness control of the microscope illumination individually for left and right microscope.
  - [**+**] - increase brightness (slowly)
  - [**++**] - increase brightness (fast)
  - [**-**] - reduce brightness (slowly)
  - [**--**] - reduce brightness (fast))
- Alternatively the desired brightness value (in %) can be set using the numerical input field below the control.
  - With the cursor click in the field.
  - Set the value via keyboard.
  - Click *[Enter]* at the keyboard to confirm.

Zoom

- The function „Zoom“ determines the display detail of the whole video image of the camera.
- 4 magnification options are available.
- Clicking the desired magnification key changes immediately the display detail for both microscope images..

Magnification and Field of View:

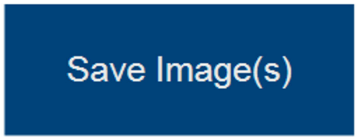
Objective 5x/0.15	Zoom 1x	Zoom 2x	Zoom 3x	Zoom 4x
Field of view [µm²]	1555*2074	778*1037	398*518	194*259
Magnification [Camera-Pixel/ Monitor-Pixel]	4,72	2,35	1,18	0,59
Interpretation	Large Field of View		Normal	High Magnification

Application Recommendation:

for manual alignment:

- For alignment accuracy > 1 µm: 4x
- For alignment accuracy < 1 µm: 8x
- For overview and target search: 1x and 2x

Save Image(s):



- Clicking this key saves the current camera images to a "DICM" folder.
- Each file name contains the microscope/date/time:

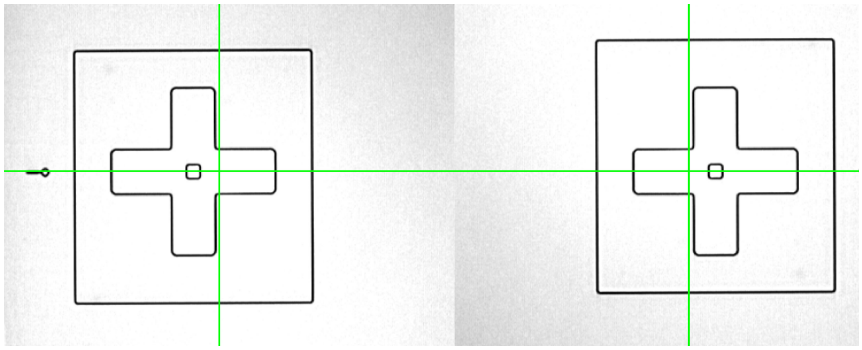
  Top_Left-2019.02.15-10.59.29

Cross Hairs:



- Clicking this key displays a cross hair over each camera image.
- The cross center corresponds to the center of the camera image.

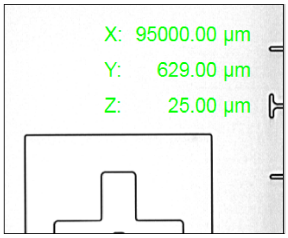
Because of distortion errors, it is advantageous to align the mask targets to the cross hair.



Coordinates:

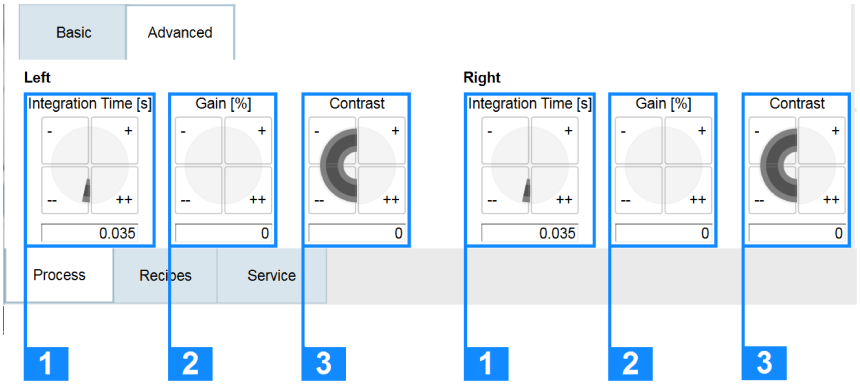


- Clicking this key displays the coordinates of the microscope in the corresponding camera image.



Tab "Advanced"

NOTICE!
Only use the individual setting in tab „Advanced“ if the settings for illumination and focus in the basic settings are not sufficient.



1	**Integration Time [ms]**
2	**Gain [%]**
3	**Contrast**

Integration Time

- Period of time where the sensor is exposed to light.
- Setting recommendation: 10...30 ms

Gain

- (= Analog Gain), determines how strongly the signal of the camera sensor is increased. The whole signal is increased inclusive the background noise.
- Gain may be helpful for bad lighting conditions.
- As the total image quality will be reduced, gain should only be used for special conditions, e.g. bad lighting conditions.
- Setting recommendation: 0%

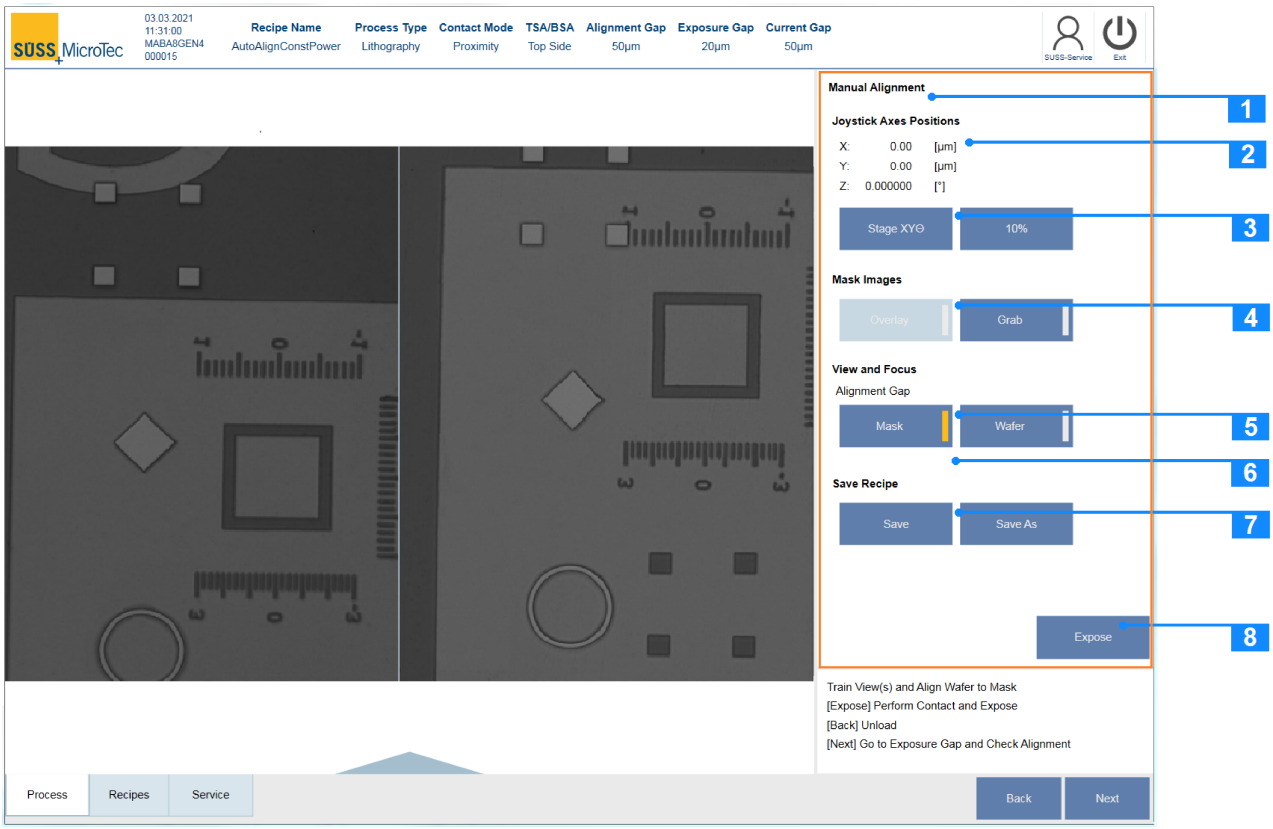
Contrast

- Influences the gamma curve.
- Setting recommendation: 0

2.4 Process View: Navigation/ Dialog Frame

2.4.1 Process View for Manual Alignment

As soon as the substrate has reached the alignment gap the right frame shows displays and control elements depending on the selected process. The screen below shows the dialog frame for the manual alignment.



1	**Manual Alignment view**	5	**Focus Positions**
2	**Axes Positions**	6	**Single Microscope Alignment**
3	**Selection Axis and Speed**	7	**Recipe Saving**
4	**Selection for Mask Image**	8	**Function Key *[Expose]***

Manual Alignment View

- Display of all relevant displays and control elements
- Individually adapted to the process.
- Depending on the process the control elements are active or inactive (shown grayed out)

Axes Positions

- Display of all axes positions
- Valid for the selected axis/axes that are assigned to the joystick (selection with function key)

Selection Axis/Axes

One-Way Toggle Key



With this key you select which axis shall be moved by joystick.

- **Stage XYΘ:**
  X-,Y- and Θ-axis for alignment.
  The joystick moves the chuck in the corresponding direction for alignment of substrate to mask.
  - This selection is only available if the substrate is in alignment gap.
- **Left TSA XY Focus:**
  Left TSA Focus:
  X-, Y- and focus-axis (Z) for left top side alignment microscope (TSA)
  - The axes X, Y and focus are active in alignment and exposure gap and as long as no mask image has been „grabbed“.
  - After „Grab“ only the focus can be adjusted.

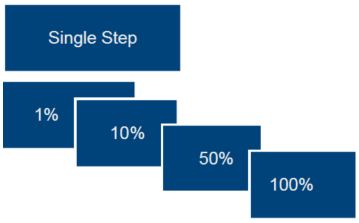


- **Right TSA XY Focus:**
  Right TSA Focus
  X-,Y- and focus-axis (Z) for right top side alignment microscope (TSA).
  - The axes X, Y and focus are active in alignment and exposure gap and as long as no mask image has been „grabbed“.
  - After „Grab“ only the focus can be adjusted.

- **Both TSA Focus:**
  Focus-axis (Z) for left and right top side alignment microscope synchronously.
  - This key can only be selected if a mask image has been „grabbed“.
    Chapter 2.4.1 “Process View for Manual Alignment” on page 36 and in *Chapter 10 “ALIGNMENT CHECKS (AL Checks)” on page 158*

Speed Selection

One-Way Toggle Key



With this key the speed for the axis to be moved by the joystick is selected:

- **Single Step:**
- With each deflection of the joystick the selected axis performs one step. The step width is adjustable in the service view.
- **1% /10% /50% /100%** different speed levels are available.
- The visible speed options can be defined in the service view.

Mask Image Selection

On/Off-Switches with "LED"



- The LED is on if the function is switched ON.
- **Grab:**
  - Is only active, if the focus position (5) „Mask View“ is selected.
  - The live image of the mask will be stored.
    The microscope axes for X- and Y direction will be locked.
  - As soon as the key is switched OFF, the stored mask image will be deleted.
    The brakes for the microscope axes for X- and Y direction will be released.

- **Overlay:**
  - Is only active if a „grabbed“ image is available.
  - If switched ON, the stored mask image will be overlain the live image of the substrate.
  - If switched OFF, only the live images are visible on the screen.

Focus Positions

On/Off-Switches with "LED"



- The LED is on if the function is switched ON.
- **Mask View:**
  - The microscopes move to the focus position for the mask. The corresponding illumination and camera parameters will be set.
- **Wafer View:**
  - The microscopes move to the focus position for the wafer. The corresponding illumination and camera parameters will be set.

As soon as focus and illumination are readjusted in the current focus position the new values will be stored temporarily in the current recipe and will be used if driving again into this position. The values will be stored permanently in the recipe with [Save] or [Save as].

Single Microscope Alignment

On/Off-Switches with "LED"



- As soon as the check box „Single Microscope Alignment“ in the recipe is ticked (check mark) the keys are displayed and active in the process dialog frame.
- The display starts as soon as the wafer is in alignment gap.

- **Left Target:**
  - Move to microscope position of left microscope for the left target

- **Right Target:**
  - Move to microscope position of left microscope for the right target

For Details see Chapter 6.2 "Manual Top Side Alignment Single Microscope"

Recipe Saving

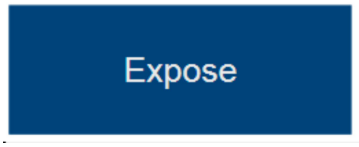


Function Keys

- As soon as a parameter [focus, illumination, position] is changed these keys become active and the modified values can be saved.
- **Save:**
  - The values are saved in the currently used recipe.
- **Save As:**
  - The values are saved in a new recipe with a new name.

NOTICE!
If not stored with *[Save]* the current values will still be used for the next wafer until a new recipe will be loaded.

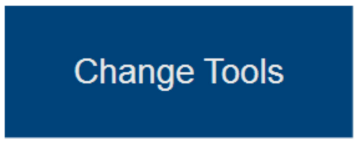
Expose



Function Key

- The function key in the process dialog frame is always active.
- Clicking that key will start the contact process, the microscopes will drive to their exposure position and exposure will be started.

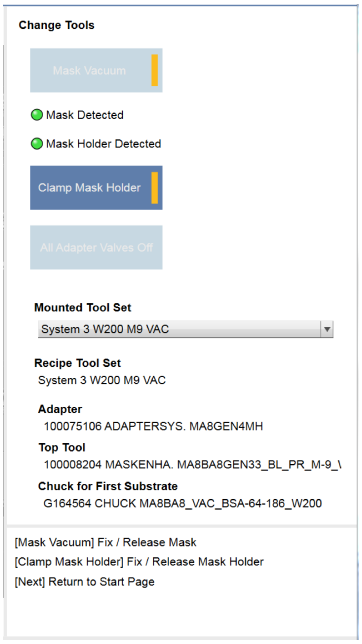
2.4.2 Dialog Frame *"Change Tools"*



Function Key

- As soon as the function key, displayed in the dialog frame of the start screen is clicked, the view will be switched to the dialog frame *"Change Tools"*.
- The function key is only active if a recipe is selected.

Change Tools



Dialog Frame

- The user guidance shows in this view that:
  - the mask vacuum can be switched On and Off.
  - the mask holder can be clamped or released in the stage.
  - all adapter valves can be switched off.
  - with *[Next]* you can return to the start screen.

- Two sensor displays (LEDs) show:
  - whether a mask holder is loaded (*“Mask Holder Detected”*)
  - whether a mask is fixed with vacuum at the mask holder (*“Mask Detected”*)
  - Sensor display „gray“: no mask/ no mask holder
  - Sensor display „green“: mask / mask holder detected

- With the drop down menu *“Mounted Tool Set”* the currently used tool set can be selected.
- The information below shows the tool set of the currently selected recipe *“Recipe Tool Set”*, consisting of:
  - Adapter Frame
  - Top Tool
  - Chuck

NOTICE!
If *“Mounted Tool Set”* and *“Recipe Tool Set”* are not identical, an error will be displayed on the start screen.

NOTICE!
The user is responsible to verify that the components of the selected tool set match with the built in tool set.

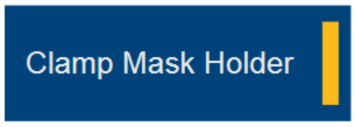
Mask Vacuum



Function Key

- For switching ON/OFF of the vacuum to fix the mask at the mask holder.
- As soon as the mask holder is loaded and clamped in the machine the mask vacuum cannot be switched OFF. This prevents the mask from accidentally dropping from the mask holder.

Clamp Mask Holder



Function Key

- For switching ON/Off of the clamping of the mask holder in the machine.
- Clamping is only possible if the mask holder is correctly loaded (sensor is on) and the mask is fixed with vacuum. Otherwise the function key remains grayed out.
- As long as the mask holder is not clamped a process start is not possible.

All Adapter Valves Off



Function Key

- For switching OFF all valves which influence the adapter frame.
- Switching off is necessary if the adapter frame shall be exchanged. Otherwise a vacuum leak or air pressure leak may occur if removing the adapter frame.

As long as the machine detects a loaded mask, the function key [All Adapter Valves Off] can not be enabled.

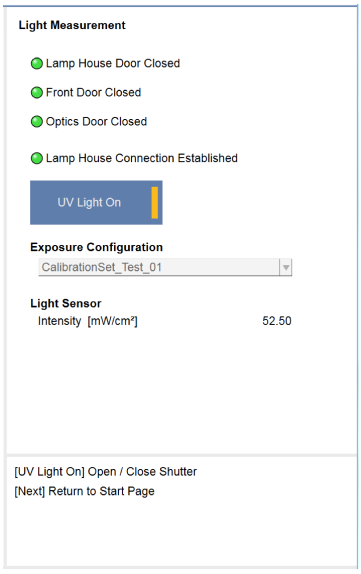
2.4.3 Dialog Frame "Light Measurement"



Function Key

- Once the function key in the dialog frame of the start screen is clicked the view changes to dialog frame „Measure Light“.

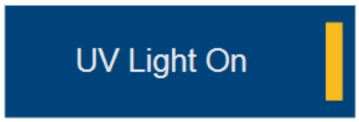
Light Measurement



Dialog Frame

- Four sensor displays (LEDs) show:
  - whether the lamp house door is closed ("Lamp House Door Closed")
  - whether the front cover is closed ("Front Door Closed").
  - whether the optics cover is closed ("Optics Door Closed").
  - Sensor display "gray": cover is open.
  - Sensor display "green": cover is closed.
  - whether a lamp house/ light source is connected ("Lamp House Connection Established")

The LED for "Lamp House Connection Established" indicates if a UV-LED light source is connected or if a CPC200/350 shall be used in remote mode.



Function Key

- To open/ close the shutter for exposure.
- Exposure only will be started if all covers are closed. (all sensor LEDs are green).

Exposure Configuration

Drop Down Menu

- displays all available exposure configurations
- with UV-LED light source, the individual line can be selected for light measurement.

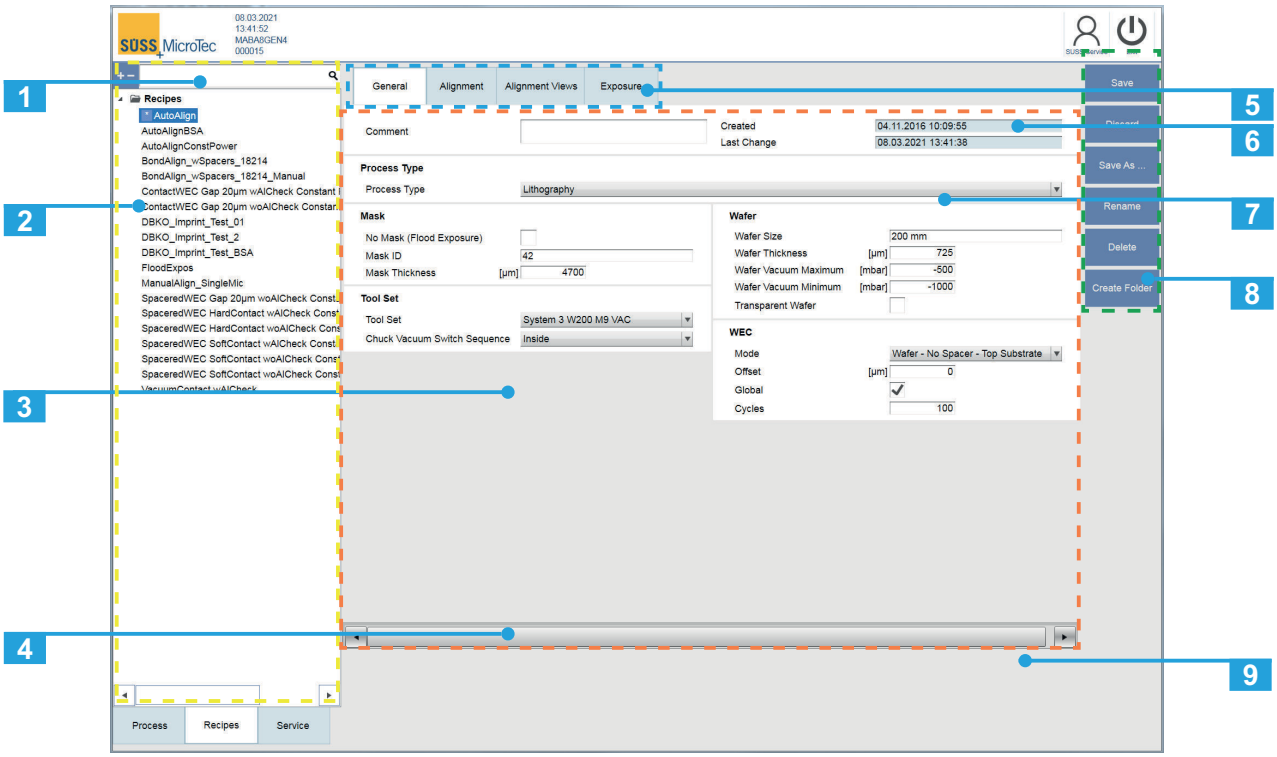
Light Sensor

Display

- once the shutter is open, the built-in light sensor measures the intensity and the result is displayed.

2.5 Recipe View

2.5.1 Overview



1	**Recipe Search**
2	**Recipe Folder List (yellow line)**
3	**Parameters Field (orange line)**
4	**Scroll Bar**
5	**Tabs for the Recipe Pages (blue line)**
6	**Recipe Information**
7	**Process Type Selection**
8	**Function Keys (green line)**
9	**Error Information Line** **(only visible if an error occurs in the recipe)**

Recipe/Folder Search Line

- Recipe and folder names can be individually named.
- The search field on top of the list provides alphabetical search for recipes and folders

Recipe Folder List

- Display of all folders and recipes within folder in alphabetic order.
- Recipe names can be individually named.
- With search field on top of the list for search of recipe names

Process Type Selection

- Drop Down Menu
- Selection of process type (Lithography, Bond Alignment, Process Table)

Recipe Marking

Depending on the state of the recipes they are marked individually:

*	Changed recipe
>	Recipe currently in use
!	Error in recipe or in tooling

Tabs

- Tabs are used to organize the recipe parameters.
- Each tab represents one recipe page. Clicking the tab will open the page and gives access to the corresponding parameters at that page.
- Depending of the selected *"Process Type"* the number of tabs varies.

Process Type: Lithography

- This process type is used for all lithograpy processes
- Following tabs are displayed for this process type:
  - **General**
  - **Alignment**
  - **Alignment Views**
  - **Exposure**

Process Type: Bond Alignment

- This process type is used for all bond align processes
- The software has to be configured for this process.
- Following tabs are displayed for this process type:
  - **General**
  - **Alignment**
  - **Alignment Views**
  - **Bond Alignment**

Process Type: Process Table

- Process table is used for imprint processes.
- The software has to be configured for this process.
- Following tabs are displayed for this process type:
  - **General**
  - **Process**
    and when the tab *"Process"* is selected, 2-4 additional tabs (depending on the number of substrates to be processed) are displayed:
  - **Table**
  - **Steps**

A detailed description of the pages and their parameters you find in
↳ *Parameters of the Tab "General"*

Parameter Field

- The parameter field contains all parameters of a recipe page.
- Depending on the selected machine mode, different parameters are displayed.
- The group name changes depending on the process type:
  - Lithography: Mask/ Wafer
  - Process Table: Top/ Bottom Substrate
    Bond Alignment: Top/ Bottom Substrate
  - Process Table
- The parameters can be defined at this point.
- Input of the individual parameter:
  - Direct input via keyboard
  - Selection via drop down menu
  - Selection via check box
- Parameters which are not allowed to be changed are grayed out.
- Selection of a certain function determines the whether parameters are displayed, active, grayed out or hidden.

NOTICE!
A recipe currently in use for a process cannot be edited, saved or copied.
All other recipes can be edited and saved at any time.

Scroll Bar

- If the screen size or the area of the frame is not sufficient to display all contained information a scroll bar is showed to move the section of the display.

Recipe Information

- In the field „Recipe Information“ the date of issue and the date of last change is displayed.
- Additional information can be added by the user in a field for notes.
- The recipe information field can be expanded or hidden by clicking on the arrow in the upper left corner.

Function Keys

- Six keys with different functions for recipe and folder creation. With these keys recipes and folders can be created, renamed, saved or deleted:
  - **Save**
  - **Discard**
  - **Save as**
  - **Rename**
  - **Delete**
  - **Create Folder**

- Function keys that are not valid in the current view are displayed grayed out.

Error Information Line

- In the error information line the number of errors which may occur during recipe creation or modification or if selecting wrong tooling are displayed.
- Moving and expanding the error field upwards will show the detailed list of errors.

  A detailed description of the error function can be found in *Error Messages*

Tool Tip

- For each parameter a tool tip is available.
- As soon as the cursor is positioned on the parameter field a display field shows help information concerning input or selection.

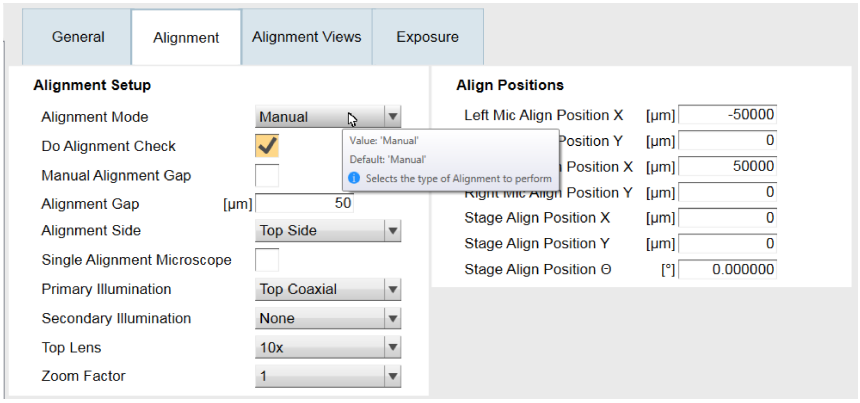
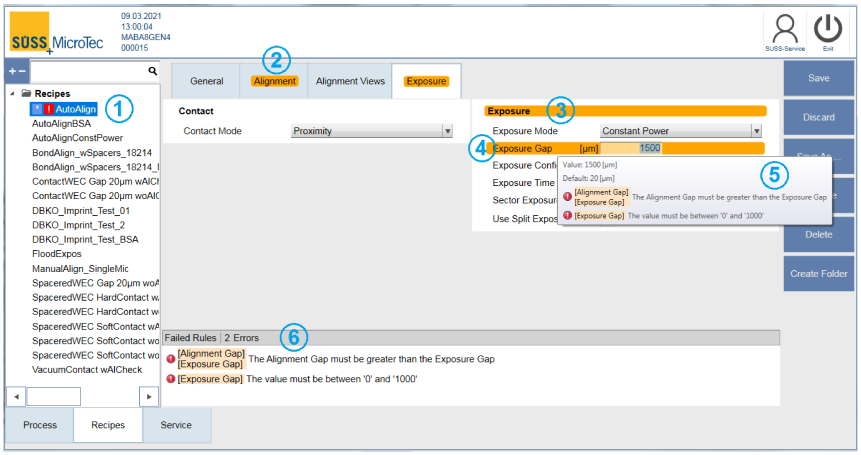


Fig. 2 - 1: Tool Tip

Error Messages

Several Displays

- If a wrong parameter value is input/selected or if a parameter value becomes incorrect during process the error is displayed in different ways at the user GUI.



1	**Red marking in recipe name**
2	**Colored marking of the tab**
3	**Colored marking of the group name**
4	**Colored marking of the parameter line**
5	**Display window with detailed information**
6	**Error information line with detailed infos about the error**

2.5.2 Parameters of the Tab "General"

Tab *"General"* for Process Type "Lithography" and "Bond Alignment"

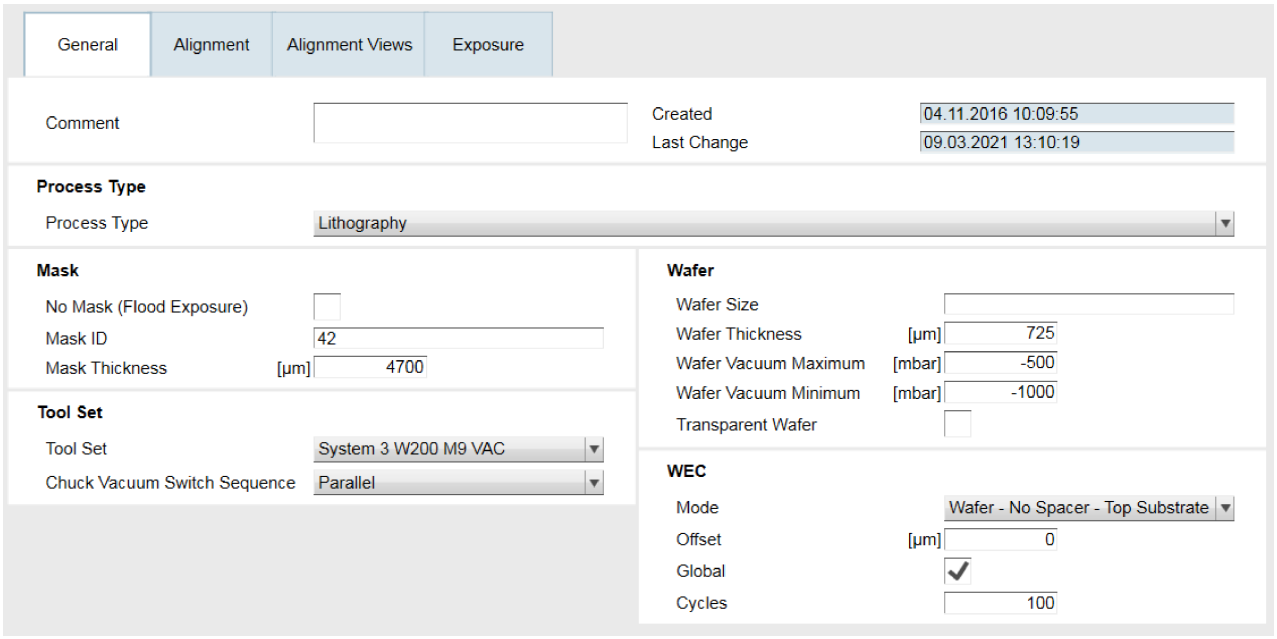


Fig. 2 - 2: Tab "General" in Recipe View for Process Type "Lithography"

Depending on the selected "Process Type" the naming is different:

- Lithography: Mask/ Wafer
- Bond Alignment: Top Substrate/ Bottom Substrate

Mask

No Mask (Flood Exposure)*

Check Box

- If checked the process "Flood Exposure" is selected.
- If checked, the *"WEC"* group and the tabs *"Alignment"* and *"Alignment Views"* disappear from the GUI.

Flood Exposure:

For flood exposure no mask is used ande therefore no alignment is necessary. No wedge error compensation is made during this process.

This mode has been designed e.g. for applications where image reversal resist is used.

Chapter 11.4 "Flood Exposure" on page 169

Mask ID*

Numeric Input Field

- Use this field to enter the number via keyboard if the mask has an identification number.
- If left blank, the value is set to „0".

Mask Thickness

Numeric Input Field

- All input values in [µm]
- Allowed values: 0 to 17.700
- The thickness of the mask can be entered via keyboard.
- The thickness specification is necessary to calculate the travel distance which the z-axis moves fast until the speed is slowed down. This optimizes the throughput.
  If the thickness is set too high throughput will be decreased. If it is set too low an error may occur.

* not valid for bond alignment

Wafer

Wafer Thickness

Numeric Input Field

- All input values in [µm]
- Allowed values: 0 to 17.700

- The thickness of the wafer can be entered via keyboard.
- The thickness specification is necessary to calculate the travel distance which the z-axis moves fast until the speed is slowed down. This optimizes the throughput.
  If the thickness is set too high throughput will be decreased. If it is set too low an error may occur.

Wafer Vacuum Minimum

Numeric Input Field

- All input values in [mbar]
- Allowed values: -1000 to 0
- Lower tolerance limit for wafer vacuum.
- If the value falls below the limit an error message will be displayed.

Wafer Vacuum Maximum

Numeric Input Field

- All input values in [mbar]
- Allowed values: -1000 to 0
- Upper tolerance limit for wafer vacuum
- If exceeding the limit an error message will be displayed.

Transparent Wafer

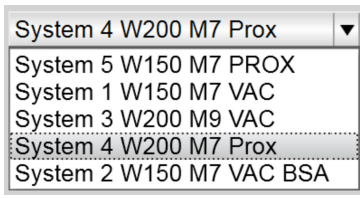
Check Box

- Defines if a wafer is transparent.
- The process flow might be different, if a transparent wafer is used, e.g. in BSA case the microscopes can see through the wafer. Therefore grabbing of alignment targets may not be not necessary.

Tool Set

The group „Tool Set“ defines parameters of the tool set components. The tool set determines the „Process Type“ in which the MA/BA Gen4 works.

Tool Set



Drop Down Menu

- Selection of all available tool sets. Definition of the tool set is done in service view.
- Each tool set following components and conditions are assigned to:
  - Allowed mask loading mode (top- or bottom loading)
  - Used adapter frame
  - Used mask holder/ upper substrate holder (top tool)
  - Used chuck

Chuck Vacuum Switch Sequence

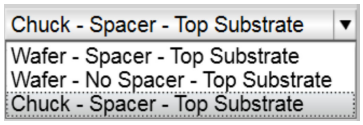


Drop Down Menu

- A selection in this menu is only possible if the tool set includes a special chuck (combination chuck for use with 2 substrate sizes).
- The combination chuck uses 2 independent vacuum circuits:
  - **Inside**
  - **Outside**
- In this menu you can choose whether only one of both shall be used (Inside/ Outside)
  - **Parallel**
- If a chuck has only one vacuum circuit (standard) automatically „Inside“ is selected. The other options cannot be selected (crossed out).

WEC

WEC Mode



Drop Down Menu

- You can select if the wedge error compensation is performed in contact, if spacers between mask and substrate shall be used to set the parallelism or if you use the non-contact gap setting mode.
  - Wafer - Spacer - Top Substrate
    Wedge error compensation with spacers in mask holder
  - Wafer - No Spacer - Top Substrate
    Wedge error compensation in contact
  - Chuck - Spacer - Top Substrate
    Wedge error compensation for non-contact gap setting.

Non-Contact Gap Setting (NCGS):

The NCGS function enables WEC and consecutive alignment without touching the wafer surface.
This WEC mode is only available for process type "Lithography".

- WEC is performed directly between top substrate and chuck, without lower substrate. The WEC-head is kept clamped.
- The thickness of the wafer has to be known.
  Enter the wafer thickness into the input field *"Wafer Thickness"* in group *"Wafer"*.
- After loading the lower substrate the gap is calculated and the Z-axis with the clamped WEC-head drives to this position.

NOTICE!

For wedge error compensation with spacers a mask holder with spacers has to be used.

WEC Offset

Numeric Input Field

- All input values in [µm]
- Allowed values: 0 to 1000
- Entry of a value greater than „0“ means that this value is added to the alignment gap defined in the recipe.
  - Example:
    A WEC offset of 10 µm increases the alignment gap about 10 µm.
- The entry of a value greater than „0“ can be necessary because of several reasons e.g.:
  - If a very soft photo resist is used the spacers could be pressed into the resist. This would lead to a alignment gap that is in reality smaller than the defined gap of the recipe.
  - During wedge error compensation a mask bending may take place which also leads to a smaller alignment gap.

NOTICE!

To measure the real distance between mask and wafer during the different process steps (wedge error compensation, alignment gap, exposure gap) it is recommended to check it from time to time with a suitable measuring device (e.g. Heidenhain).
This is also reasonable during development of new processes.

Global — **Check Box**

- if checked, one wedge error compensation is done at the beginning of a cassette/batch of wafers.
- The WEC can be performed with spacers directly against the chuck. (WEC Mode "Chuck-Sapacer-Top Substrate" must be pre-selected).
- The WEC-head is clamped in this position and stays clamped during a predefined number of cycles.
  The subsequently loaded substrates are processed with this WEC-head position.
- The wafer thickness must be well known.
-

Cycles — **Numeric Input Field**

- Allowed values: 1 to 1000000
- Defines the number of substrates which are allowed to be processed with the same Global WEC.
- If the maximum number of cycles is reached, the operator is prompted to perform a new global WEC: "Load Recipe Chuck Without Wafer"
  or to terminate the process with *[Back]*.

2.5.3 Parameters of the Tab "Alignment"

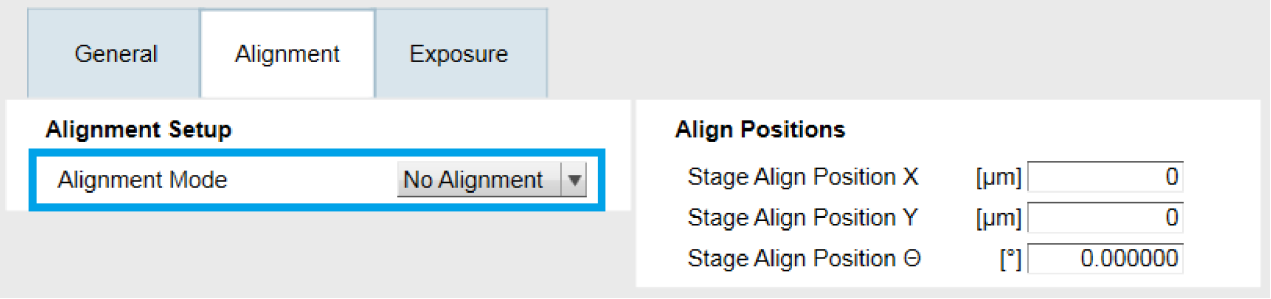


Fig. 2 - 3: Tab "Alignment" in Recipe View: Mode "No Alignment"

- If alignment mode "No Alignment" is selected, no parameters for alignment are displayed.
- Only the align positions for the stage are visible and can be edited.

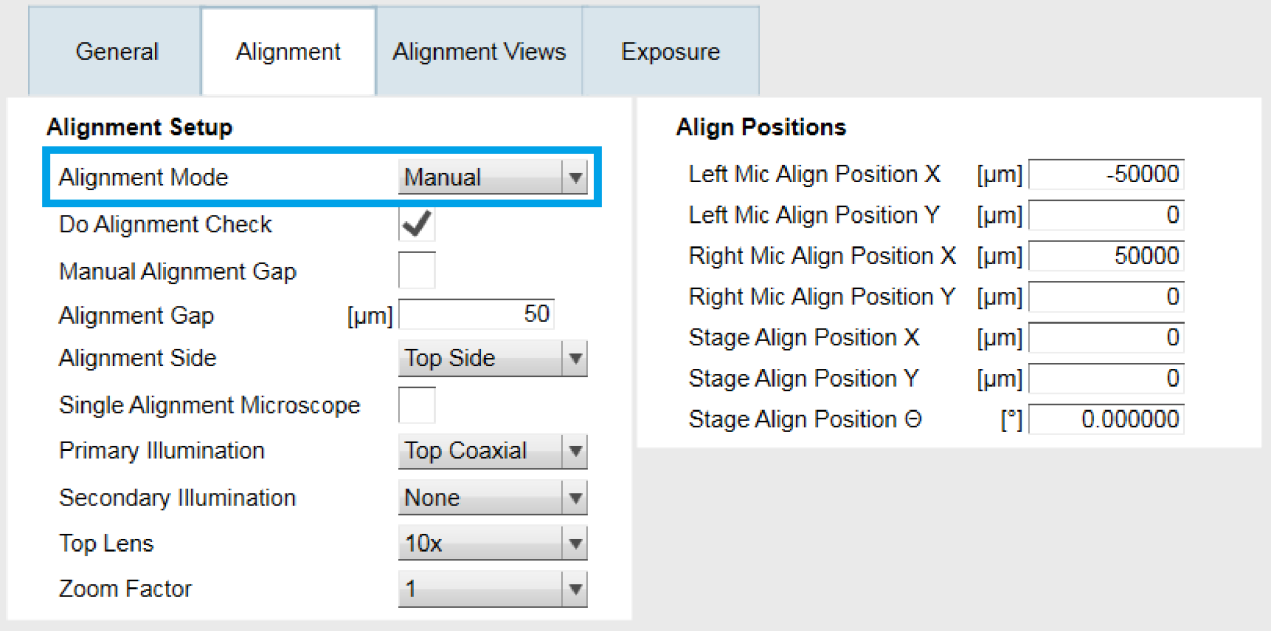


Fig. 2 - 4: Tab "Alignment" in Recipe View: Mode "Manual"

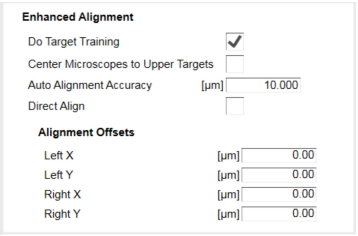


Fig. 2 - 5: Tab Alignment in Recipe View: Mode "Auto"

- If alignment mode "Auto" is selected, additionally the group "Enhanced Alignment" is displayed.

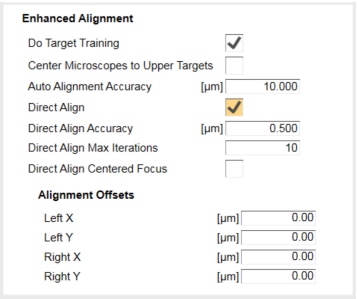


Fig. 2 - 6: Mode "Auto" - "Direct Align" selected

- If the check box "Direct Align" is checked, additional parameters for direct align definition are displayed.

Alignment Setup

Alignment Mode



Drop Down Menu

- Selection of all available alignment modes
  - **No Alignment:** No alignment, e.g. for "First Exposure"
  - **Manual:** Manual alignment with joystick
  - **Auto:** Auto Alignment

Do Alignment Check

Check Box

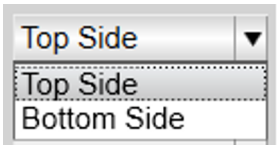
- If the check box is ticked the process will be stopped at two different wafer positions:
  - **AL-Check:** Wafer in exposure gap/ contact
  - **Contact Check:** Wafer in contact after contact program (e.g. vacuum contact)
- The alignment can be checked at these positions.

Alignment Gap

Numeric Input Field

- All input values in [µm]
- Allowed values: 0 to 1000
- Definition of alignment gap between mask/upper substrate and lower substrate

Alignment Side



Drop Down Menu

- **Top Side**
  Alignment is performed from above.
  Substrate alignment patterns have to be visible through the mask.
- **Bottom Side**
  Alignment is performed from below.
  Mask alignment patterns have to be grabbed and stored.
  The images of the mask alignment patterns are overlaid the real wafer patterns.

Chapter 7.1 “Manual Top Side Alignment (TSA)” on page 101

Chapter 7.3 “Manual Bottom Side Alignment (BSA)” on page 111

Alignment Single Microscope

Check Box

- If the check box is ticked, only the left microscope is used for alignment.
- This option is used for small substrate pieces, for substrate widths smaller than the minimum microscope distance.

see Chapter 6.2 "Manual Top Side Alignment Single Microscope"

Primary Illumination



Drop Down Menu

- **None**
  - no illumination (e.g. during first exposure without alignment)
- **Top Coaxial**
  - top light illumination for TSA, parallel to the optical path
- **Top IR**
  - top light infrared illumination
- **Top Ring Light**
  - top light ring illumination
- **Bottom Coaxial**
  - top light illumination from below for BSA, parallel to the optical path
- **Bottom IR**
  - transmitted light infrared illumination

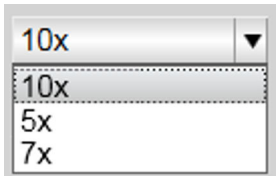
Secondary Illumination



Drop Down Menu

- **None**
  - no illumination (e.g. during first exposure without alignment)
- **Top Coaxial**
  - top light illumination for TSA, parallel to the optical path
- **Top IR**
  - top light infrared illumination
- **Top Ring Light**
  - top light ring illumination
- **Bottom Coaxial**
  - top light illumination from below for BSA, parallel to the optical path
- **Bottom IR**
  - transmitted light infrared illumination

Alignment Top Lens



Drop Down Menu

- shows all available objective magnifications e.g.
  - 10x
  - 5x
  - 7x

Enhanced Alignment

Do Target Training

Check Box

- If the check box is ticked the auto alignment process with target training will be performed.

Auto Alignment Accuracy

Numeric Input Field

- All input values in [µm]
- Allowed values: 0 to 1000
- Definition of minimum alignment accuracy to allow the substrate to be exposed.
  If the value is exceeded, the process is stopped before exposure.

Direct Align

Check Box

- If the check box is ticked the option "Direct Align" becomes active and will be performed during the process.
- Direct Align is only possible in Alignment Mode "Auto".
- A detailed description of "Direct Align" can be found in *Chapter 8.5 “Direct Align (DA) Option” on page 148*

Direct Align Accuracy

Numeric Input Field

- All input values in [µm]
- Allowed values:0 to 1000
- Definition of minimum alignment accuracy to allow the substrate to be further processed.
- If the value is exceeded, the process is stopped and the operator has to decide how to proceed.

Direct Align Iterations

Numeric Input Field

- Allowed values:0 to 100
- Definition of maximum number of loops to reach the defined "Direct Align Accuracy".
- If the value is exceeded, the process is stopped and the operator has to decide how to proceed.

Centered Focus

Check Box

- Enables the *“Centered Focus”* mode to avoid switching the focus between mask and wafer targets during the target search at Direct Align.
- *“Centered Focus”* moves the microsope focus in the middle between mask and wafer. It is used for small exposure gaps within the depth of focus.
- The *“Centered Focus”* is a trained position, not a calculated position.
- Training is done in exposure gap and the microscope positions have to be adjusted so that both mask and wafer targets are in focus.

Alignment Offsets

Numeric Input Field

- All input values in [µm]
- Allowed values: -1000 to 1000
- Input of individual offsets that are added or subtracted from the final position found by the automatic alignment procedure.
- The offsets are also displayed and can be edited in the process/ navigation frame "Train Target and Views" during auto alignment process.

2.5.4 Parameters of the Tab "Alignment Views"

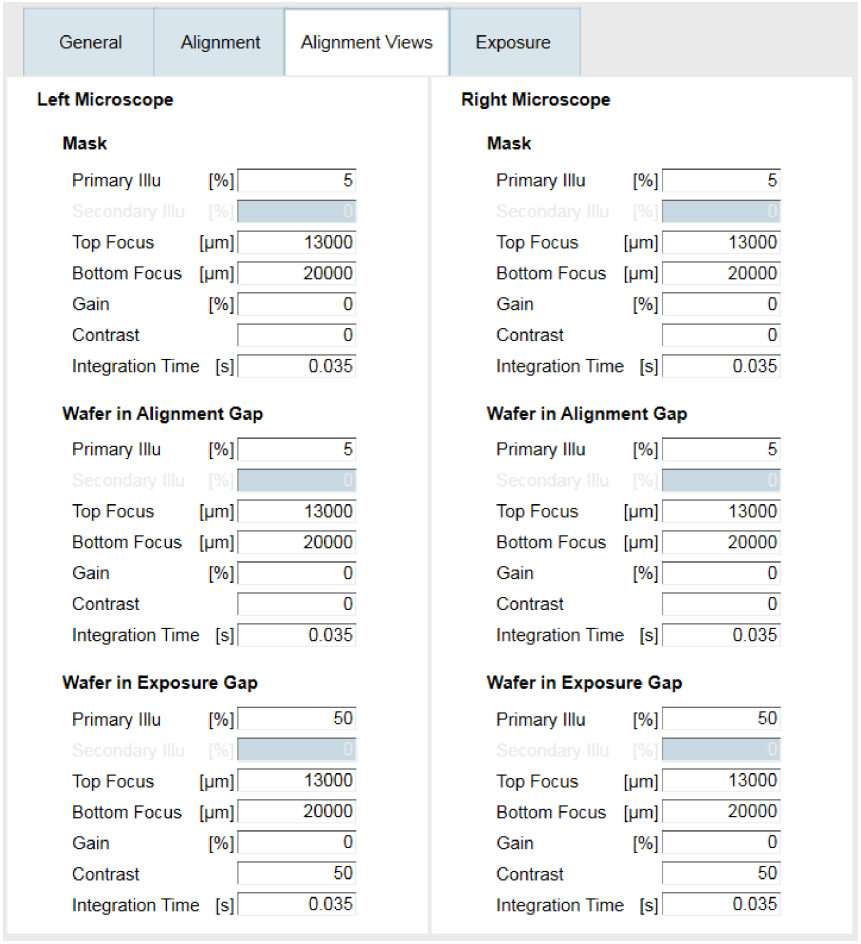


Fig. 2 - 7: Tab "Alignment Views" in Recipe View

All parameters of the tab „Alignment Views“ refer to the corresponding focus position of right or left microscope.

Focal Positions

Mask

- In lithography process this is the focal plane of the mask
- In bond process this is the focal plane of the upper substrate.

Wafer in Alignment Gap

- Focal plane of the lower substrate (on the chuck) in alignment gap.

Wafer in Exposure Gap

- Focal plane of the lower substrate (on the chuck) in exposure gap.

Parameters

Illumination Values
- Primary Illu, Secondary Illu

Focus Position Values
- Top Focus, Bottom Focus

Camera Values
- Gain, Contrast, Integration Time

2.5.5 Parameters of the Tab "Exposure"

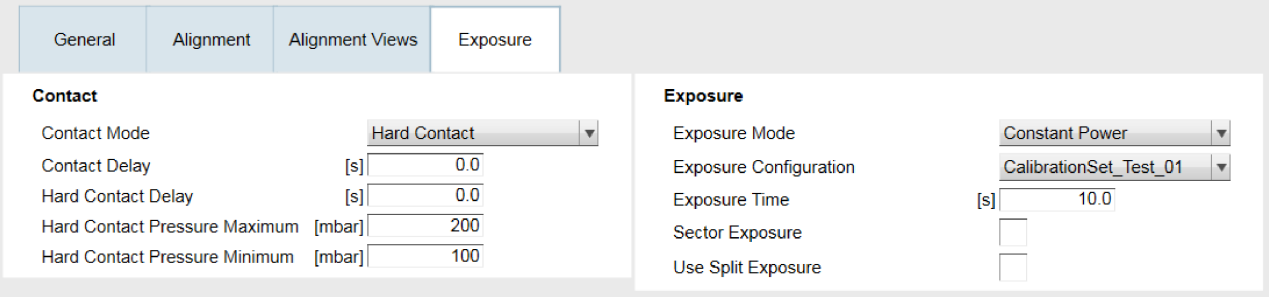
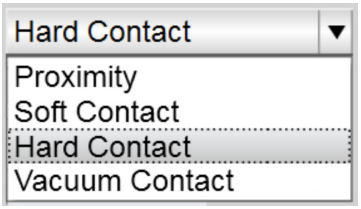


Fig. 2 - 8: Tab "Exposure" in Recipe View

Contact

The group „Contact“ defines parameters for the selected contact mode of a recipe. The parameters are partly valid and only visible for specific contact modes.

Contact Mode



Drop Down Menu

- Shows all available contact modes between mask and substrate.
- Depending on the selected contact mode in group „Contact“ and „Exposure“ specific parameters can be defined.

Proximity	Defined gap between mask and substrate.
Soft Contact	Contact between mask and substrate. Substrate remains fixed on the chuck with vacuum.
Hard Contact	Contact between mask and substrate. Substrate is press against the mask with nitrogen pressure
Vacuum Contact	Contact between mask and substrate. Using a special vacuum contact chuck it is possible to create a vacuum chamber. With this mode mask and substrate will reach the best possible contact.

A detailed description of all contact modes can be found in ↳ *Chapter 9 “CONTACT/ EXPOSURE PROCESSES” on page 153*

Contact Delay

Numeric Input Field

- All input values in [s]
- Allowed values: 0 to 10
- In **Soft Contact** mode this parameter defines a delay time between achieving contact between mask and wafer and the start of exposure.
- In **Hard Contact** mode this parameter defines a delay time between the step of pressing the wafer against the mask (with nitrogen) and start of exposure.
- In **Vacuum Contact** mode this parameter defines a delay time between achieving contact between mask and wafer and build up the vacuum chamber. Trapped air between mask and wafer can exhaust within this delay time. Contact will be improved.

Hard Contact Pressure Maximum

Numeric Input Field

- All input values in [mbar]
- Allowed values: 0 to 1000
- Upper tolerance limit for hard contact pressure
- If the limit is exceeded the machine will stop and an error message will be displayed.

Hard Contact Pressure Minimum

Numeric Input Field

- All input values in [mbar]
  Allowed values: 0 to 1000
- Lower tolerance limit for hard contact pressure
- If the pressure falls below the limit the machine will stop and an error message will be displayed.

Pre Vacuum Delay

Numeric Input Field

- All input values in [s]
- Allowed values: 0 to 10
- In **Vacuum Contact** mode this parameter defines the period of time between start of the pre-vacuum and start of the main vacuum for the vacuum chamber.
- This delay time enables a slow buildup of the vacuum chamber and avoids air trapping between mask and wafer.

Vacuum Delay

Numeric Input Field

- All input values in [s]
- Allowed values: 0 to 10
- In **Vacuum Contact** mode this parameter defines the period of time between start of the main vacuum for the vacuum chamber and switch off the chuck vacuum that fixes the wafer.
- If the chuck vacuum shall not be switched off, it defines the period of time between start of the main vacuum for the vacuum chamber and start of exposure.
- This delay time enables a slow buildup of the vacuum chamber and avoids air trapping between mask and wafer.

Chamber Vacuum Maximum

Numeric Input Field

- All input values in [mbar]
- Allowed values: -1000 to 0
- Upper tolerance limit for vacuum contact pressure
- If the pressure falls below the limit the machine will stop and an error message will be displayed.

Chamber Vacuum Minimum

Numeric Input Field

- All input values in [mbar]
- Allowed values: -1000 to 0
- lower tolerance limit for vacuum contact pressure
  If the limit is exceeded the machine will stop and an error message will be displayed.

Release Wafer

Check Box

- If this checkbox is ticked, the vacuum under the wafer will be switched off and all lines will be closed as soon as the vacuum chamber has been built up completely.
- For an optimum exposure result this check box should be ticked. This guarantees the closest possible contact between mask and wafer.
- The check box may be deselected e.g. if there is a risk of loss of alignment accuracy in case of „releasing“ the wafer from the chuck.

Wafer/Chuck Release Delay

Numeric Input Field

- All input values in [s]
- Allowed values: 0 to 10
- In **Vacuum Contact** process this parameter defines the period of time between switch-on main vacuum for the vacuum chamber and switch-off of chuck vacuum.
- This delay enables a slow buildup of the contact between mask and wafer and avoids air trapping between mask and wafer.

Wafer/Mask Release Delay

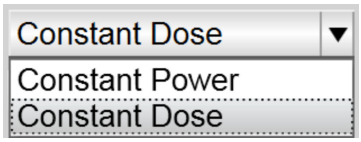
Numeric Input Field

- All input values in [s]
  Allowed values: 0 to 10
- In **Vacuum Contact** process this parameter defined the period of time between opening of the vacuum chamber and switch-on of the nitrogen flow between wafer and mask.
- This delay enables a slow reduction of the contact between mask and wafer and enables the releasing of the wafer from the mask.

Exposure

The group „Exposure“ defines all parameters, which are relevant for the exposure process. The parameters are partly valid and only visible for specific contact modes.

Exposure Mode



Drop Down Menu

- shows all available exposure modes

Constant Power	The exposure time is defined and the electric power will remain constant during the exposure time period.
Constant Dose	The desired exposure dose is defined. with a sensor in the exposure optical path the dose is measured during exposure. The shutter is kept open until the defined does is reached. Fluctuation of intensity can be equalized with this method.

Exposure Time

Numeric Input Field

- All input values in [s]
- Allowed values: 0 to 36.000
- For exposure mode **Constant Power** the desired exposure mode is defined in this field.

Sector Exposure

Check Box

- If ticked, the wafer can be exposed a number of times without leaving the exposure gap.
- This check box is selectable for exposure mode **Constant Power** and **Constant Dose**.
- Once it is selected, an additional parameter is displayed:

Exposure Sectors

Numeric Input Field

- Allowed values: 2 to 10
- Each field can be exposed with a different exposure time.

A detailed description can be found ↳ *in chapter "Sector Exposure".*

Use Split Exposure

Check Box

- If ticked, the total exposure time can be split and a delay time between the time segments can be programmed .
- This check box is only visible and selectable for exposure mode **Constant Power**.
- Each exposure time segment has the same exposure time which is defined with the parameter "Exposure Time".
- Once it is selected, two additional parameters are displayed:

Split Exposure Count

Numeric Input Field

- Allowed values: 0 to 1000
- Number of segments in which the total exposure sequence shall be split.

Split Exposure Delay

Numeric Input Field

- All input values in [s]
- Allowed values: 0 to 1000
- Waiting time between each exposure segment. Each delay has the same time.

A detailed description can be found *in chapter "Split Exposure".*

Exposure Dose

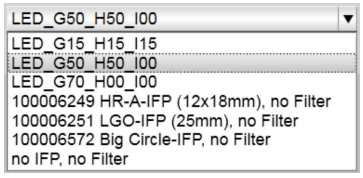
Numeric Input Field

- All input values in [mJ/cm²]
- Allowed values: 25 to 99999
- For exposure mode **Constant Dose** the desired exposure dose is defined in this field.

A detailed description can be found *in chapter "Constant Dose".*

Exposure Configuration

Drop Down Menu



Shows all optics versions which are stored in the configuration.

- All available optics versions are defined in this menu.
- If a UV-LED light source is used, all defined LED-configurations are additionally displayed.
- For the dose measurement it is necessary to select the valid optics combination (e.g. used filter, aperture, optics combination) to load the suitable calibration parameters.

Exposure Gap

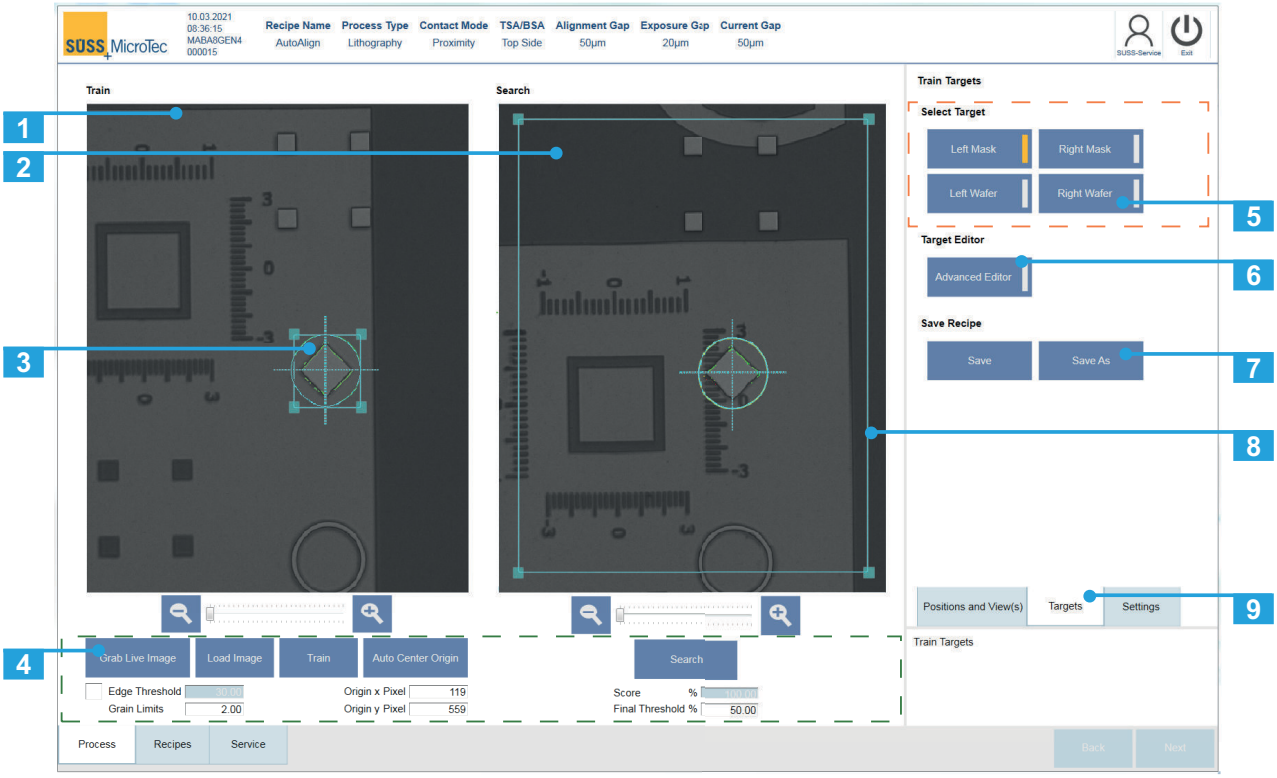
Numeric Input Field

- All input values in [µm]
- Allowed values: 0 to 1000
- In **Proximity** mode in this field the exposure gap between mask and wafer is defined.
- The value for the exposure gap must not be bigger than the value for the **Alignment Gap** (defined in tab „**Alignment**“, group „**Alignment Setup**“).

2.6 Auto Alignment - Target Training View

2.6.1 Overview

This view is only visible if the alignment mode in the current recipe is set to „**Auto**“.



1	Train Target Screen
2	Search Target Screen
3	Bounding Box for Target Model Definition (with graphical feedback)
4	Function Keys and Parameters for Training and Search
5	Function Keys/Select Target
6	Function Key for Access to Advanced Editor
7	Function Keys/Recipe Saving
8	Bounding Box for Search Region Definition (with graphical feedback)
9	Tabs for Position/View, Target Training and Settings

2.6.2 Function Keys and Parameters (4)

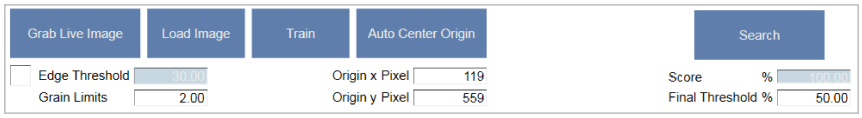


Fig. 2 - 9: Function Keys and Parameters for Auto Alignment

Grab Live Image



Function Key

- Pressing this function key grabs the live image from the selected microscope/ camera with the selected view (e.g. Mask View) and updates the train image.

Load Image



Function Key

- Pressing this function key opens the explorer and enables loading of an already saved image for target training.

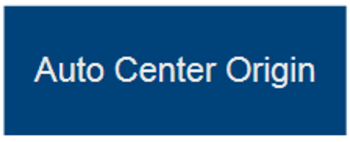
Train



Function Key

- Pressing this function key starts the pattern recognition algorithm for the selected microscope/camera and view (e.g Mask View).
- The result of the training is visually displayed.

Auto Center Origin



Function Key

- Pressing this function key starts the calculation of the origin (center of the trained target model) of the trained target.
- The result of the calculation is visually displayed as a cross hair. • Automatic detection of the origin is only possible for symmetric target.

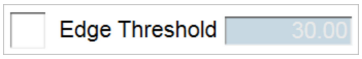
Search



Function Key

- Pressing this function key start an automatic search for the trained target model within the defined search region.
- The result of the search is visually displayed.

Edge Threshold



Check Box and Numeric Input Field

- The parameter „Edge Threshold“ defines the absolute minimum value of edge magnitude below which the edge direction will be randomized.
- As long as the check box is NOT ticked an automatic value defined by the image recognition system will be set for training.
- If ticked, the desired threshold can be set in the numeric input field.

A detailed description can be found *in chapter "Edge Threshold and Grain Limits"*

Grain Limits



Numeric Input Field

- The parameter „Grain Limits“ controls the size of features detected by the image recognition system.
- The desired limit can be typed in the numeric input field.

A detailed description can be found *in chapter "Edge Threshold and Grain Limits"*

Origin X/Y Pixel



Numeric Input/Display Field

- The two fields display the coordinates of the current origin position of the trained target model. (The coordinate origin is set to the upper left corner of the video image.)
- The target model origin can be set automatically using the function key [Auto Center Origin] or by drag and drop of the cross hair. Then the current coordinates are displayed in the fields.
- Alternatively the target model origin can be set by typing the coordinates numbers directly in the input fields.

Score



Display Field

- This field displays the score value for the target search in the defined search region after clicking the function key *[Search]*.

Final Threshold



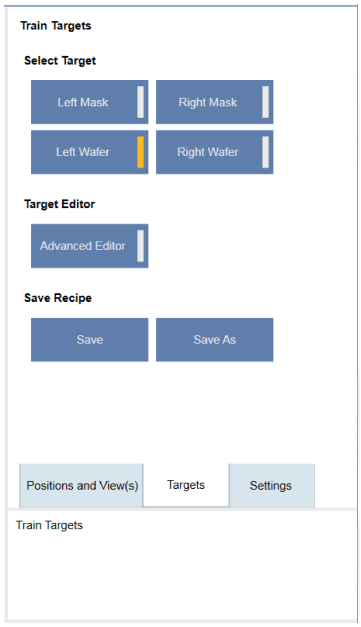
Numeric Input Field

- The parameter Final Threshold is used to determine whether the found target model (within the search region) matches with the trained target model.
- Scores greater or equal to the input value are valid matches.

2.6.3 Dialog Frame: Train Targets

The tab *"Targets"* shows besides the Train and Search Screen with their function keys and parameters the dialog frame "Train Targets:

Train Targets



Dialog Frame

- The user guidance shows in this view:
  - the current selected target to be trained (Select Target)
  - the access to the "Advanced Editor" (Target Editor)
  - the possibilities for recipe saving (Save Recipe)

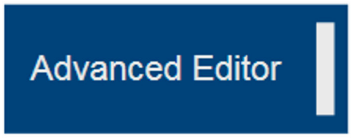
Select Target



Function Key

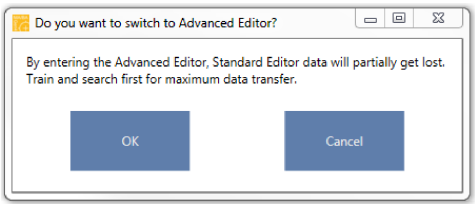
- Each function key gives access to the respective view.
- For each view a target training is necessary for a successful automatic alignment.
- The currently active and displayed view (for Train and Search) is displayed through the yellow "LED" in the function key.

Target Editor



Function Key

- This key gives access to the VisionPro Editor.
- For difficult targets this editor provides multiple options for improvements.
- If clicked a warning window pops up:

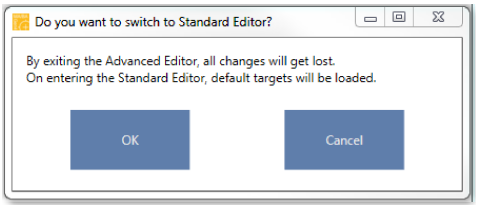


NOTICE!

Only for experienced users!

The "Advanced Editor" should only be used if the user is especially trained for it.
Details for the operation with the "Advanced Editor" can be found in the special "Addendum Auto Alignment Cognex Patmax and VisionPro".

- If you want to leave the "Advanced Editor", click the function key again.
- If clicked a warning window pops up:



Save Recipe



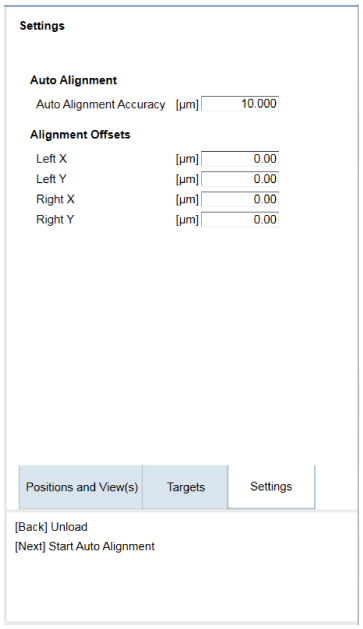
Function Keys

- As soon as a parameter is changed these keys become active and the modified values can be saved.
- **Save:**
  - The values are saved in the currently used recipe.
- **Save As:**
  - The values are saved in a new recipe with a new name.

2.6.4 Dialog Frame: Settings

The tab *"Settings"* shows the current recipe parameters for alignment accuracy and alignment offsets:

Settings



Dialog Frame

- The user guidance shows in this view:
  - numeric input field for *"Auto Alignment Accuracy"*
  - numeric input fields for *"Alignment Offsets"* for each Left/Right X/Y offsets
  - all inputs in [µm]

These parameters can be changed during the process for the current substrate. The changes are immediately written to the current recipe and remain valid as long as they are not overwritten or the software is closed. The current recipe is displayed with "*" and the operator is asked before closing the software whether he wants to save these changes in the recipe..

2.7 Service View

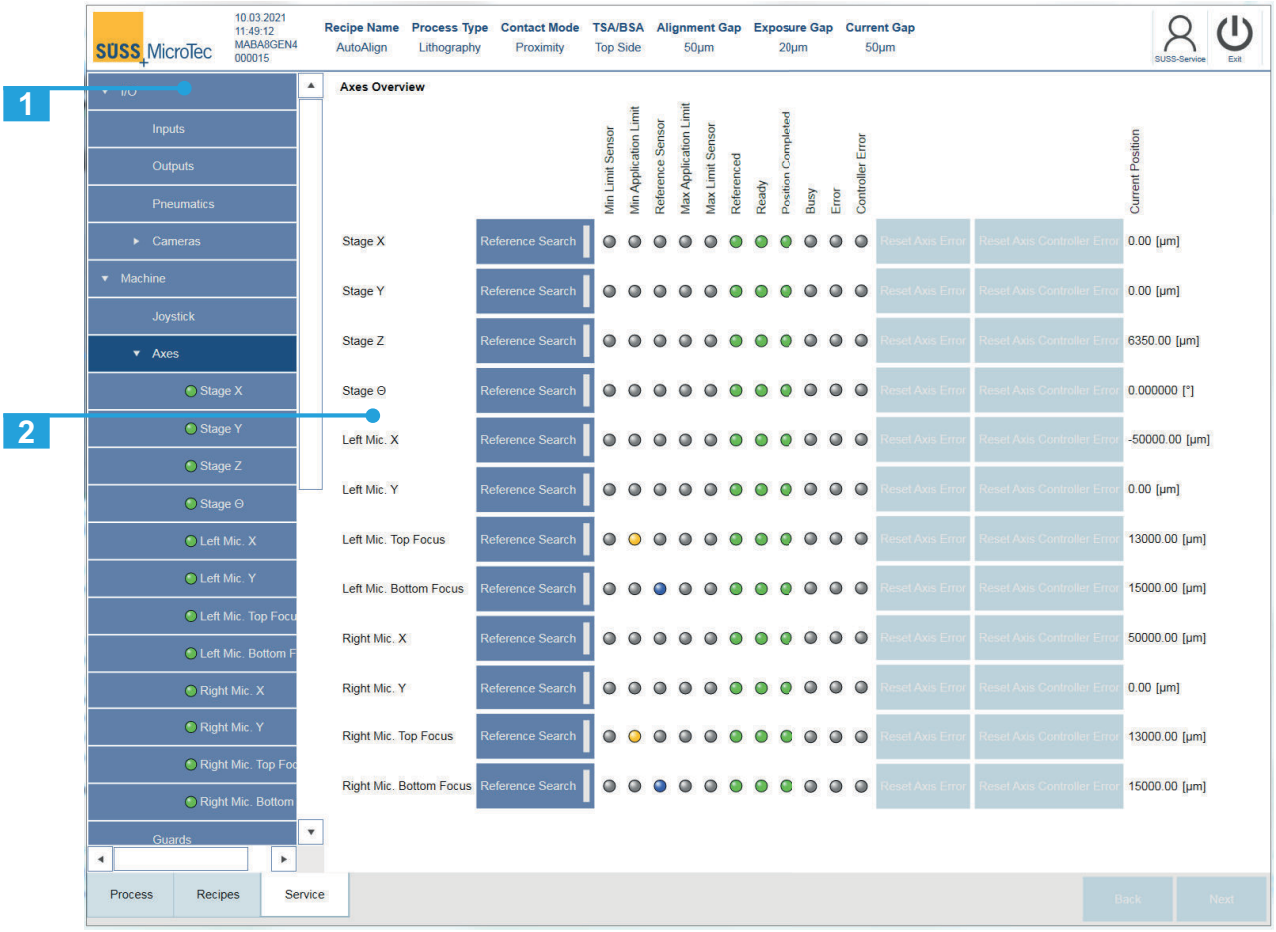
CAUTION!

Danger of Machine Damage!

Wrong input values and modifications of safety adjustments may damage the machine.

► Only trained personnel is allowed to perform modifications.

2.7.1 Overview



1	Drop Down Menu for Service Views	2	Parameter Fields

- Service represents a view of the „running machine“. That means that with „Service“ you can look inside the machine while operating.
- Service requires user rights.
- Service contains low level pages with sensors and actuators for assembly and trouble shooting.
- Service contains configuration pages (tool, axes...)
- Service contains supporting routines for calibration (constant dose, WEC).

- Jumping from Service back into the process without initialization is only allowed for experts. Every change in Service requires an initialization of the machine.
- Within Service no protection from collision is available.

Machine Information

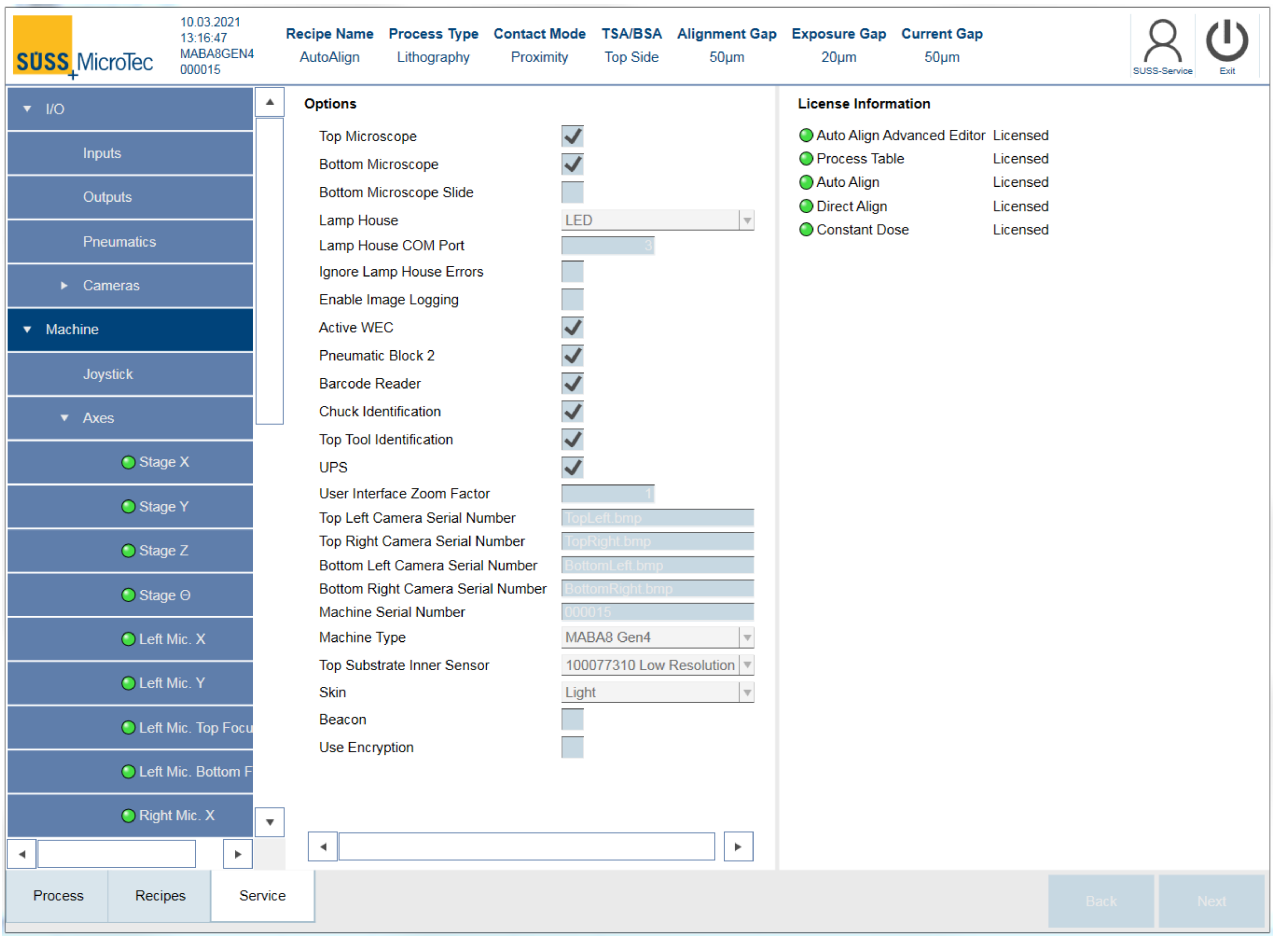


Fig. 2 - 10: Overview of Options and Licence Information

Options

The frame "Options" shows all built in features and modules of the machine:

- microscopes
- lamp house/ light source
- ignore errors
- logging option
- active WEC
- barcode reader/ identifications
- UPS
- serial numbers

Licence Information

The frame "Licence Information" provides with information concerning active licences within the machine.
All options are listed and the "LED" indicates if a valid licence is available:

- Auto Align Advanced Editor - gives access to the VisionPro Editor during target training.
- Process Table - enables imprint processes
- Auto Align - enables automatic alignment of the substrates
- Direct Align - enables accuracy checks in different positions and direct corrections
- Constant Dose - enables exposure dependent of the actual measured dose of the exposure light.

3 USER and GROUP MANAGEMENT

3.1 Initial State at Delivery



- The access for user selection and login is realized with this function key in the GUI title line.
- After software start the user role "Operator" is automatically pre-selected.

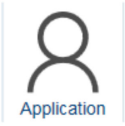
► Click on the function key to open the sub-window *"User Login"*:



- The drop down menu shows all available users.
- 4 user roles are initially available
- The user can be changed at any time.



1. Click the desired user in the drop down menu.
2. Enter the password.
3. Click *[OK]* to confirm.



➔ The selected user is displayed on the function key in the title line.

3.1.1 Default Users and their Permissions

Operator The default user "Operator" cannot be modified. He is pre-defined and remains unchanged in the drop down user list.

- is allowed to operate the mask aligner. This includes:
  - Initialization
  - Loading of the tools (mask holder, chuck)
  - Process selection
  - Process navigation
  - Access to Service in view mode (no input possible)
  - Perform light measurement tasks
- **No permission** for creating, changing or deleting of recipes, recipe parameters or service parameters.
- No password required.

Application

The default user "Application" cannot be modified. He is pre-defined and remains unchanged in the drop down user list.

- is allowed to operate the mask aligner. This includes:
  - all permissions of user role „Operator“.
  - Creating and changing of recipes
  - Changing of recipe parameters
- **No permission** for changing of service parameters.
- The user role is password protected.
- The password can be changed.

Service

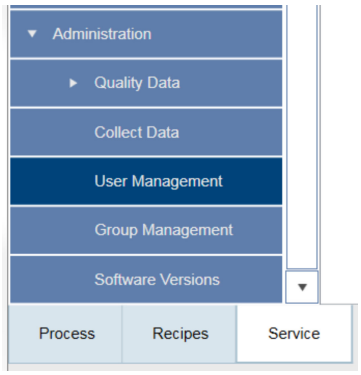
The default user "Service" cannot be modified. He is pre-defined and remains unchanged in the drop down user list.

- is allowed to operate and service the mask aligner. This includes:
  - all permissions for user role „Application“.
  - Use of all functions in service mode, as long as no process is running.
- **No permission** for using service functions during a running process.
- The user role is password protected.
- The password can be changed.

SUSS-Service

- Internally defined default user. Cannot be changed or deleted.
- Only accessible for SUSS MicroTec service personnel!

3.2 Service Page: User Management



The user management can be accessed in the tab *“Service”*, page: *“Administration”*, sub-page: User Management.

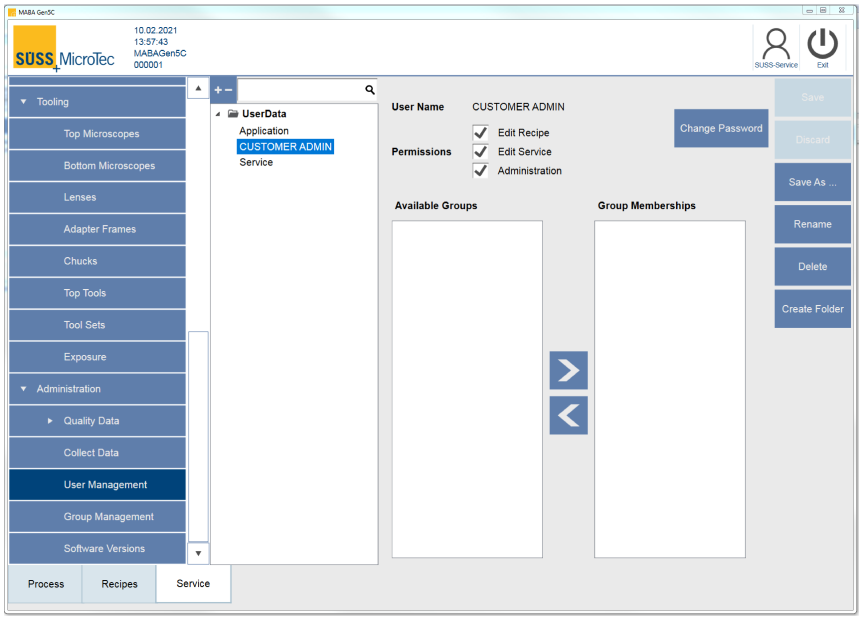
The the content of the service page “User Management” is only visible if you have administration rights.

Initially only the "SUSS-Service" has these rights.

► *During installation, SUSS service has to create an adiministration user with the corresponding permission for the customer.*

3.2.1 How to Create a New User

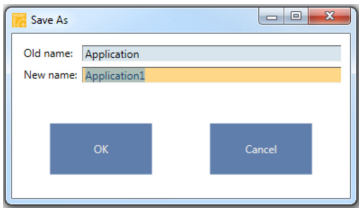
Initial Service Page: User Management



UserData	Default folder, cannot be changed, renamed or deleted.
Application	Default user with the permission *"Edit Recipe"*, cannot be changed, renamed or deleted.
Service	Default user with the permissions *"Edit Recipe"* and *"Edit Service"*, cannot be changed, renamed or deleted.
CUSTOMER ADMIN (example)	Customer user with administration permissions

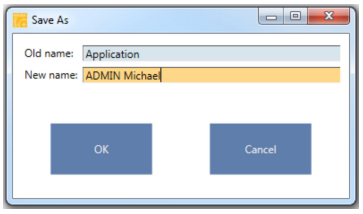
How to creat a new user:

To create a new user you must log in with administration permissions.



- Click one of the default users (here: "Application").
- Click the function key *[Save As...]*

► The "Save As..." sub-window opens.



- Enter a new name for the user and confirm with *[OK]*.

► The sub-window "Set initial password for new user" opens.



- Enter a new password and re-enter it.
- Confirm with *[OK]*.

► The new user is added to the user list and the permissions can be set.



Any modification in the user profile has to saved with *[Save]*.

As long as there are unsaved modifications the user name is marked with a [*].

3.2.2 How to Create a New Folder

How to create a new folder:

You can create folders to organize the different users.

- Click on the default folder *“UserData”*.
- Click the function key *[Create Folder]*.

► The sub-window "Create Folder" opens.

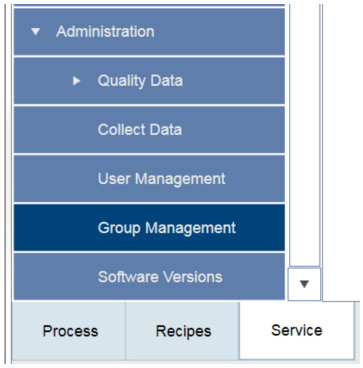
- Enter a name for the new folder and confirm with *[OK]*.

► The new folder is listed under the default folder.

You can move users with "Drag and Drop" into the folder.

If you want to remove a user from the folder you have to move it to another folder or into the default folder “User Data.”.

3.3 Service Page: Group Management



The group management can be accessed in the tab *“Service”*, page: *“Administration”*, sub-page: Group Management.

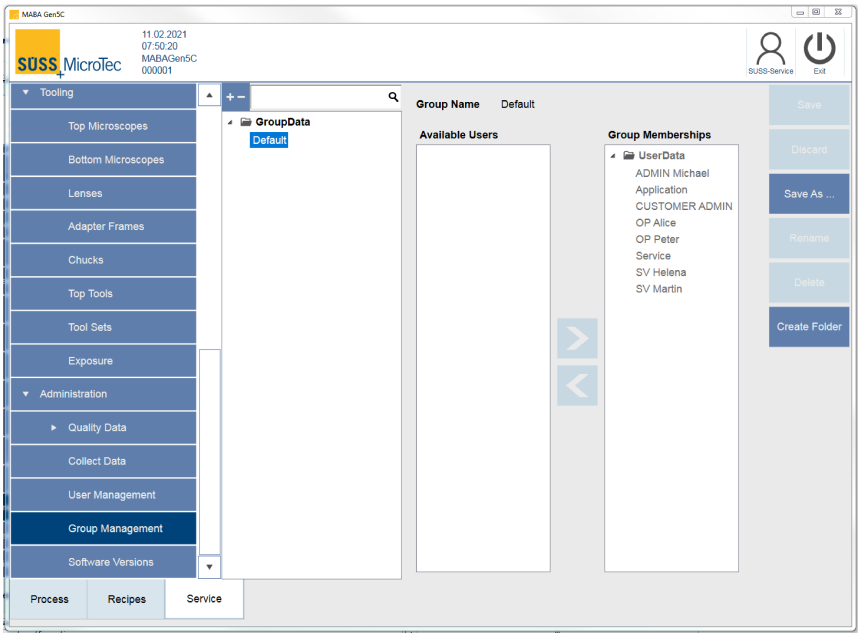
The the content of the service page “Group Management” is only visible if you have administration rights.

Initially only the "SUSS-Service" has these rights.

► *During installation, SUSS service has to create an adiministration user with the corresponding permission for the customer.*

3.3.1 How to Create a New Group

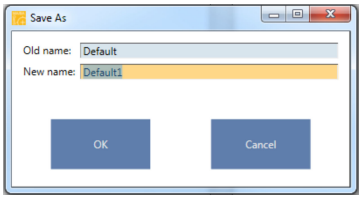
Initial Service Page:
Group Management



GroupData	Default folder, cannot be changed, renamed or deleted.
Default	Default group, cannot be changed, renamed or deleted.
Available Users	List of all users that are created in the user management (the users are listed in this column once a new folder has been created.
Group Memberships	List of all users in a group folder (the users are listed in this column once a new folder has been created and users are assigned to this group.

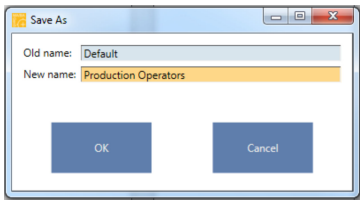
How to creat a new group:

To create a new group you must log in with administration permissions.

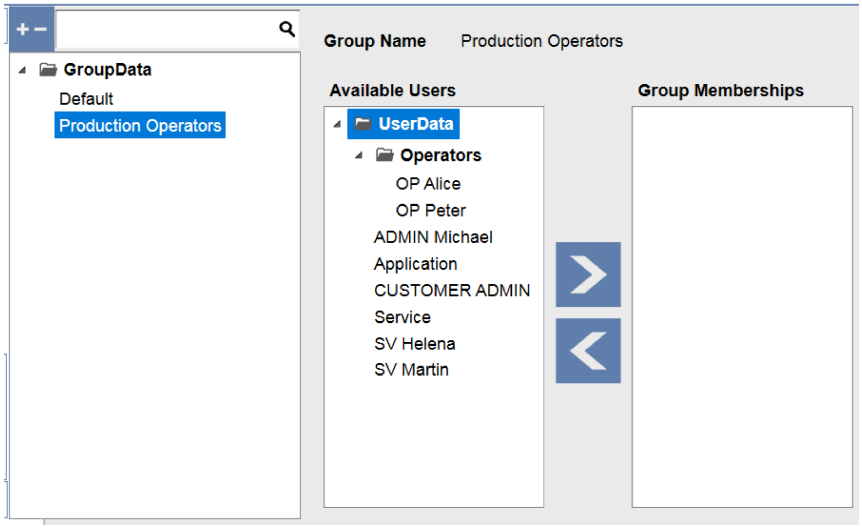


- Click the default group *“Default”*.
- Click the function key *[Save As...]*

► The "Save As..." sub-window opens.



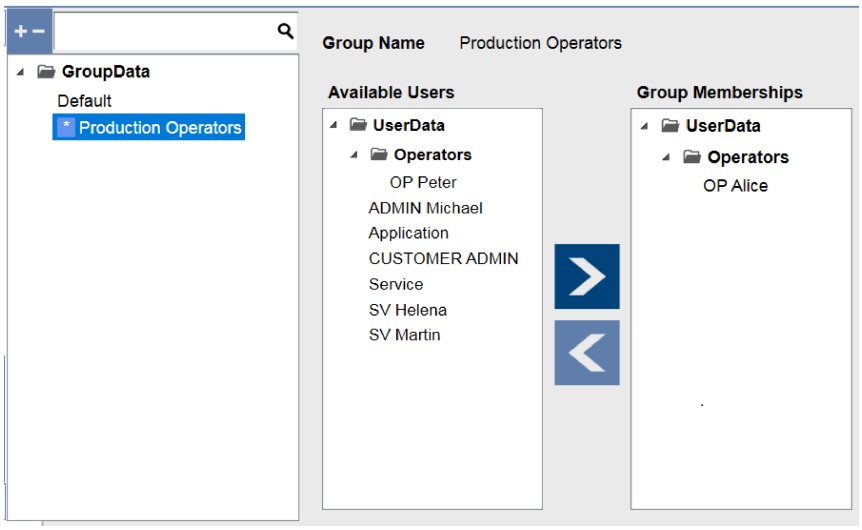
- Enter a new name for the group and confirm with *[OK]*.



► The new group is listed and the column *"Available Users"* is filled with all created users and user folders if you click the new group name.



- Click the group name .
- Click one of the available users or one folder, if you want to add all users of a folder.
- Click the upper *[Arrow]* key to add the user/folder to the group.



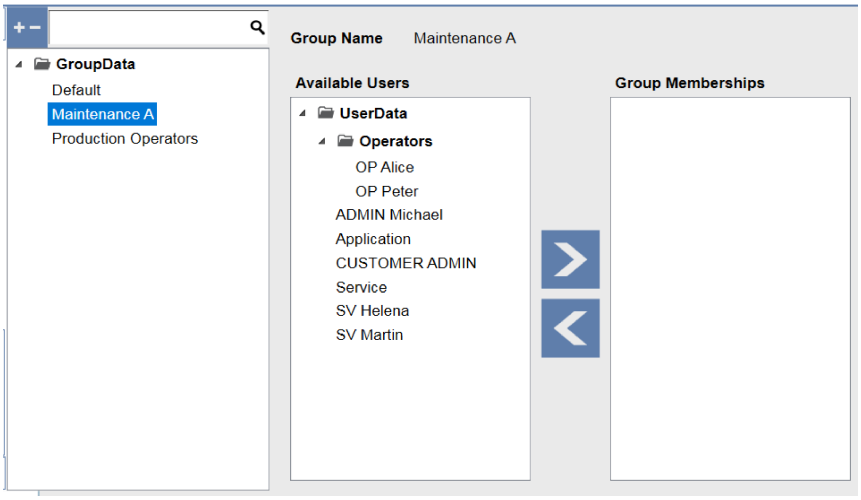
► The selected user/folder is now listed in the *"Group Memberships"* column.

- If you selected a whole folder, all users within the folders are switched to the *“Group Memberships”* column.
- If you selected one user of a folder, only the user is switched, but the corresponding folder in which the user is listed will be displayed also.
- Once you added users to the selected group, the group name is marked with a [*].

Save

- Click *[Save]* to save all changes for the group.

Allowed group membership:



- For every new group that you create ALL users/folders are listed in the column *“Available Users”*.

► That means that the same user can be member of multiple groups.

3.4 Assignment of Rights for the Recipe Folders

Once the user and group managemant has been defined, you can assign individual rights for each recipe folder in your global recipe list.

You must have administrator rights to edit the group rights.

Initial view at the start page:

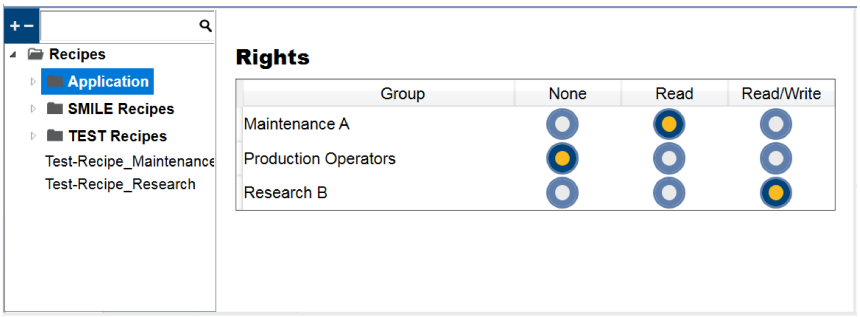
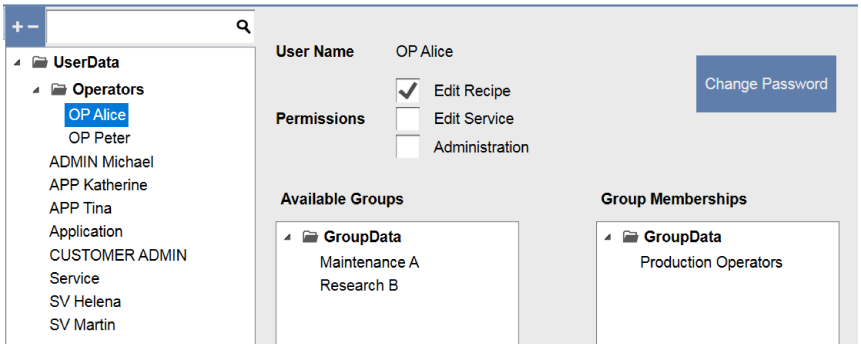


Fig. 3 - 1: Group Rights: Example

- All created recipe folders are listed.
- The root folder *"Recipes"* also contains 2 recipes.
- The rights are displayed for the selected folder *"Application"*.
- The group rights can be edited for each individual recipe folder.
- The *"Rights"* table contains all user groups, pre-defined in the group management.
- Radio buttons are used to set the individual group right:
  - **None:**
    Group members cannot see the folder and the recipes in it
  - **Read:**
    Group members can see the folder and the recipes and can open the recipes and see the parameters.
  - **Read/Write:**
    Group members can see the folder and the included recipes. They can open the recipes and change the parameters.

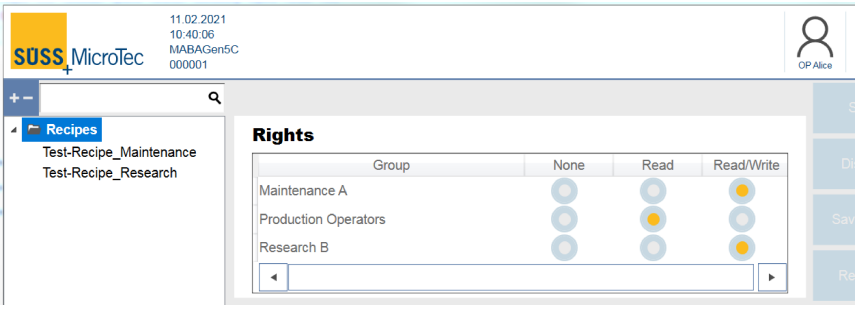
3.4.1 User Rights Example: *OP Alice*

User rights of inidividual user *OP Alice*:



- The user has the permission: *"Edit Recipe"*.
- The user is member of the group: *"Production Operators"*

Rights of the group *Production Operators* for recipe folders:



- The group ***Production Operators*** has *"None"* rights for the recipe folders **Application, SMILE Recipes** and **Test Recipes**. (listed in the example Fig. 3 - 1). Therefore the group and its members cannot see these folders.
- The group ***Production Operators*** has *"Read"* rights for the folder **Recipes**. Therefore the group and its members can see this folder and also the recipes of this folder.

Result for the user *OP Alice:*

- The user ***OP Alice*** is logged in.
- ***OP Alice*** can open the recipes in the folder **Recipes** and can read the parameters.
- ***OP Alice*** cannot edit the parameters although the individual user has "Edit" rights in the user management.

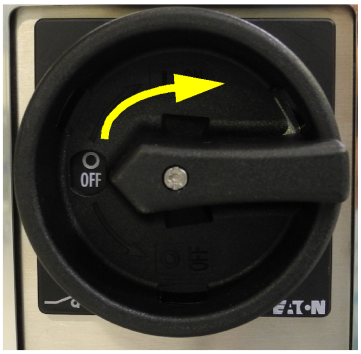
► The group rights for the recipe folders are above the individual user rights.

4 POWER-ON and PROCESS PREPARATION

4.1 Switching On

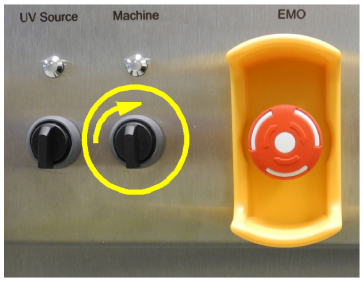
Before switching on the mask aligner:

- Make sure that all components are ready for operation.
- If activated before, the EMO has to be reset.
- The monitor has to be switched on.



1. Switch on the main switch

- Turn the main switch which is located at the right side of the machine clockwise to „ON“.



2. Switch on the machine

- Turn the rocker switch for the machine located at the front plate clockwise.
  The machine is operable, the indicator light is on.



3. Start the software

- After switching on the machine the PC will be booted automatically.
- On the desktop double click the icon „MABAGen4“
- The software will be started and a splash screen is displayed until the loading/start sequence is terminated.
- As soon as the program is loaded the User GUI of the MA/BA Gen4 will be displayed.

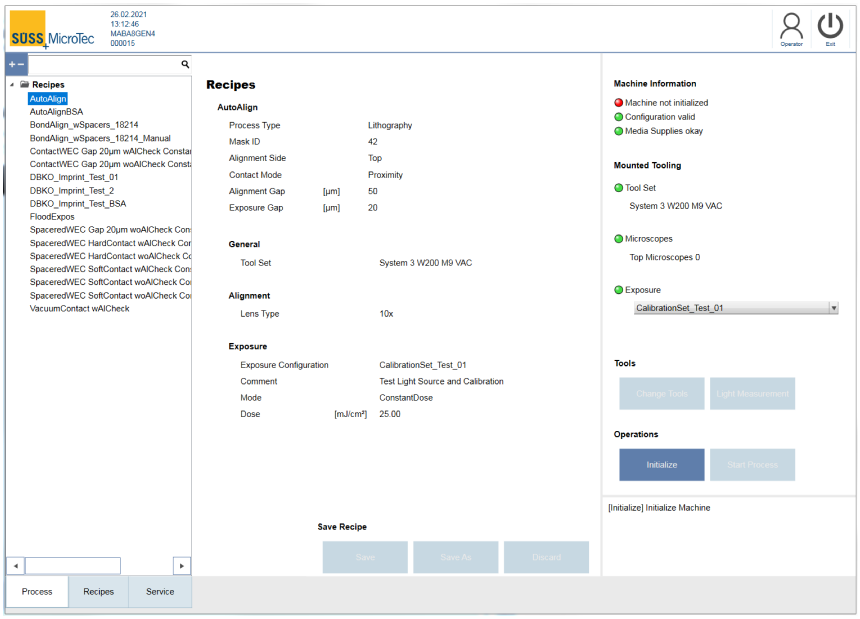


Fig. 4 - 1: User GUI MA/BA Gen4 - Before Initialization



4. Switch on the mains voltage for the power supply

- Turn the rocker switch for the UV Source at the front plate clockwise. The indicator light is on. The corresponding power supply becomes operable.

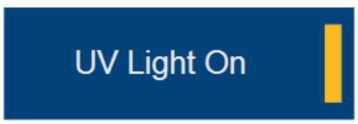
5. Initialize the machine
(*Chapter 4.2 “Initialization” on page 85*)

Working with a CPC350 Power Supply:



6. Start the lamp

- After initialization click the function key *[Light Measurement]* in the group *“Tools”*.
  The Navigation/ Dialog Frame opens.



- Click the function key *[Lamp On]*.
  The lamp is ignited with the CPC350.
  The "LED" of the function key is switched on.

NOTICE!

Before starting the process you have to wait until the lamp has reached its operating temperature.
(Details see individual lamp data sheet).

NOTICE!

If you try to start the process before you have switched on the lamp with *[Lamp On]*, the lamp will be switched on automatically when clicking the function key *[Start Process]*.
The process is stopped because the lamp has not yet reached its operating temperature and the above listed message is displayed.

Context: Lamp house lamp was turned on while preparing the process
Problem: The lamp needs to be warmed up after turning it on
Solution: Wait the necessary time (see service manual) for the lamp to be warmed up before continuing the process.

Fig. 4 - 2: Message - Lamp Warm Up

Working with a CIC1200 Gen2 Power Supply:



6. Start the lamp

- After switching on the "UV Source" at the machine the display of the CIC shows „STAND-BY“.

1. Press the button *[ON]*.
A confirmation window at the touch panel of the CIC1200 Gen2 prompts you to confirm the ignition of the lamp.

2. Click *[IGNITE]* to ignite the lamp.
The current state shows "WARM UP".

3. As soon as *“Act . Power”* and *“Set Power”* match, the current status shows: "LAMP ON"
The status bar shows: *“Lamp ready”*.

The lamp is now ready for operation.

A detailed description of the starting procedure and more details concerning operation can be found in the manual of the CIC1200 Gen2.

4.2 Initialization

After software start:

- The mask aligner is ready for initialization
- All available recipes are displayed.
- Each recipe can be checked, edited or deleted.
- New recipes can be created.



6. Initialize

After software start the function key *[Initialize]* is the only active key.

- Click the function key.
- Initialization of all sub-assemblies and components will start.

Initialization is only possible if the transport slide is loaded and clamped.
If this is not the case the user guidance prompts to do so.



- During initialization the user guidance shows:

  "Machine is initializing"
  "[Back] to cancel Initialization"

- With *[Back]* initialization can be stopped at any time.

4.3 Recipe Selection



7. Start Process

- After completed initialization the user guidance shows:

  „[Light Measurement] Start Light Measurement“
  „[Initialize] Initialize Machine“
  „Select Recipe and [Change Tools]“
  „Select Recipe and [Start Process]“

- Click the desired recipe in the recipe list to select it for the process.
- If you want to change tools (e.g. the mask or chuck) click the function key *[Change Tools]* to get access to the dialog frame *“Change Tools”*.
- Click the function key *[Start Process]* if your tools are already loaded.
- The process for the selected recipe is started.

The recipe in use cannot be modified during process. All other recipes can be edited, stored or deleted in the recipe view.

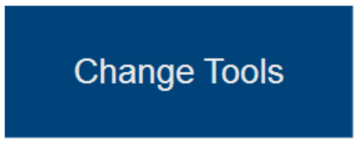
The process start with [Start Process] is only possible if:

► *Adapter frame, mask holder and mask are loaded correctly and the top side microscopes are swivelled in.*

If this is not the case the user guidance prompts to do so.

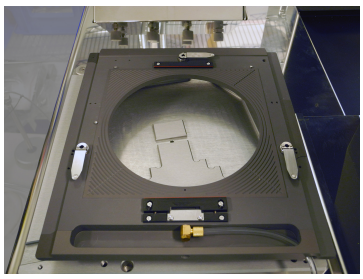
4.4 Load Mask and Mask Holder

- Load the correct tools (mask holder, chuck) for the process.
- Load substrate.

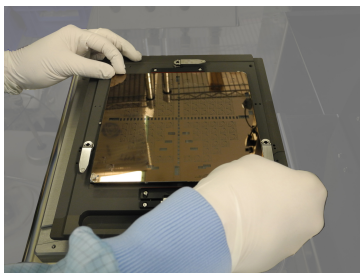


- Click the key *[Change Tools]* at the start screen to switch to the dialog frame for mask changing.

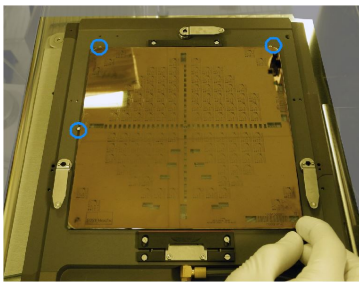
Bottom Loading Mask Holder



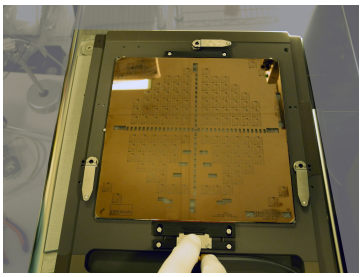
1. Put mask holder on parking station with vacuum plane up.



2. Load mask...



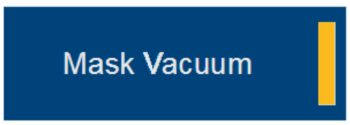
and push it against the three stop pins (blue circles).



3. Clamp the mask with the mechanical clamping.

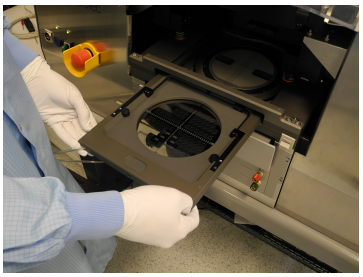


4. Plug in the connecting hose for mask vacuum into connector "Top Substrate Outer Vacuum".

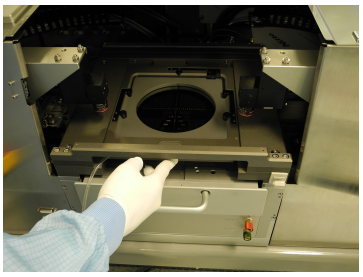


5. Click the key*[Mask Vacuum]* to switch on the mask vacuum.

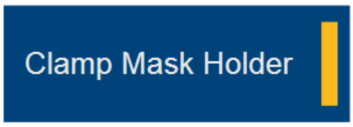
- The mask is now fixed on the mask holder.
- The LED „Mask Detected“ in the dialog frame „Change Tool Set“ is green.



6. Load mask holder into mask holder frame in the machine.



7. Be sure to load the mask holder all the way to the stop.



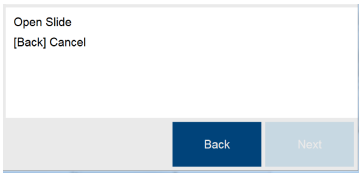
8. In dialog „Change Tool Set“ activate the clamping for the mask holder with the key *[Clamp Mask Holder]*.

- The mask holder is now fixed in the adapter frame.
- The LED „Mask Holder Detected“ in the dialog frame „Change Tool Set“ is green.



9. Click the key *[Next]* to leave the dialog frame and to return to the start screen.

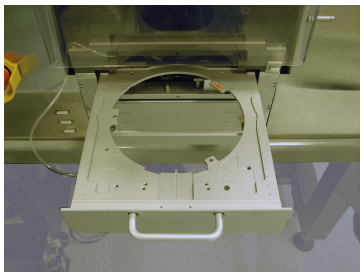
4.5 Load Chuck and Substrate



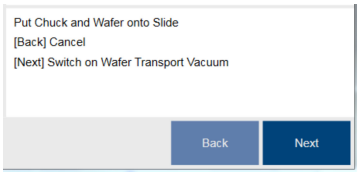
1. Open transport slide (pull forwards).

- After process start the user guidance shows:

  „Open Slide“
  „[Back] Cancel“



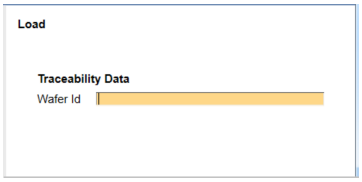
- Pull transport slide with handle forward.



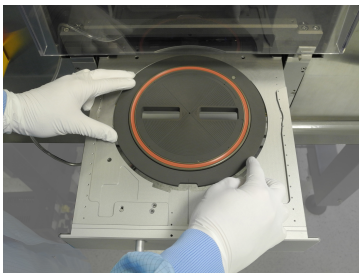
2. Load chuck and substrate onto the transport slide.

- The user guidance shows:

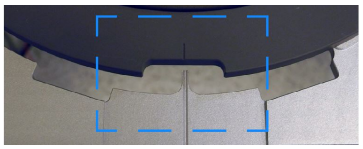
  „Put Chuck and Wafer onto Slide“
  „[Back] Cancel“
  „[Next] Switch on Wafer Transport Vacuum“



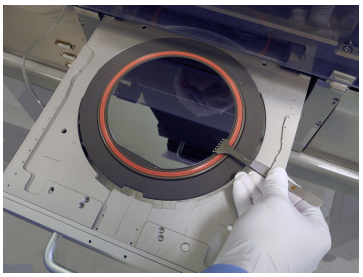
The dialog frame *“Load”* provides the option to enter a wafer-ID. This ID is stored in the wafer data and is logged with other process information. If no ID is available leave the input field empty.



- Load the chuck on the transport slide.



- Take care that the marking on the chuck is adjusted to the marking of the transport slide.

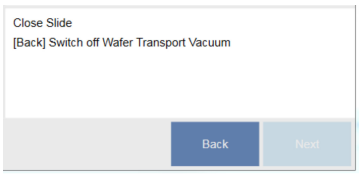


- Put the substrate onto the chuck.



- Click function key *[Next]*

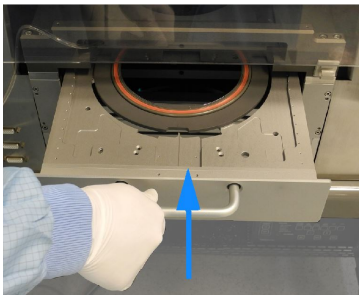
  The transport vacuum is switched on and the wafer is fixed on the chuck. (This prevents the wafer from shifting during transport)



3. Close transport slide (push backwards).

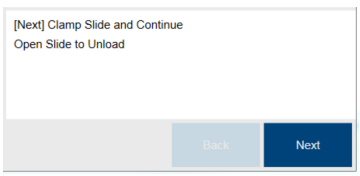
- The user guidance shows:

  „Close Slide“
  „[Back] Switch off Wafer Transport Vacuum“



- Push transport slide with handle backwards.

  Be sure to move the slide all the way back to the stop.



4. Clamp transport slide.

- The user guidance shows:

  „[Next] Clamp Slide and Continue“
  „Open Slide to Unload“



- Click function key *[Next]*

  Clamping of the transport slide is activated.

Once the transport slide is clamped, the z-axis will drive upwards, transfers the chuck with the wafer and wedge error compensation (WEC) will be performed.

The chuck with the substrate stop in alignment gap. The graphical user interface displays following screen:

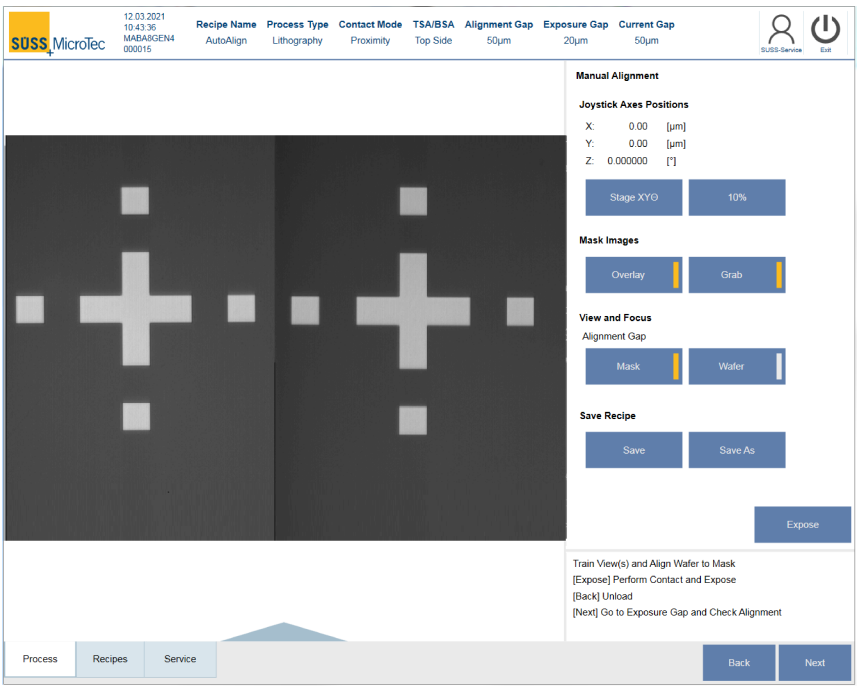


Fig. 4 - 3: Graphical User Interface - Manual Alignment View

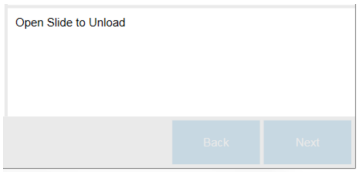
5 END OF PROCESS and POWER-OFF

5.1 Unload Chuck and Substrate

After Exposure:

- Unload substrate
- Unload process tooling (chuck, mask holder).

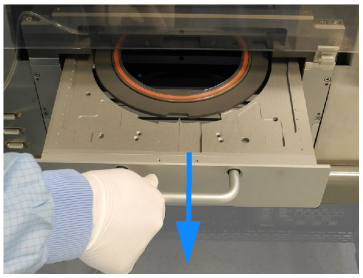
Once exposure is finished, the z-axis with chuck and substrate will move downward and the clamping of the transport slide will be released.



1. Open transport slide (pull forward).

- The user guidance shows:

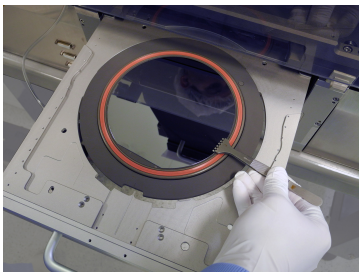
  „Open Slide to Unload“



- Pull transport slide at the handle forward.

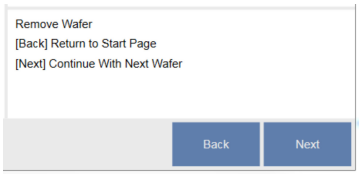
  Be sure to move the slide all the way out.

From this moment the active recipe is no longer blocked for process and can be edited freely.



2. Unload substrate.

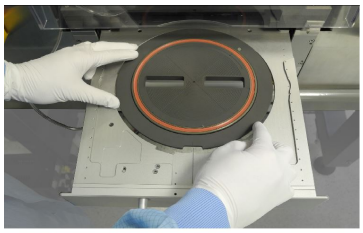
- Remove the substrate from the chuck using tweezers.

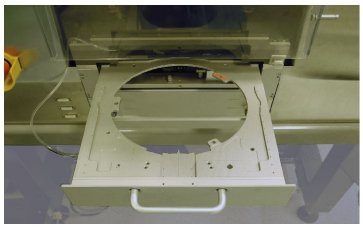




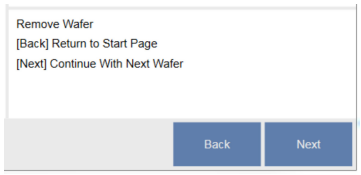
3a. Return to Start Page and Remove chuck.

- If a new process shall be started using a different wafer/ substrate size or a different contact process which needs a special chuck, the chuck can now exchanged.
- Click *[Back]* to return to start page and to terminate the current process.





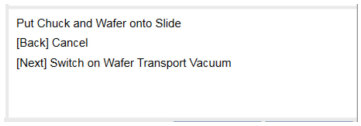
- Remove/ Exchange the chuck.
- Select a new recipe, load tools and start a new process,
- or unload the mask holder and mask, terminate the software and shut down the machine.





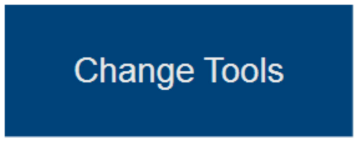
3b. Restart the loaded process and load a new substrate onto the chuck/ transport slide.

- If the next substrate shall be processed using the same process and chuck the process with the loaded recipe can be restarted.
- Click the key *[Next]*.
- The user guidance shows:



- **„Put Chuck and Wafer onto Slide“**
  „[Back] Cancel“
  „[Next] Switch on Wafer Transport Vacuum“

5.2 Unload Mask Holder and Mask



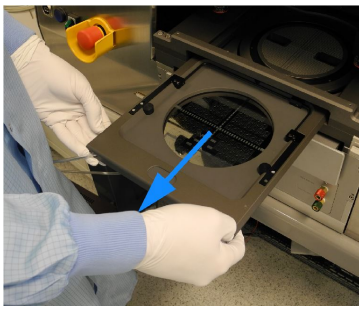
- Click the key *[Change Tools]* at the start screen to open the dialog frame for mask changing.

Bottom Loading Mask Holder

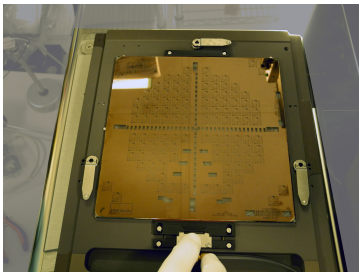


1. In Dialog „Change Tool Set“ release the clamping for the mask holder by clicking the key *[Clamp Mask Holder]*.

- The clamping for mask holder with mask in the adapter frame is now released.
- The LED „Mask Holder Detected“ in dialog frame „Change Tool Set“ turns to gray.



2. Pull mask holder carefully forward out of the mask holder frame.

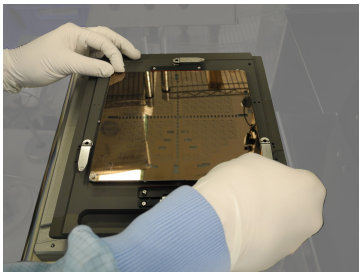


3. Put mask holder with bottom side up onto the park station. Open the mechanical clamping for the mask (pull it back).

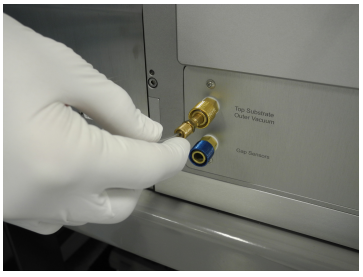


4. Click the function key *[Mask Vacuum]* to switch off the mask vacuum.

- The mask is now loosened on the mask holder.
- The LED „Mask Detected“ in dialog „Change Tool Set“ turns to gray.



5. Remove the mask carefully from the mask holder.



6. Remove the connecting hose for the mask vacuum from the machine.

- The mask holder can now be removed for save storage.

5.3 Switching Off

Before switching off the mask aligner:

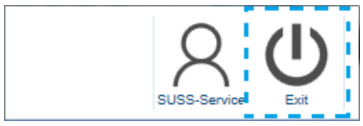
- Make sure that the program is in idle mode.
- Make sure that no substrate is in the machine.
- Make sure that the mask/ upper substrate has been unloaded.



1. Switch off the lamp at the CIC1200.

- Press the key *[OFF]*

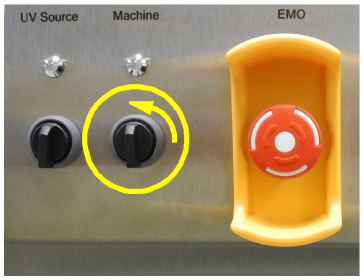
In the user manual of the CIC1200 Gen2 a detailed description of the switch-off sequence and more details for operation can be found.



2. Terminate the software

- In the title line of the GUI click the key in the right edge.
- The software will be terminated immediately.

3. Shut down the PC



4. Switch off the machine

- Turn rocker switch of the machine at the front plate counterclockwise.

The machine is switched off.



5. Switch off the UV light

- Turn rocker switch for the UV light at the front plate counterclockwise.
  - If operated with the power supply CPC350 the lamp is switched off automatically.
  - If operated with the power supply CIC1200 the power supply is switched off.



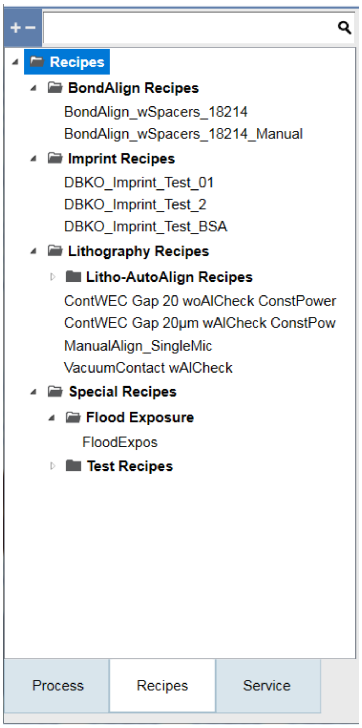
6. Switch off the main switch

- Turn main switch at the right side of the machine counterclockwise to „OFF“.

6 ADMINISTRATE and EDIT RECIPES

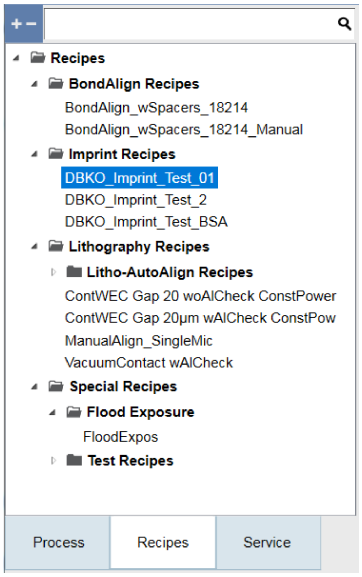
6.1 Load Recipe for Process

After Initialization:



- After initialization the list of all available recipes is displayed at the left side in process view.
- The list is displayed in alphabetic order.

Select a Recipe:



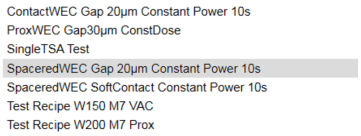
- Click a recipe from the list.
- The recipe is selected (with blue background of recipe name)
- In case you cannot find the recipe you can search for it, using the search field on top of the recipe list.

Start Process:



- Click the function key *[Start Process]*.
- The process for the substrate with the selected recipe will be started.
- Once the process will be finished and the substrate is unloaded a new process can be started.
- The last used recipe has a gray background and remains selected until a different recipe will be selected.

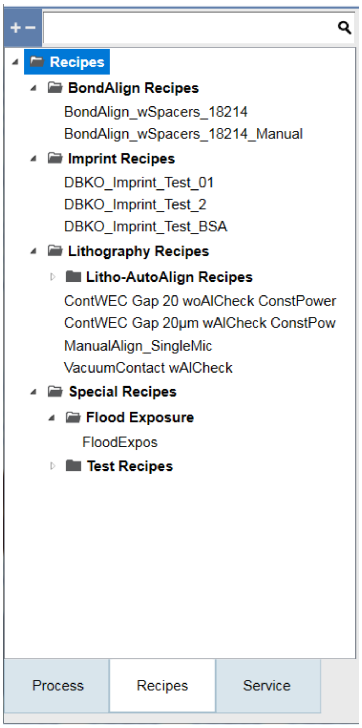
End of Process and Start of a New Process:



6.2 Edit Recipes

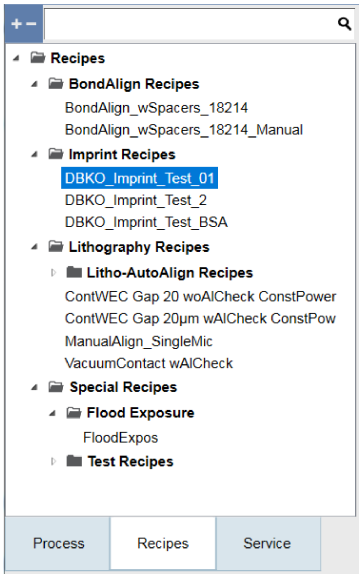
- Editing of a recipe is possible as soon as the software has been started and the process view is displayed.
- Editing of an active recipe is only possible if the process is not yet started or currently running.
- Recipes that are not active (running) are able to be edited in recipe view at any time.

After Software Start:



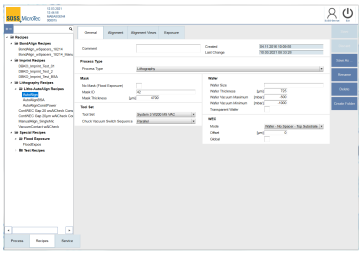
- At the left side of the screen all stored recipes are listed.
- The list is displayed in alphabetic order.

Select a Recipe:



- Click a recipe from the list.
- The recipe is selected (with blue background of recipe name)
- In case you cannot find the desired recipe, you can search for it using the search field on top of the recipe list.

Switch to Recipe View:



- Click the tab „Recipes“.
- Select an existing recipe.
- Adapt the parameters to your needs.

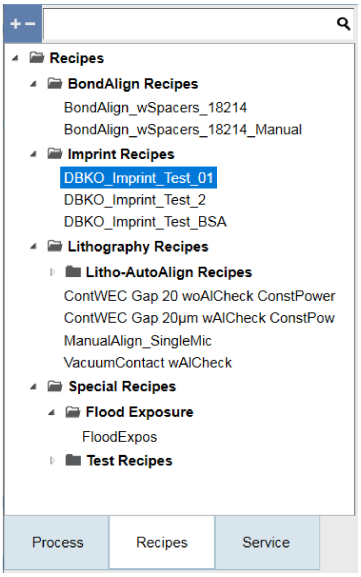


- Click the function key *[Save]*.

All changes are now saved to the selected recipe.

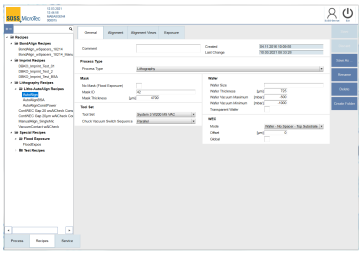
6.3 Create a New Recipe

After Initialization:



- After initialization the main screen of the graphical user interface displays the process view.
- At the left side of the screen all stored recipes are listed.
- The recipes can be organized in folders.
- On top of the list is search field for an alphabetical search of a recipe. The repices within a folder are displayed in alphabetic order.

Switch to Recipe View:

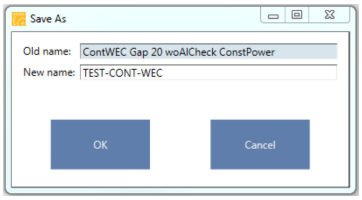


- Click the tab „Recipes“.
- Select a recipe from the recipe list.
- Adapt the parameters to your needs.



- Click the function key *[Save As...]*.

The "Save As..." Dialog Window pops up:



- Type the desired name for the new recipe in the free text field.
- Confirm with *[OK]*.
- The new recipe is now part of the recipe list can be selected for process.

6.4 Administrate Recipes

Recipes are created in the "Recipe View" which is accessible by clicking the tab *“Recipes”*.

Recipes can be organized in folders.

The folders are also created in the "Recipe View".

Folders are listed in alphabetical order and the recipes within the folders also.

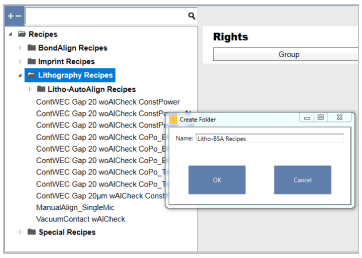
Recipes and folders can be moved by "Drag and Drop".

Create a new Recipe Folder:

- Click the tab *“Recipes”* and open the recipe view.
- Click the folder *“Recipes”* on top of the recipe list if you want to create a folder within this main folder...
- or click an already existing folder to create a folder within the selected folder.



- Click the function key *[Create Folder]*.



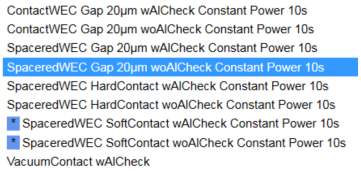
- Type in the desired folder name and confirm with *[OK]*.

6.5 Temporary Recipe Parameters

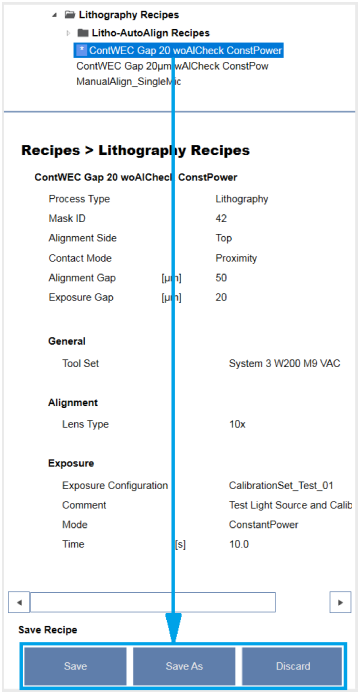
During a running process some parameters may be changed temporarily by the operator, e.g.:

- Microscope positions
- Focus positions
- Illumination parameters
- Camera parameters
- X-,Y-,Θ-positions of the alignment stage

Theses parameter changes are displayed continuously in the recipe editor but are only stored temporarily in RAM memory.



- Recipes with temporarily modified parameters are marked with a star (with blue background color).
- During machine operation several recipes can be handled without saving or discarding temporarily modified parameters immediately.



- If a recipe with temporarily modified parameters is selected (blue background color) but not currently used in a running process, the function keys for recipe saving will be active in the main window (see blue frame):
  - Click *[Save]* to overwrite the existing recipe.
  - Click *[Save As]* to save the changes by creating a new recipe.
  - Click *[Discard]*to discard the changes.

With *[Save]* or *[SAVE AS]* the data will be saved permanently. (This can be compared with text modifications in an editor e.g. WORD which are displayed immediately but only stored if saved to the file).

TIP!
If you loose orientation during process because of moving the axes or changing of camera parameters you can proceed as follows:

- Unload the wafer without exposure.
- Discard the temporary modified parameters with *[Discard]*.
- Re-load the wafer using the non-modified recipe.

Result: The axes will be at their original positions.

During switch-off of the software no reminder will ask for saving the temporary parameters.
All changes that have not been saved before will be discarded.

7 MANUAL ALIGNMENT

7.1 Manual Top Side Alignment (TSA)

Basic Configuration

- 2 microscopes with a choice of objectives with different magnifications and depth of focus ranges.
- Each microscope image is displayed on the screen with an individual digital camera.
- Possibility for image storage to overcome depth of focus problems.
- Possibility to check the alignment accuracy before exposure.

NOTICE!

On the mask there has to be an area without structures (clear field) around the alignment marks otherwise the alignment marks on the substrates are not visible.

Requirements:

- Select a recipe that is suitable for top side alignment:
  - The parameter **Alignment Mode** has to be „Manual“
  - The parameter **Alignment Illumination Primary** has to be „Top Coaxial“.

7.1.1 Focussing and Positioning of Microscopes to the Mask

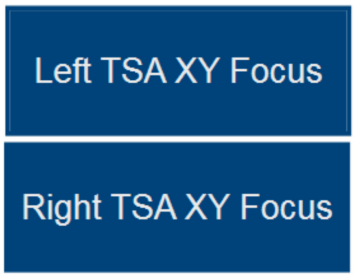


- The focus position *[Mask View]* is selected automatically after the wafer is loaded.
- If there are already stored microscope position values in the recipe the machine will move to these positions. That means that the microscopes are already pre-adjusted and only have to be fine adjusted.

Adjust X, Y and Focus with the Joystick:

- Select joystick mapping for one microscope with one-way toggle key for microscope movement:

  [Left TSA XY Focus] or *[Right TSA XY Focus]*

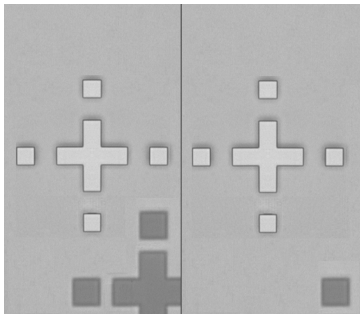


- Select desired speed.
- Move the microscope in X and Y until the alignment marks appear in the image field on the monitor.



- Adjust focus for the selected microscope. If necessary reduce speed.
- Adjust iteratively to the desired ideal microscope position.
- Select the joystick mapping for the other microscope and adjust as well.

Result of Adjustment:



- Finally both microscopes are adjusted so that the alignment marks of the mask are focussed and appear in the center of the image field.
- The current microscope positions will be stored in the recipe and the microscopes will move to these positions as soon as this recipe is selected.
- Depending on the selected alignment gap the wafer structures below are displayed more less in focus condition and can be aligned to the mask during the next step.

7.1.2 Aligning Substrate to Mask in Small Alignment Gap

If in the recipe an alignment gap is programmed which is smaller than the depth of focus range of the objectives, the alignment of the wafer structures to the mask can be performed in the next step.

- The microscopes can remain in [Mask View] distance.
- If necessary the focus can be adjusted to see both mask and wafer image in focus.

Align X, Y and Θ with Joystick:



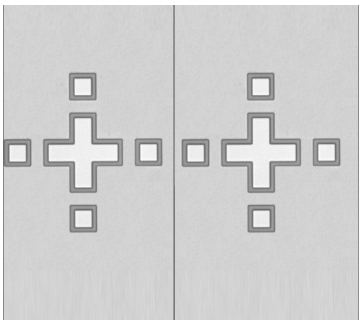
- Select joystick mapping for stage movement with one-way toggle key.

  [Stage XYΘ]



- Select desired speed.
- Move the stage until the alignment marks of the wafer are perfectly adjusted to the mask alignment marks.
- For fine alignment you may use *[Single Step]*.
  Each deflection of the joystick executes one single step in the corresponding direction.

Alignment Result:

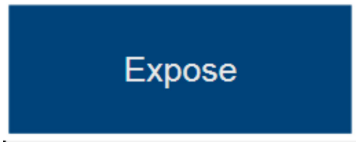


- Finally mask and wafer are perfectly aligned to each other.

Exposure:



- Once the alignment is sufficient, start exposure process with key *[Expose]*.



Alternatively:

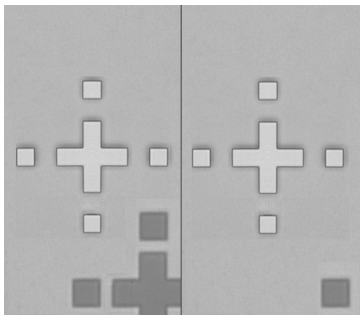
- If the check box „Do Alignment Check“ is ticked (check mark) in the recipe you can check the alignment accuracy in exposure gap before exposure.
  Click *[Next]* to go to „Alignment Check“. (see chapter 5.5 Alignment Checks (AL Check))
- In addition you have the possibility at this point to unload the wafer without exposure by clicking *[Back]*.

7.1.3 Aligning Substrate to Mask in Large Alignment Gap

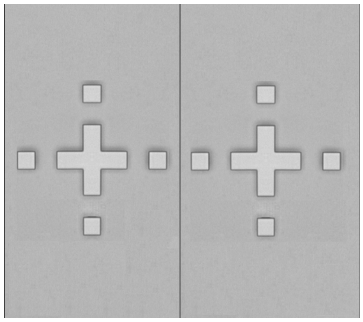
For various reasons it makes sense to protect mask and wafer using a large alignment gap (> 50 µm). in this case the depth of focus range of the objectives is not sufficient to display both wafer and mask structures focussed on the screen.

- To reach an optimum alignment result, the focussed mask images will be saved temporarily (grabbed) and displayed on the monitor. They will be overlaid the real wafer images.
- The real wafer alignment marks can be aligned to the grabbed mask alignment marks.
- The alignment accuracy can be checked with both mask and wafer in exposure gap (AL-Check).

Preparation for "Grabbing":



- After adjustment of the microscopes ↳ *Chapter 7.1.1 “Focussing and Positioning of Microscopes to the Mask” on page 101*the mask alignment marks are displayed well adjusted on the screen.



- For saving of the mask images it is recommended that no wafer structures are visible in the area of the mask alignment marks, to get a clear image of the marks when grabbing them.
  - Move the wafer in X, Y and Θ until no wafer structures will be visible (clear field position)
  - For this purpose choose *[Stage XYΘ]* at the one-way toggle key and move the wafer until you find a clear area.
  - If necessary readjust the focus of the microscopes.

"Grabbing" the Mask Images





- Precondition for „Grabbing“ is that the focus position of the microscopes is set to *[Mask View]*.
  Click the key *[Grab]*.
  - The mask images will be saved temporarily.
  - The key *[Overlay]* is selected automatically. The mask images remain visible on the screen.
  - At this point the microscopes can be a only moved for focussing but not in X, Y or Θ

7.2 Manual Top Side Alignment Single Microscope

Basic Configuration:

- 1 microscope with a choice of objectives with different magnifications and depth of focus ranges.
- The microscope image is displayed on the screen with an individual digital camera.
- Possibility for image storage to overcome depth of focus problems. • Possibility to check the alignment accuracy before exposure.

NOTICE!

On the mask there has to be an area without structures (clear field) around the alignment marks otherwise the alignment marks on the substrates are not visible.

Requirements:

- Select a recipe that is suitable for top side alignment:
  - The parameter Alignment Mode has to be „Manual“
  - The parameter Alignment Illumination Primary has to be „Top Coaxial“.
  - The recipe parameter „Single Side Microscope“ has to be selected. (check box in tab „Alignment“).

Preparation:

- After initialization the video image of the left microscope is displayed in process view.
- As soon as mask and wafer are loaded and the wafer has reached the alignment gap, the right microscope will be automatically moved into a parking position towards right front.

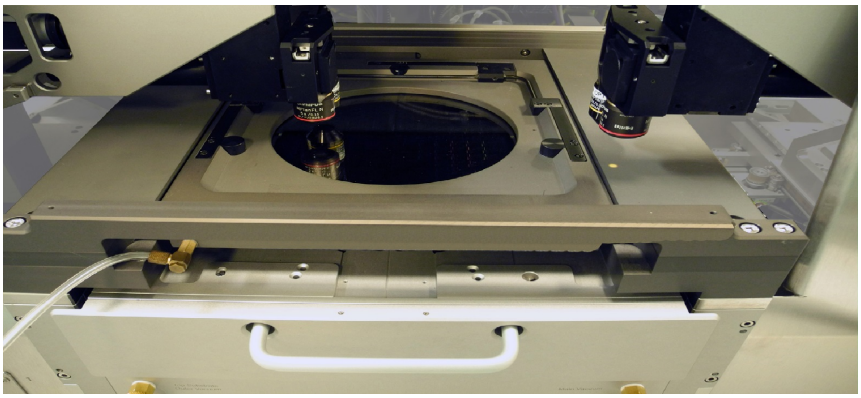
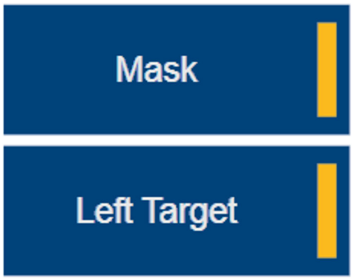


Fig. 7 - 1: Parking Position of Right Microscope



- The navigation window displays the operational elements for alignment.
  Additionally there are two On-/Off-keys *[Left Target]* and*[Right Target]*.

7.2.1 Position and Focus Microscope on Left Mask Target



- The focus position *[Mask View]* and the position *[Left Target]* are selected automatically after loading the wafer.
- If the there are already stored microscope position values in the recipe the machine will move to these positions. That means that the microscope is already pre-adjusted and only has to be fine-adjusted.

Adjust X, Y and focus with joystick:



- Select the joystick mapping with the one-way toggle key for microscope movement of the left microscope.

  Only *[Left TSA XY Focus]* is available.

- Select the desired speed.
- Move the microscope in X and Y until the desired alignment marks appear in the video image on the screen.
- Readjust focus. If necessary reduce speed.



7.2.2 Position and Focus Left Microscope on Right Mask Target

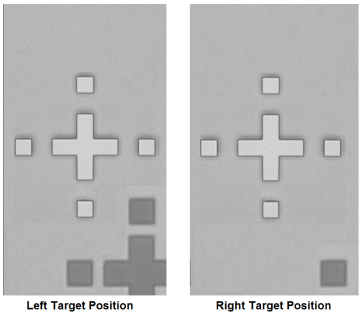


- Click the key *[Right Target]*.
- The microscope moves to the right target position.
- Adjust the microscope in X and Y until the desired alignment mark appears in the video image on the screen.



- Readjust focus. If necessary reduce speed.

Alignment Result:



- Finally both microscope positions are adjusted so that the alignment marks of the mask are focussed and appear in the center of the image field.
- The current microscope positions will be stored in the recipe and the microscope will move to these positions as soon as this recipe is selected.
- Depending on the selected alignment gap the wafer structures below are displayed more less in focus condition and can be aligned to the mask during the next step.

7.2.3 Aligning Substrate to Mask in Small Alignment Gap

If in the recipe an alignment gap is programmed which is smaller than the depth of focus range of the objective, the alignment of the wafer structures to the mask can be performed in the next step.

- The microscope can remain in [Mask View] distance.
- If necessary the focus can be adjusted to see both mask and wafer image in focus.



- Select *[Left Target]*. The microscope moves to the stored positions.

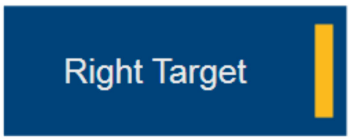
Align X, Y and Θ with joystick:



- Select joystick mapping for stage movement with one-way toggle key

  [Stage XYQ]

- Select desired speed.
- Move the stage in X- an Y-direction until the alignment marks of the wafer are perfectly adjusted to the mask alignment marks.



- Select *[Right Target]*. The microscope moves to the stored positions.
- Move the stage in X- an Y-direction until the alignment marks of the wafer are perfectly adjusted to the mask alignment marks.

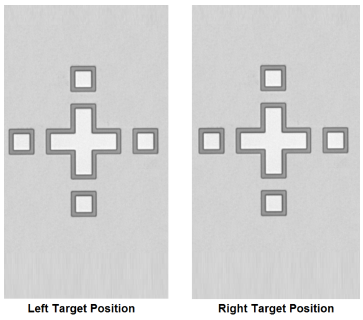


- The alignment of the rotational error (Θ) has to be performed by moving between left and right and aligning iteratively.



- For fine alignment you may use *[Single Step]*.
  Each deflection of the joystick executes one single step in the corresponding direction.

Alignment Result:



- Finally mask and wafer are perfectly aligned to each other.

Exposure:





- Once the alignment is sufficient, start exposure process with key *[Expose]*.

Alternatively:

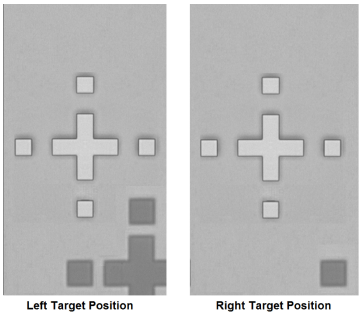
- If the check box „Do Alignment Check“ is ticked (check mark) in the recipe you can check the alignment accuracy in exposure gap before exposure.
  Click *[Next]* to go to „Alignment Check“. *Chapter 10 “ALIGNMENT CHECKS (AL Checks)” on page 158*
- In addition you have the possibility at this point to unload the wafer without exposure by clicking *[Back]*.

7.2.4 Aligning Substrate to Mask in Large Alignment Gap

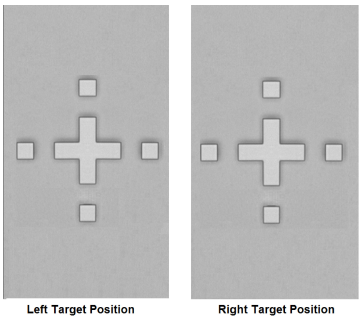
For various reasons it makes sense to protect mask and wafer using a large alignment gap (> 50 µm). in this case the depth of focus range of the objectives is not sufficient to display both wafer and mask structures focussed on the screen.

- To reach an optimum alignment result, the focussed mask images will be saved temporarily (grabbed) and displayed on the monitor. They will be overlaid the real wafer images.
- The real wafer alignment marks can be aligned to the grabbed mask alignment marks.
- The alignment accuracy can be checked with both mask and wafer in exposure gap (AL-Check).

Preparation for "Grabbing":



- After adjustment of the microscope positions for *[Left Target]* and *[Right Target]* (*Chapter 7.2.1 “Position and Focus Microscope on Left Mask Target” on page 106* and *Chapter 7.2.2 “Position and Focus Left Microscope on Right Mask Target” on page 106*) the mask alignment marks are displayed well adjusted on the screen.



- For saving of the mask images it is recommended that no wafer structures are visible in the area of the mask alignment marks, to get a clear image of the marks when grabbing them.
  - Move the wafer in X, Y and Θ until no wafer structures will be visible (clear field position)
  - For this purpose choose *[Stage XYQ]* at the one-way toggle key and move the wafer until you find a clear area.
  - If necessary readjust the focus of the microscopes.

"Grabbing" the mask image:

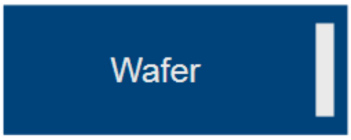
- Precondition for „Grabbing“ is that the focus position of the microscope is set to [Mask View].



- Click the key *[Grab]*.
  - The mask image will be saved temporarily.
    The key *[Overlay]* is selected automatically. The mask images remain visible on the screen.
  - At this point the microscope can be a only moved for focussing but not in X, Y or Θ.

Adjust wafer target in the image area:

- For a better overview the grabbed mask image can be hidden. For that purpose click the key *[Overlay]* to switch it off.

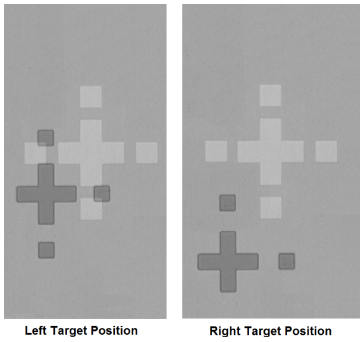


- Click the key *[Wafer View]* to switch to wafer view.

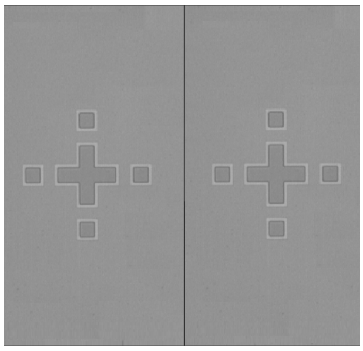


- Select [Stage XYQ] for mapping the joystick for stage movement.
- Select a high speed to move the wafer structures roughly into the field of view of the microscope.

Align wafer target to the grabbed mask target:

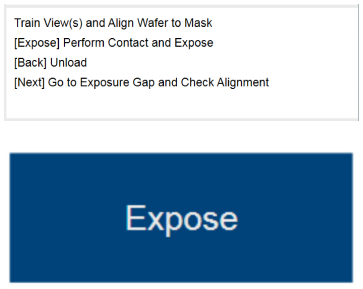


- Click the key *[Overlay]* to overlay the grabbed mask images.



- Select a slower speed for stage movement to fine align the wafer alignment marks in X, Y and Θ to the grabbed mask images.

Exposure:



- Once the alignment is sufficient, start exposure process with key *[Expose]*.

Alternatively:

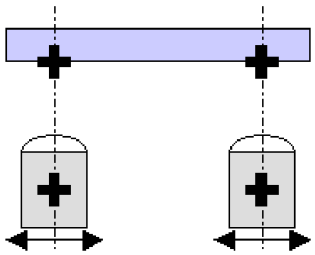
- If the check box „Do Alignment Check“ is ticked (check mark) in the recipe you can check the alignment accuracy in exposure gap before exposure.
  Click *[Next]* to go to „Alignment Check“. (*Chapter 10 “ALIGNMENT CHECKS (AL Checks)” on page 158*)
- In addition you have the possibility at this point to unload the wafer without exposure by clicking *[Back]*.

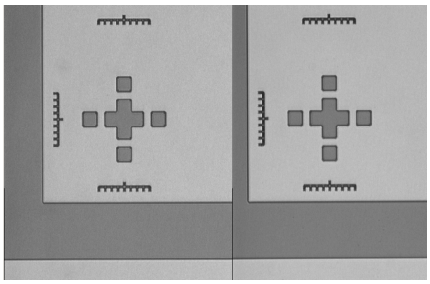
7.3 Manual Bottom Side Alignment (BSA)

7.3.1 Alignment Principle

This process enables alignment of patterns, located at the lower side of a substrate to mask patterns which shall be exposed onto the upper side of the substrate.

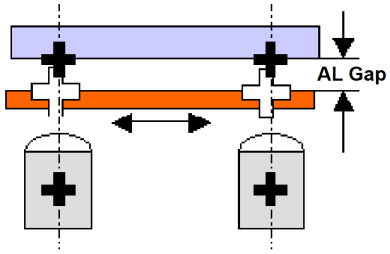
Saving the mask alignment targets

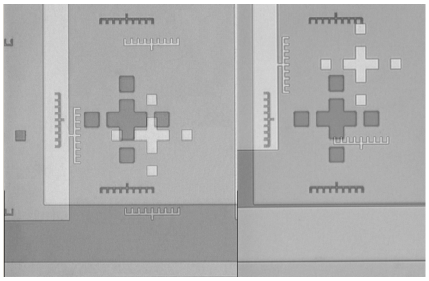




- ► Load mask.
- ► Adjust and focus BSA microscopes to the alignment targets.
- ► Save the images of the mask alignment targets.

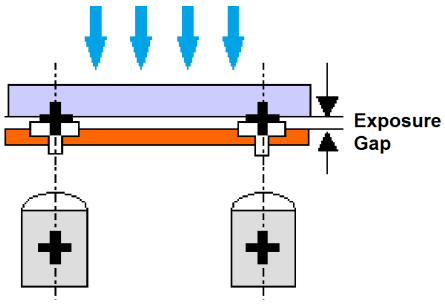
Position the wafer alignment targets in the field of view

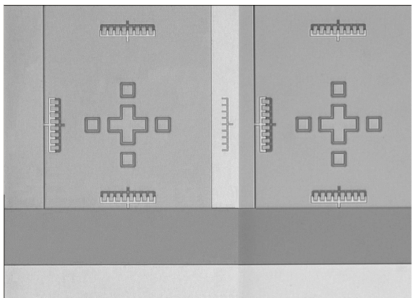




- ► Load Chuck and Wafer.
  The wafer patterns are on the lower side of the substrate.
- ► Move the wafer to position the alignment marks in the field of view.
- ► Overlay the images of the mask patterns

Align wafer to mask and expose





- ► Align the real-time wafer alignment marks to the stored mask alignment marks.
- ► Move the wafer into alignment gap and expose.

7.3.2 Equipment for BSA Process

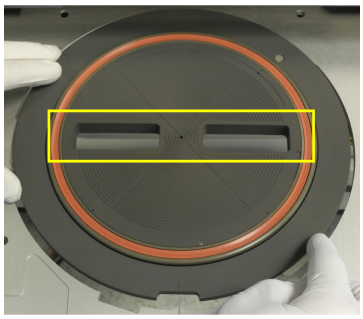


Fig. 7 - 2: BSA Chuck with Windows

- Chuck with „windows“ for view of microscopes

or

- Chuck with glass windows*

or

- Glass chuck*

* For chucks with glass windows and glass chucks a modified process sequence is valid which is described separately in *Chapter 7.3.7 “Process Sequence with Glass Chuck or Chuck with Glass Windows” on page 117*

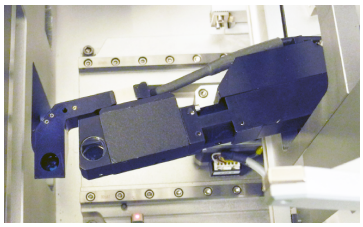


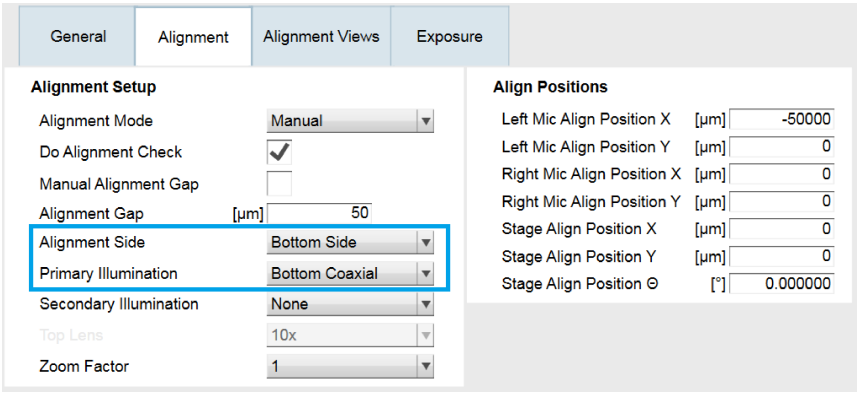
Fig. 7 - 3: BSA Microscope

- 2 BSA microscopes with fixed built-in objectives.
- Each microscope image is transferred onto the screen via digital camera.

Additional Requirements:

- Recipe, that is suitable for BSA alignment.
- Tool set, that is suitable for BSA alignment.
- Mask holder with mask is loaded (*Chapter 4.4 “Load Mask and Mask Holder” on page 86*)

7.3.3 Special Recipe Parameters for BSA Alignment



BSA Parameters:

- Alignment Side: **Bottom Side**
- Primary Illumination: **Bottom Coaxial**

Stage- and Microscope Positions:

The BSA microscopes have to be adjusted so that they can look through the chuck windows onto the mask patterns.

- Set the „Stage Align“ positions X, Y, Θ in the recipe to „0“. The chuck is at its center position.
- Set the microscopes centric to the BSA windows:
  - Measure the positions of the chuck windows and enter the positions into the „Align Positions“ of the microscopes.
  - Go to „Train Mask“ condition and position the microscopes with the joystick to the center of the chuck windows (only possible if the mask is rather transparent).

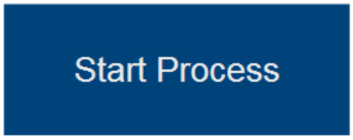
7.3.4 Train Mask Alignment Targets

This operation sequence is valid for the use with chucks with windows (no glass windows or glass chuck).

It is recommended for the first training of the mask to load the chuck with the transport slide to be sure that the mask alignment marks will be visible in the windows.
For all other wafers the transport slide with the chuck can remain in their outer position. This is time saving for the process.

Focus and Adjust Microscopes

After initialization the process view shows the video images of the microscopes.



- Once the mask is loaded and the recipe is selected the process can be started with *[Start Process]*.

Train Mask

- After process start the process navigation/ dialog frame shows: „**Train Mask**“.

  At this particular time the wafer is not yet loaded.

- If the there are already stored microscope position values in the recipe the machine will move to these positions. That means that the microscopes are already pre-adjusted and only have to be fine adjusted.

Adjust Focus with Joystick X,Y:

- Select joystick mapping with the one-way toggle key for microscope movement of one microscope.



► *[Left BSA XY Focus]* or

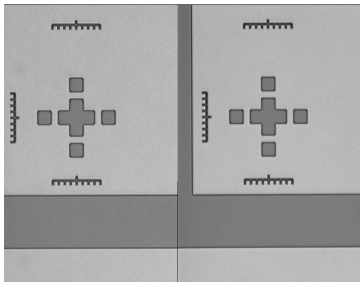


► *[Right BSA XY Focus]*



- Select the desired speed.
- Move the selected microscope in X and Y until the desired alignment targets will appear in the image view on the monitor.
- Adjust focus of the selected microscope. If necessary reduce the speed.
- Adjust iteratively until the desired, ideal microscope position is found.
- Then select the joystick mapping for the other microscope and repeat the adjustment procedure for this microscope.

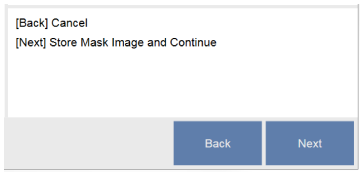
Adjustment Result:



- Finally both microscopes are adjusted, the alignment targets are positioned centric and focussed in the corresponding image field.
- The current microscope positions are stored temporarily and the microscopes will be moved toward these positions as long as the process of the current recipe will be used.

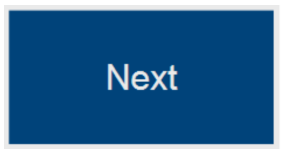
If the positions shall be stored permanently in the recipe or if a new recipe with these position shall be created, this can be done with the function keys [Save] or [Save as] respectively.

Save Mask Images



- The user guidance shows:

„[Next] to Store Mask Image“
„[Back] Cancel“



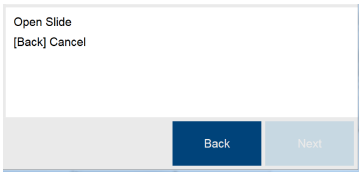
- Click the function key *[Next]*.
  The mask images will be grabbed and saved.

Result:

- The images of the mask alignment targets are grabbed and saved and can be superimposed the real wafer images.

7.3.5 Load Chuck and Substrate

Once the mask images are saved the process navigation /dialog frame displays „Load“.



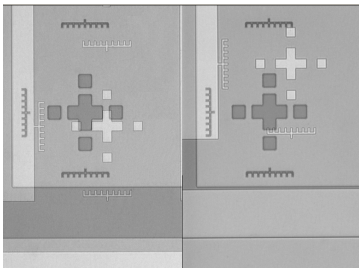
- The user guidance shows:

„Open Slide“
„[Back] Cancel“

Chuck and substrate can be loaded. The detailed description for loading can be found in ↳ *Chapter 4.5 “Load Chuck and Substrate” on page 88*

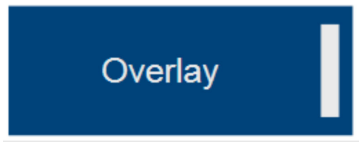
7.3.6 Align Substrate to Mask

NOTICE!
After training and saving of the mask images the BSA microscopes cannot be moved in X and Y.

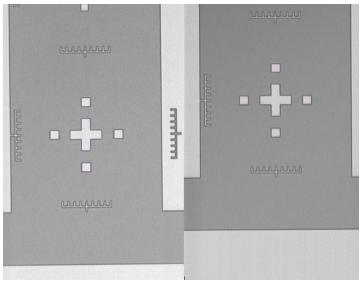


- The process navigation/ dialog frame shows „**Manual Alignment**“.
- As soon as the wafer has reached the alignment gap, the screen displays the patterns of the lower side of the wafer.
- The trained mask images are superimposed.

For a better overview for the coarse positioning of the wafer and for adjustment of the focus position of the wafer alignment marks the „Overlay“ function can be switched off.



- Click the function key *[Overlay]*. The LED will be switched off.



- Only the wafer patterns are now visible on the screen.

Adjust Focus Positionsof the Wafer:

- Adjust the focus positions for the left and right BSA microscopes for the wafer patterns..



► *[Left BSA Focus]* or



► *[Right BSA Focus]*

- Select the joystick mapping for the desired microscope with the one-way toggle key.
- Select the desired speed.
- Adjust focus, switch to the other microscope and adjust accordingly.

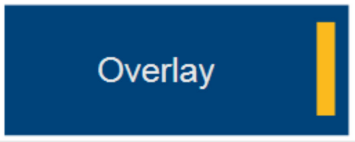
Pre-align the wafer coarsely in X,Y and θ with the joystick:

- Select the joystick mapping for stage movement with the one-way toggle key:



► *[Stage XYθ]*

- Select desired speed.
- Move the stage until the alignment marks of the wafer are about centric in the corresponding image field.



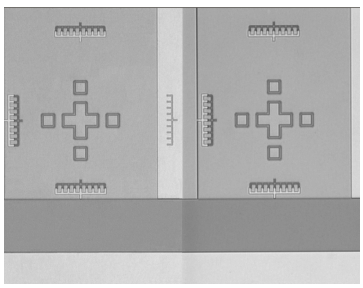
- Switch on *[Overlay]*.
- The images of the mask alignment marks will be overlaid the wafer alignment marks.
- Adjust the wafer to the mask with the joystick (mapping „Stage XYθ“).



- For fine alignment you may use *[Single Step]*.
  Each deflection of the joystick executes one single step in the corresponding direction.
- The current microscope positions are stored temporarily and the microscopes will be moved toward these positions as long as the process of the current recipe will be used.

If the positions shall be stored permanently in the recipe or if a new recipe with these position shall be created, this can be done with the function keys [Save] or [Save as] respectively.

Alignment Result:



- Finally the grabbed and saved mask alignment marks are perfectly aligned to the wafer alignment marks (at the lower side of the wafer).

Exposure:



- Once the alignment result is sufficient start the exposure process with *[Expose]*.

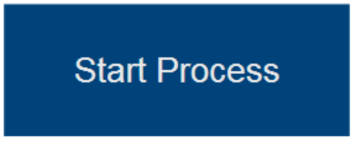
Alternatively:

- If the check box „Do Alignment Check“ in the recipe is checked the alignment accuracy can be checked before start of exposure by clicking the key *[Next]*.
  (See ↳ *Chapter 10 “ALIGNMENT CHECKS (AL Checks)” on page 158*
- In addition the wafer can be unloaded without exposure by clicking *[Back]*.

7.3.7 Process Sequence with Glass Chuck or Chuck with Glass Windows

- If using glass chucks or chucks with glass windows the chuck has to loaded BEFORE alignment and grabbing of the mask alignment marks to take into account the changed focus positions caused by the glass inserts.
- The use of glass chuck/ chuck with glass windows has to be configured in the tool set. This guarantees that the process sequence will be adapted to this equipment.

Focussing and Positioning of Microscopes to the Mask

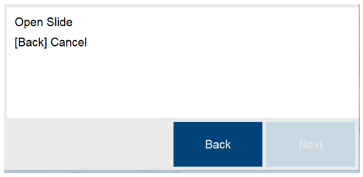


- After initialization the process view displays the video images of the microscopes.
- Once the mask is loaded and the recipe is selected the process can be started with the key *[Start Process]*.

Ready to Load Chuck

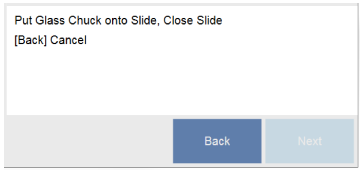
- After process start the process navigation/ dialog frame shows: „Ready to Load Chuck“.

  At this particular time the wafer is not yet loaded.
- If there are already stored microscope position values in the recipe the machine will move to these positions. That means that the microscopes are already pre-adjusted and only have to be fine adjusted.



- The user guidance shows:

„Open Slide“
„[Back] Cancel“



- Once the transport slide is pulled out the user guidance shows:

„Put Glass Chuck onto Slide. Close Slide“
„[Back] Cancel“

- Load the glass chuck/ chuck with glass windows and push back the transport slide with the chuck.

Chuck on Slide

- The process navigation/ dialog frame shows „**Chuck on Slide**“



- The user guidance shows:

„[Next] Move Chuck into Grab Position“
„[Back] Cancel“



- Click the function key *[Next]*.

- The z-axis moves the chuck from its position on the transport slide upward to a transfer position.

Train Mask

- The process navigation/ dialog frame shows „**Train Mask**“

From now on the sequence is identical to that for chucks without glass windows.

Chapter 7.3.4 “Train Mask Alignment Targets” on page 113

7.4 Manual Infrared Alignment

The alignment with infrared light (IR-light) enables the processing of non-transparent but IR-permeable materials like GaAs, InP, Silicon or adhesives which are used for processing of thin wafers or for applications with encapsulated structures.

- For alignment of backside or hidden structures.
- Preferably used with transmitted light application:
  - BSA-microscope + TSA-IR-illumination
  - TSA-microscope + BSA-IR-illumination
- For both procedures special infrared light sources are necessary.
- The optimum adjustment of light source to microscope is factory-made.

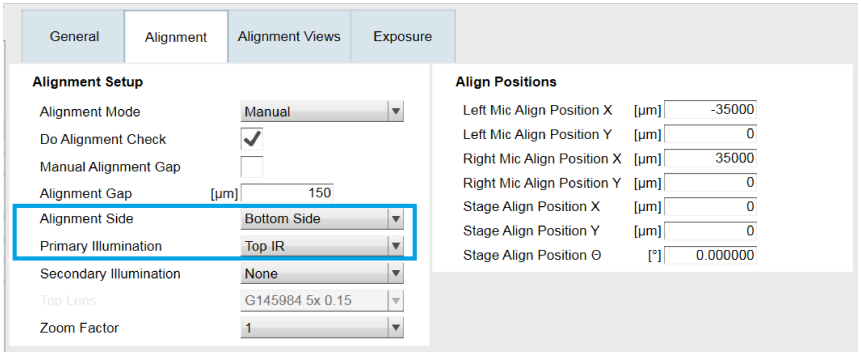
Requirements for high image quality:

- Double sided polished wafer
- Metalized targets
- No metal layers covered over the whole wafer

7.4.1 Select Recipe Parameters

Parameters for IR-BSA-Alignment:

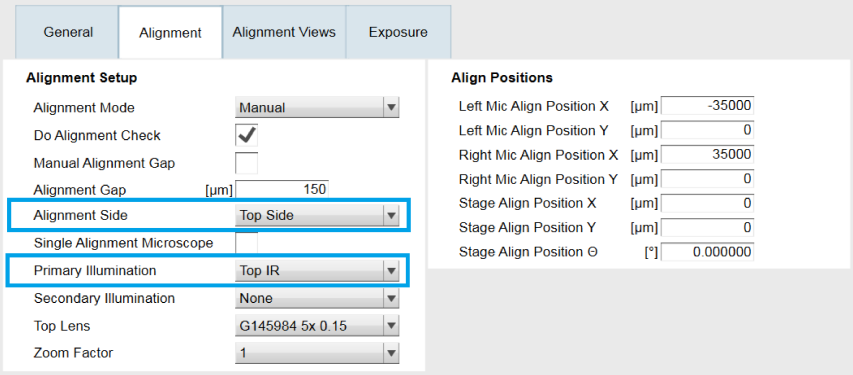
- Select tab "Recipes".
- Select tab "Alignment"



- Select Alignment Side "Bottom Side" from drop down menu.
- Select Primary Illumination "Top IR" from drop down menu.

Parameters for IR-TSA-Alignment:

- Select tab "Recipes".
- Select tab "Alignment"



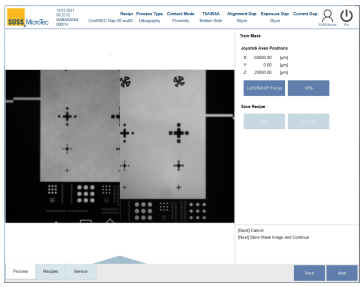
- Select Alignment Side "Top Side" from drop down menu.
- Select Primary Illumination "Top IR" from drop down menu.

IR illuminations are optional and not included in the standard machine equipment.
They must be ordered separately.

7.4.2 Sequence for IR-Bottom Side Alignment

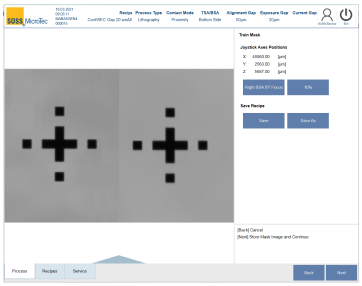
For detailed description of Bottom Side Alignment sequence see Chapter 7.3 “Manual Bottom Side Alignment (BSA)” on page 111

Load mask and adjust microscopes:



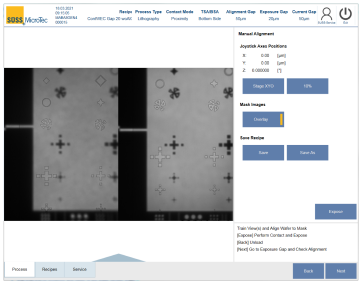
- Adjust position and focus for left and right microscope.
- Adjust left and right mask target so that they appear in the center of the field of view.

"Grab" (store) mask images and save parameters:



- If necessary increase zoom factor.
- Fine adjust all mask positions and views.
- Click either *[Save]* to save all parameters in the current recipe or click *[Save As]* to create a new recipe.
- Click *[Next]* to "grab" the mask images.

Load wafer and pre-align:



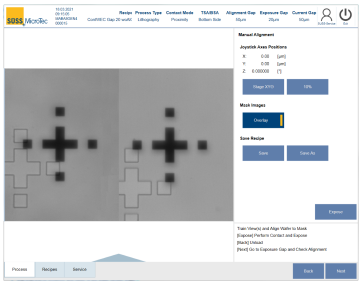
- Adjust positions and views of the wafer targets.
  The microscopes cannot be moved in X and Y direction but only in Z to adjust the focus.
- Adjust the wafer so that the wafer targets are well positioned in the center of the field of view.
- If necessary switch off *[Overlay]* for a better overview.

Adjust and train wafer view:

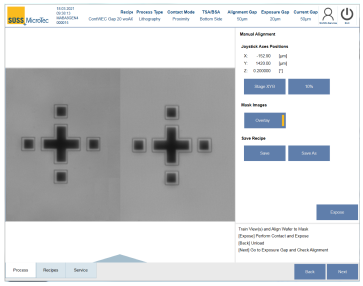


- Increase zoom factor and fine adjust wafer target position and focus.

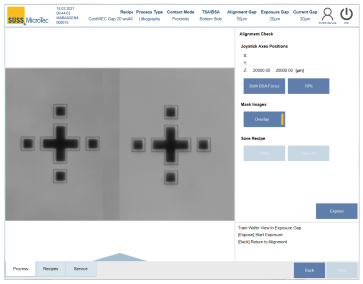
Overlay grabbed mask images and align wafer to mask:



- Click the key *[Overlay]* to see the grabbed mask targets in the field of view.
- Align the real time wafer targets to the grabbed mask targets.



Check alignment in exposure gap:



- Click *[Next]* to move the wafer into exposure gap.
- If necessary re-adjust the focus of the wafer targets.
- Check alignment accuracy.
- If necessary return to alignment gap with *[Back]* and improve alignment.

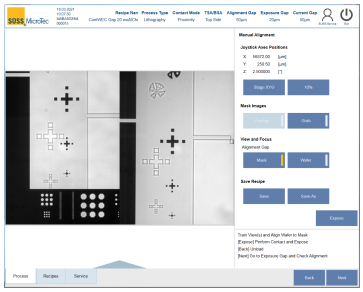
Expose:

- Finally click the function key *[Expose]* to start exposure.

7.4.3 Sequence for IR-Top Side Alignment

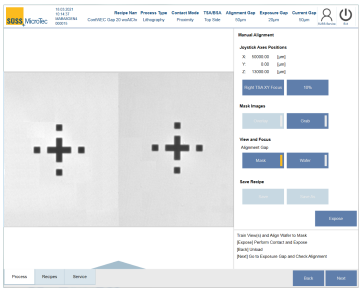
For detailed description of Top Side Alignment sequence see ↬ Chapter 7.1 “Manual Top Side Alignment (TSA)” on page 101

Load mask and wafer:



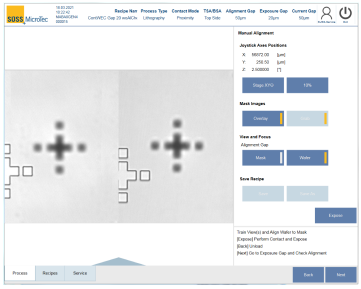
- Load mask and start process.
- Load wafer. The process stops with wafer in alignment gap.
- Adjust microscopes so that the mask targets appear in the field of view.
- If necessary pre-adjust wafer so that the wafer targets appear in the field of view.

Adjust microscopes and "grab" mask targets:



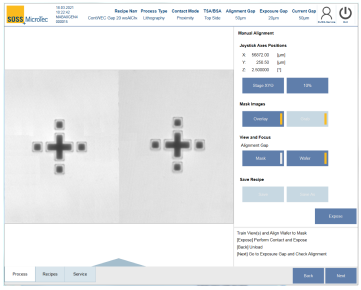
- Select *[Mask View]*.
- Train mask view: microscope positions in X/Y/Θ and focus positions.
- "Grab mask targets.

Train wafer view and save parameters:



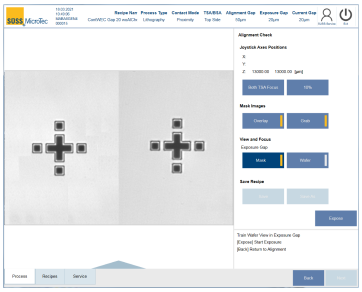
- Select *[Wafer View]*.
  If necessary switch off *[Overlay]* to adjust wafer view without disturbing mask targets.
- Train wafer view: stage positions in X/Y/Θ and microscope focus positions.
- Save parameters.

Overlay grabbed mask images and align wafer:



- Switch to *[Overlay]*
- Align real time wafer targets to grabbed mask targets.

Check alignment in exposure gap:



- Click *[Next]* to move the wafer into exposure gap.
- If necessary re-adjust the focus of the wafer targets.
- Check alignment accuracy.
- If necessary return to alignment gap with *[Back]* and improve alignment.

Expose:

- Finally click the function key *[Expose]* to start exposure.

8 AUTOMATIC ALIGNMENT

Software Licence necessary!

To get access to the alignment mode "Automatic Alignment" a software licence is necessary that has to be ordered separately.

NOTICE!

Automatic Alignment is a very complex method!

Only trained personnel should work with this mode. It is strongly recommended to take a training before working with the auto alignment process.

- The auto alignment process provides automatic positioning of substrate-to-mask without operator assistance.
- An image processing system combined with the high precision mechanics of the mask aligner allow reliable recognition of mask and substrate pattern and positioning of substrate-to-mask.

8.1 Automatic Top Side Alignment Training (AL-TSA)

Basic Configuration:

- 2 microscopes
- Each microscope image is displayed on the screen with an individual digital camera.
- Possibility for image storage to overcome depth of focus problems.
- Possibility to check the alignment accuracy before exposure.

NOTICE!

On the mask there has to be an area without structures (clear field) around the alignment targets otherwise the alignment targets on the substrates are not visible.

Recipe Requirements:

Select a recipe that is suitable for top side alignment:

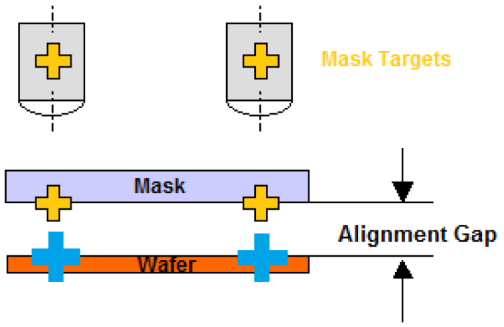
- The parameter **Alignment Mode** has to be „Auto“
- The parameter **Do Target Training** has to be selected.
- The parameter **Do Alignment Check** has to be selected.
- The parameter **Alignment Illumination Primary** has to be „Top Coaxial“.

All parameters are located in the ***“Alignment”*** tab both for the "Lithography" process type and for "Process Table" process type.

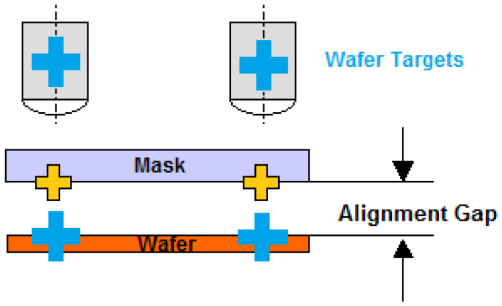
8.1.1 Alignment Training Principle

Train positions and views of mask and wafer:

Train Mask View

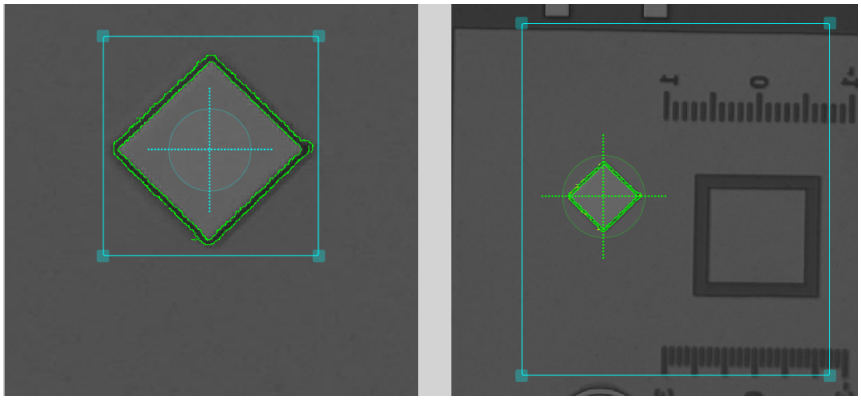


Train Wafer View



- ► Load mask and start process.
- ► Load wafer the process stops with wafer in alignment gap.
- ► The process stops displaying the step " Train Positions and View(s)"
- ► Train positions and views for the mask and wafer for left and right microscope.

Train target models and search regions for mask and wafer:



- ► Choose Tab „Targets“ and train target models and search region for each left/right mask target.
- ► Test each target for uniqueness and stability.
- ► Save all trained target model parameters in the recipe.

Test Auto Alignment:

- ► „Do Alignment Check“ has to be kept selected.
- ► Observe the auto alignment process over a longer period to verify stability and accuracy.

Run the process automatically:

► Switch off „Do Alignment Check“ and run the whole process automatically.

8.1.2 Training of Positions and Views

Preconditions:

- Used recipe has parameter Alignment Mode: „Auto“
  - The parameter **Do Target Training** is selected.
  - The parameter **Do Alignment Check** is selected.
- Mask is loaded.
- Substrate is loaded and is in alignment gap.

Starting Position:

- Once mask and wafer are loaded and the wafer is in alignment gap the process navigation displays the operational elements for training of positions and views.

Focussing and Positioning of Microscopes

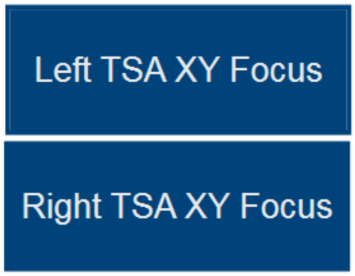


- The focus position [Mask View] is selected automatically after the wafer is loaded.

NOTICE!
The microscopes will move to positions which are pre-defined in the recipe. If there is a risk of collision or if the positions are out of range calculated default positions will be approached.

- If there are already adjusted and stored microscope position values in the recipe the machine will move to these positions. That means that the microscopes are already pre-adjusted and only have to be fine-adjusted.

Adjust X,Y and Focus with the Joystick:



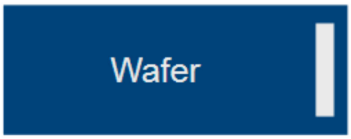
- Select joystick mapping for one microscope with one-way toggle key for microscope movement.

  [Left TSA XY Focus] or *[Right TSA XY Focus]*

- Select desired speed.
- Move the microscope in X and Y until the desired image frame appears in the field on the monitor with the desired alignment targets adjusted roughly in the center.
- Adjust focus for the selected microscope. If necessary reduce speed.

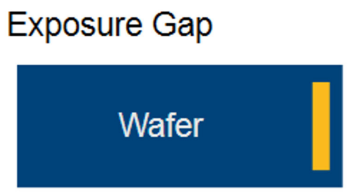


- Adjust iteratively to the desired ideal microscope position.
- Select the joystick mapping for the other microscope and adjust as well.



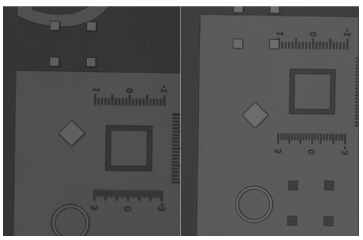
- Select *[Wafer View]* and adjust focus for left and right microscope.
- If necessary adjust the wafer position to see the desired targets in the image field of each microscope.

Option Direct Align (DA) and DA-Centered Focus:



- If in the recipe the check box *"Direct Align"* is selected, an additional function key is available in the navigation/ dialog frame *"Train Positions and Views."*
- Select the function key *[Wafer]* in view *"Exposure Gap "*to train the focus position for "Direct Align" for left and right microscope.
- The wafer is moved into exposure gap.
  - If only the check box *"Direct Align"* is selected, adjust the focus so that the wafer targets in alignment gap are focussed.
  - If additionally the check box *"Centered Focus"* is checked, adjust the focus position so that both mask and wafer targets are within the depth of focus of the microscope.

Result of Adjustment:



- Finally both microscopes are adjusted so
  - that the alignment targets of the mask are focussed and appear approximately in the center of the image field of each micro-scope.
  - that the alignment targets of the wafer are focussed (in wafer view) and visible in the image field of the microscopes.
- The current microscope positions will be stored in the recipe and the microscopes will move to these positions as soon as this recipe is selected.
- Depending on the selected alignment gap the wafer structures below the mask are displayed more or less in focus condition even in mask view.

Save all Positions and Views:

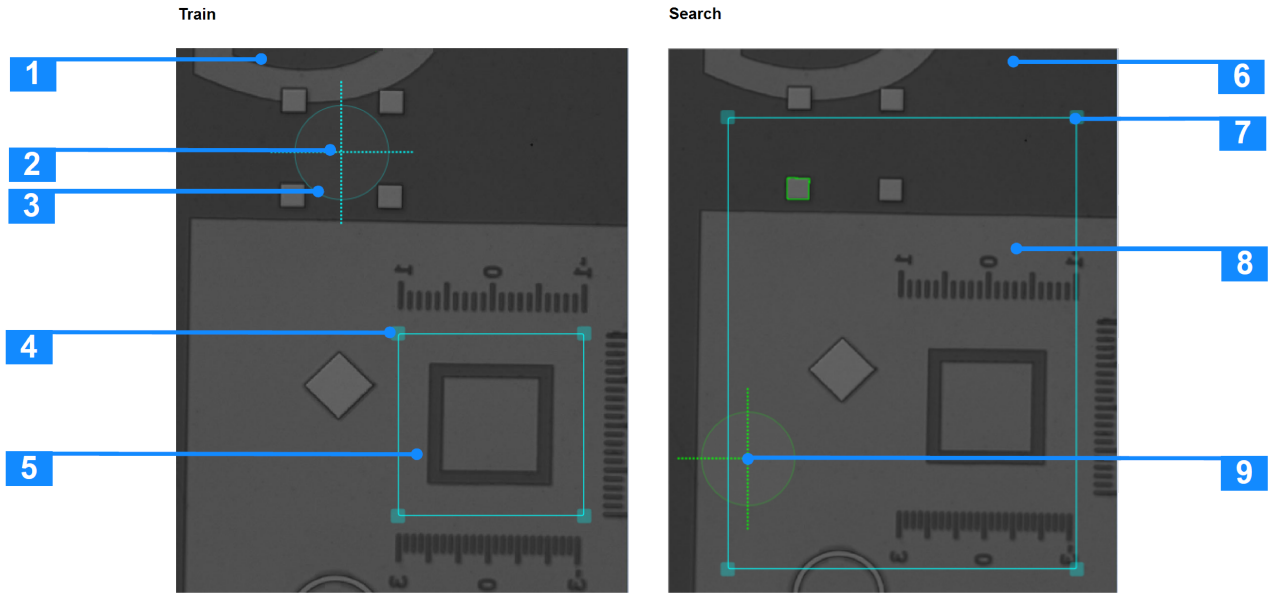




- Save all adjusted positions and views either in the current recipe with *[Save]* or create a new recipe with *[Save As]*.

8.1.3 Training of Target Model and Search Region

Display and Control Elements



1	Train Image	6	Search Image
2	Origin (Cross)	7	Handles/Bounding Box-Train Region
3	Origin Active Area (Circle)	8	Search Region
4	Handles/Bounding Box-Search Region	9	Origin (automatically detected)
5	Train Region		

Training of Target Model

Open Target Training View:

- Click the Tab [Targets] to get access to the „Train Targets View“

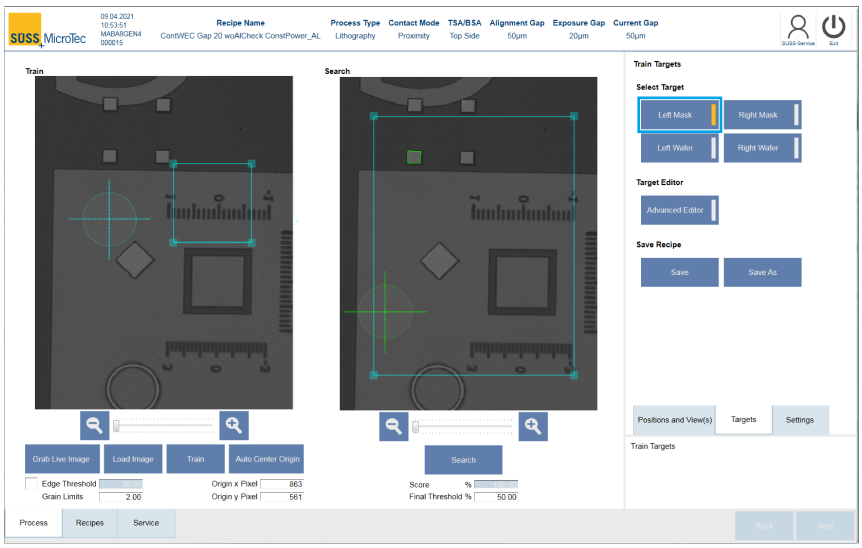


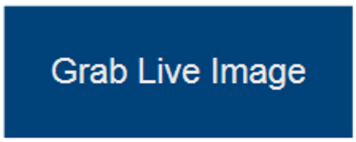
Fig. 8 - 1: Train Targets View

Select the first Target View:



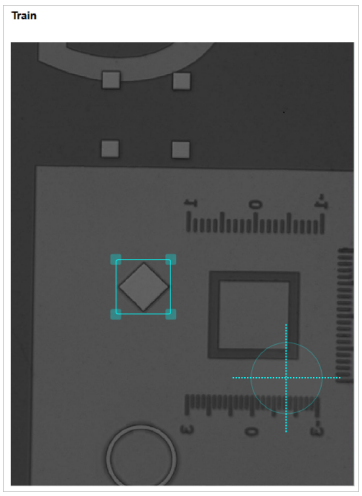
- Click the function key *[Left Mask]* .
- The Target and Search screen displays the last stored images of the left mask view.
- If no target has been trained yet, the train screen displays "Untrained".

Grab Live Image:



- Click the function key *[Grab Live Image]*.
- The real image of the left microscope in mask focus position will be stored as train image and displayed.

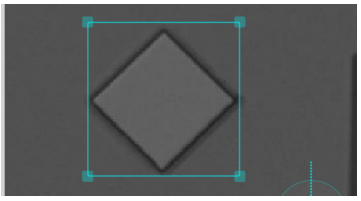
Adjust the Bounding Box for the Train Region:



- Pull the handles (little squares) at the edges of the bounding box for the train region and move the box so that the desired alignment target is positioned within train region.
- The box should surround the target closely with some space.



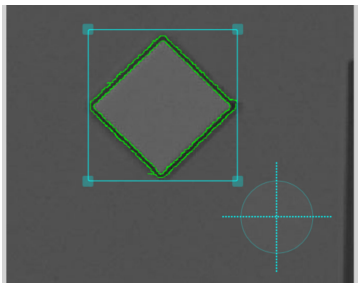
- For better adjustment increase the magnification using the slider.



Train the Target Model:



- Click the function key *[Train]* to train the target model.



- A graphical feed back ("model") will be given after training.

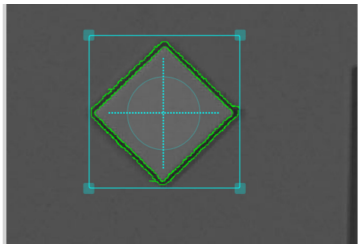
Do the initial training without selecting the parameter „Edge Threshold“. In this case the software itself determines the optimum value for this parameter.

Information about the quality of the target training and how to improve it can be found in chapter *Chapter 8.6 “Tips to Create a Good Target Model” on page 150*

Set the Origin:



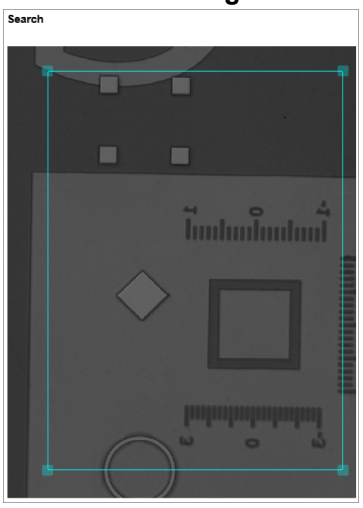
- Click the function key *[Auto Center Origin]*. The software calculates the origin of the trained target model.



- Auto Center Origin is the most accurate method to define the origin of the model. This increases the alignment accuracy.
- Auto Center Origin is only possible for symmetric targets
- If the target is not symmetric you have to adjust the origin cross:
  - by drag and drop (clicking and holding the left mouse pressed in the active area of the origin.
  - by editing the origin position in the fields „Origin X Pixels“ and „Origin Y Pixels“.

Training of Search Region

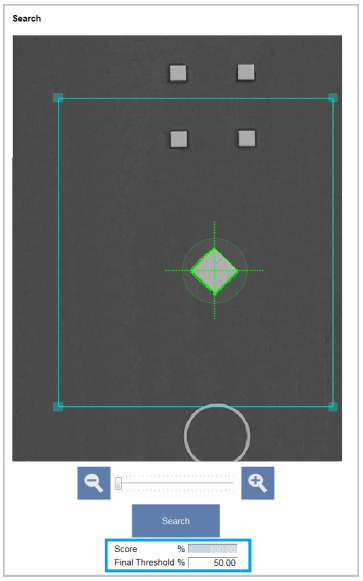
Adjust the bounding box for the Search Region:



- Pull the bounding box for the search region by its handles and move and adjust it to the desired size and position.
- The search region should be large enough to find the target even if it is badly prealigned but small enough to avoid that more than one target model could appear within the box.



- Click the function key *[Search]* to perform a test search to test the quality of pattern recognition.



- A graphical feedback will be given for the search result. And the score is displayed in the field „Score“.
- The score should be well above the defined threshold because it may vary from wafer to wafer.
  - Typical scores of good targets range from 75% to 99%.
  - Typical thresholds range from 50% to 70%.

Save all Adjustments:

- Click the function key *[Save]* to save all trained parameters in the current recipe.

As soon as target model training and test search for the first target have been completed successfully select the next target (right mask/left wafer/right wafer) and perform target model training and search region training for all other targets (steps 1-7) successively.

8.2 Automatic Top Side Alignment

8.2.1 Alignment Procedure

Requirements:

- The selected recipe is suitable for top side alignment and the parameter Alignment Mode is „Auto“.
- All positions and views are trained.
- All target models, origins and search regions are trained and saved in the recipe.

Start Process:



- Click the function key *[Start Process]*
- Proceed with the process until the wafer has reached the alignment gap and the GUI displays the view „Train Positions and Views“

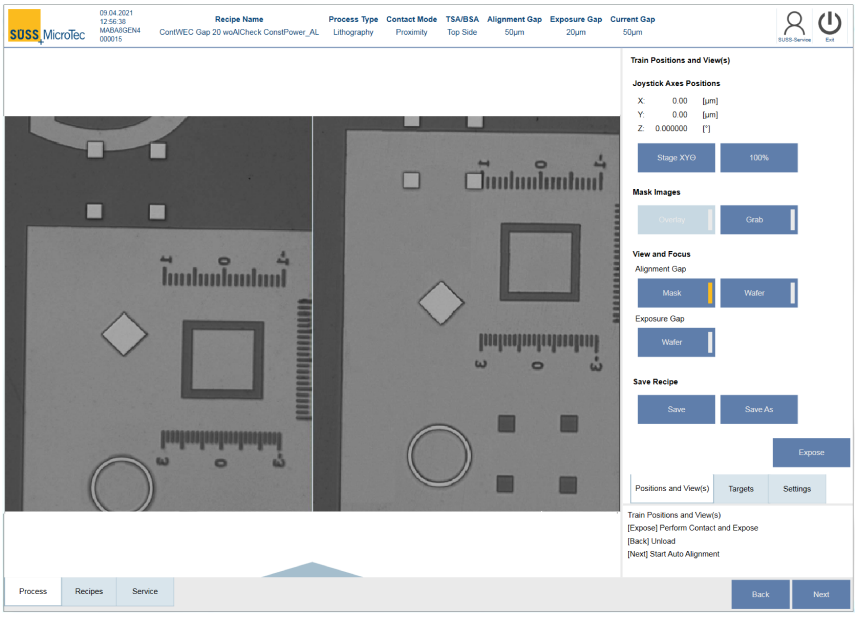


Fig. 8 - 2: Train Position and View(s)

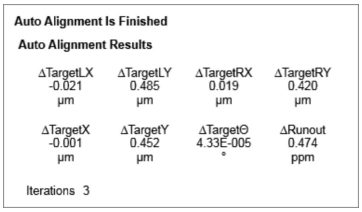
- Check whether the alignment targets of the wafer are in the field of view of each microscope.
- If not, pre-align the wafer until the targets appear in the field of view.

Start Alignment:

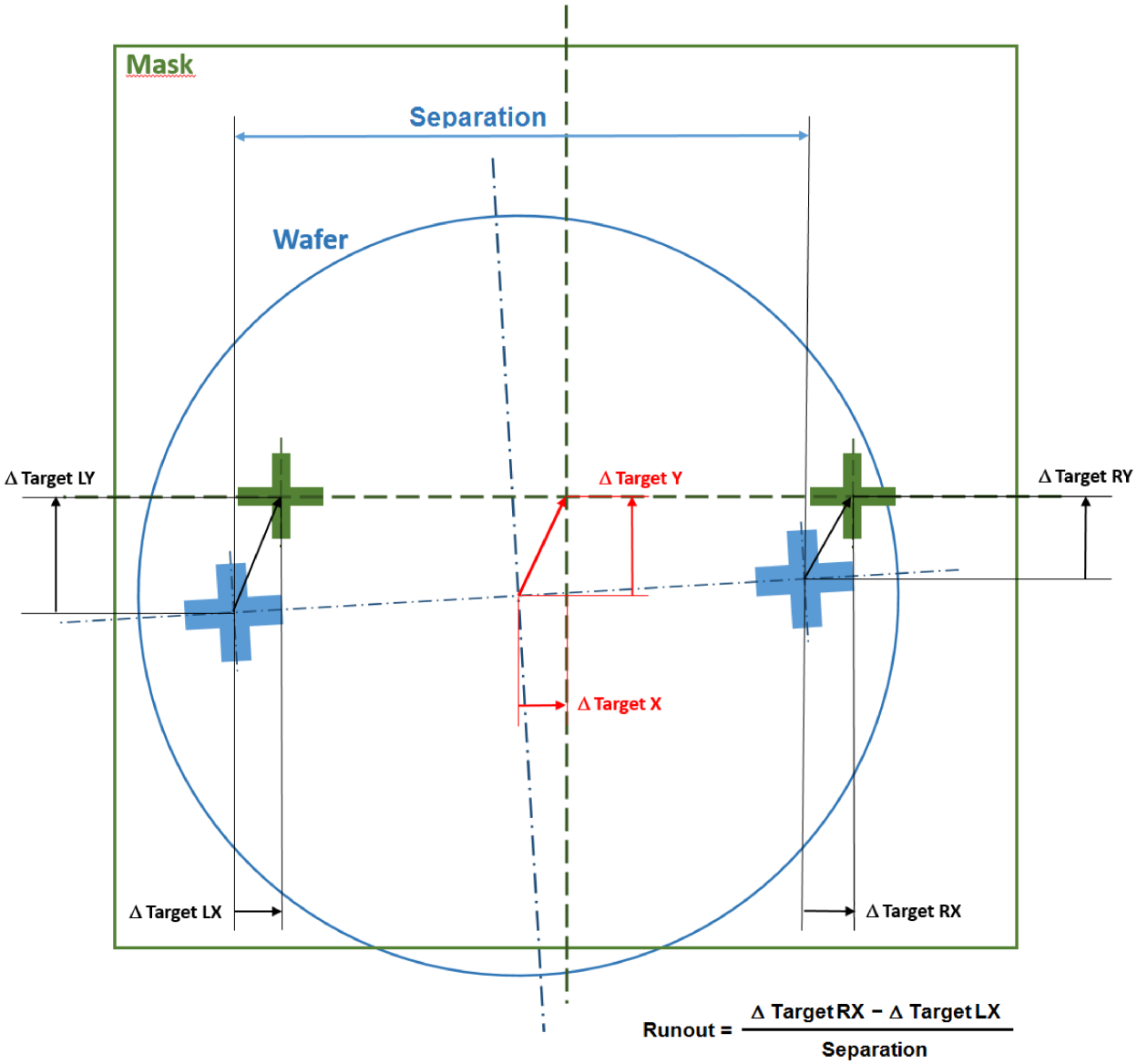


- Click the function key *[Next]*.
- The auto alignment cycle starts and the wafer will be aligned to the mask.
- As soon as the required alignment accuracy (defined with the recipe parameter „Auto Alignment Accuracy“) is reached the alignment process will be terminated at the end of the cycle.

If the check box „Do Alignment Check“ in the recipe is checked, the process will be stopped and the GUI displays the left and right microscope images with the aligned wafer.



- In the process navigation/ dialog frame the detailed alignment results are displayed.
  - All detected final deviations for left/right X-, Y- and Theta directions and run out.
  - The performed number of iterations until the required alignment accuracy has been reached.



The maximum number of iterations is 10.
It is factory-set.

Error Message:

If the required alignment accuracy cannot be reached within the 10 iterations, an error message is displayed:

```
Context: Tried to Auto Align Substrate.
Problem: 'Auto Alignment Accuracy' [µm]: '10' Was Not Reached within '10' Iterations.
Solution: Return to 'Train Positions and Views' for Manual Alignment or Target Training.
```

In this case either repeat the target training or perform a manual alignment.

8.3 Automatic Bottom Side Alignment Training (AL-BSA)

Basic Configuration:

- 2 BSA microscopes
- Each microscope image is displayed on the screen with an individual digital camera.
- Possibility for image storage to save mask targets independently from wafer targets.
- Possibility to check the alignment accuracy before exposure.

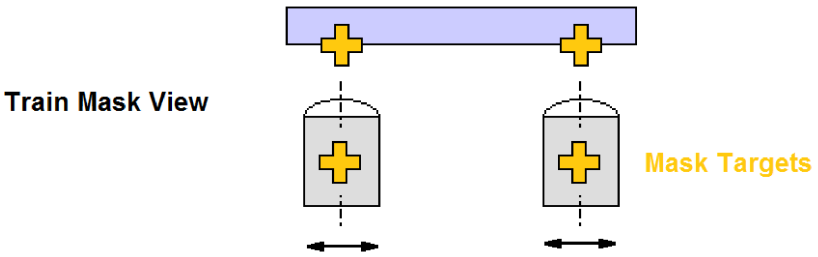
Recipe Requirements:

Select a recipe that is suitable for bottom side alignment:

- The parameter **Alignment Mode** has to be „Auto“
- The parameter **Do Target Training** has to be selected.
- The parameter **Do Alignment Check** has to be selected.
- The parameter **Alignment Illumination Primary** has to be „Bottom Coaxial“.

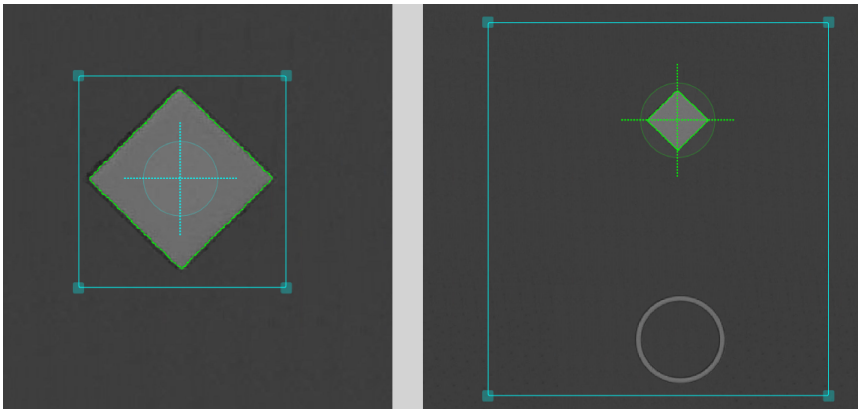
8.3.1 Alignment Training Principle

Train positions and views of mask targets:



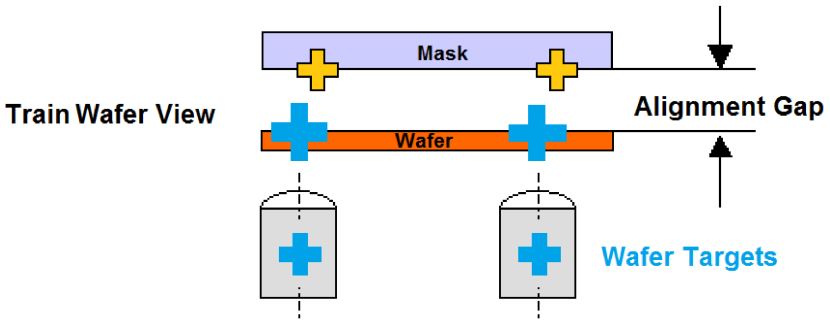
► Load mask and start process.
► The process stops displaying the step " Train Positions and View(s)
► Train positions and views for the mask for left and right microscope.

Train mask target models and search regions:



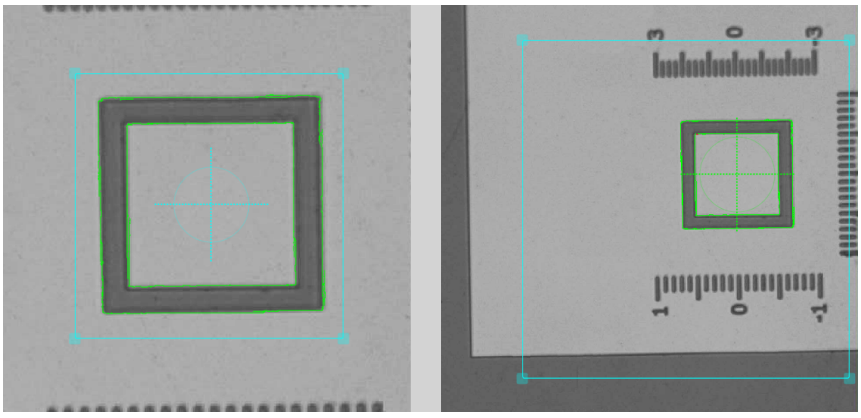
- ► Choose Tab „Targets“ and train target models and search region for each left/right mask target.
- ► Test each target for uniqueness and stability.
- ► Save all trained target model parameters in the recipe.

Load wafer and train positions and views:



- ► The wafer stops in alignment gap and the process displays the step "Train Positions and View(s)"
- ► Train positions and views for the wafer for left and right microscope.

Train wafer target models and search regions:



- ► Choose Tab „Targets“ and train target models and search region for each left/right wafer target.
- ► Test each target for uniqueness and stability.
- ► Save all trained target model parameters in the recipe.

Test Auto Alignment:

► „Do Alignment Check“ has to be kept selected.
► Observe the auto alignment process over a longer period to verify stability and accuracy.

Run the process automatically:

► Switch off „Do Alignment Check“ and run the whole process automatically.

8.3.2 Training of Positions and Views for Mask Targets

Preconditions:

- Used recipe has parameter Alignment Mode: „Auto“
  - The parameter **Do Target Training** is selected.
  - The parameter **Do Alignment Check** is selected.

Starting Position:

- Mask is loaded.
- Once the mask is loaded and the process has been started the process navigation displays the operational elements for training of positions and views.

Adjust Focus and Position of Microscopes to Mask Targets

NOTICE!
The microscopes will move to positions which are pre-defined in the recipe. If there is a risk of collision or if the positions are out of range calculated default positions will be approached.

- If there are already adjusted and stored microscope position values in the recipe the machine will move to these positions. That means that the microscopes are already pre-adjusted and only have to be fine-adjusted.

Adjust X,Y and Focus with the Joystick:

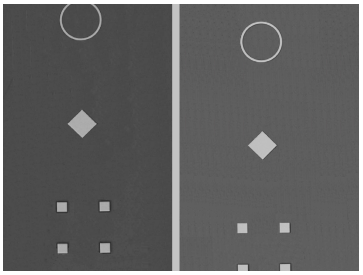


- Select joystick mapping for one microscope with one-way toggle key for microscope movement.

  [Left BSA XY Focus] or *[Right BSA XY Focus]*

- Select desired speed.
- Move the microscope in X and Y until the desired image frame appears in the field on the monitor with the desired alignment targets adjusted roughly in the center.
- Adjust focus for the selected microscope. If necessary reduce speed.
- Adjust iteratively to the desired ideal microscope position.
- Select the joystick mapping for the other microscope and adjust as well.

Result of Adjustment:



- Finally both microscopes are adjusted so
  - that the alignment targets of the mask are focussed and appear approximately in the center of the image field of each micro-scope.
- The current microscope positions will be stored in the recipe and the microscopes will move to these positions as soon as this recipe is selected.

Save all Positions and Views:



- Save all adjusted positions and views either in the current recipe with *[Save]* or create a new recipe with *[Save As]*.

8.3.3 Training of Mask Target Model and Search Region

Display and Control Elements

↳ *Chapter 8.1.1 “Alignment Training Principle” on page 125*

Training of Mask Target Model

Open target training view:

- Click the Tab [Targets] to get access to the „Train Targets View“

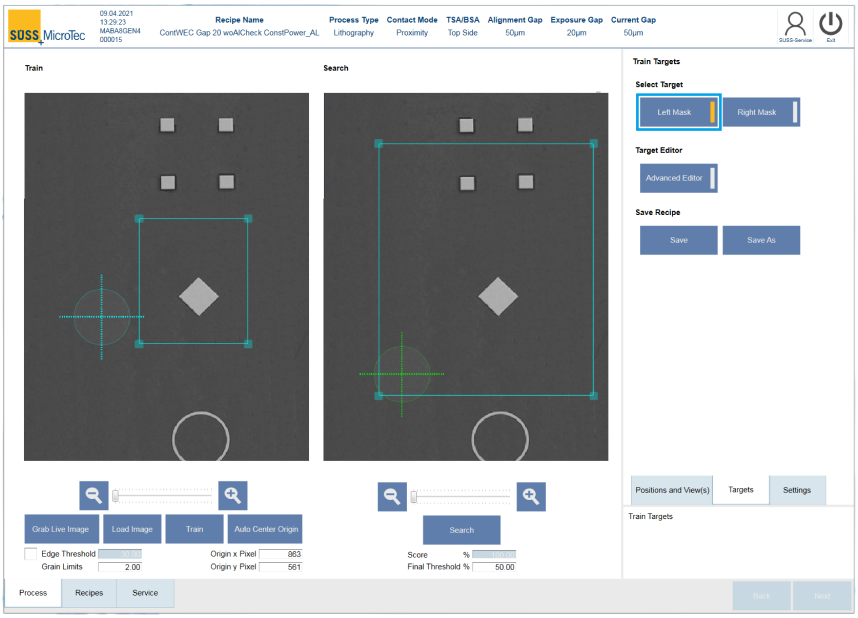


Fig. 8 - 3: Train Targets View

Select the first target view:



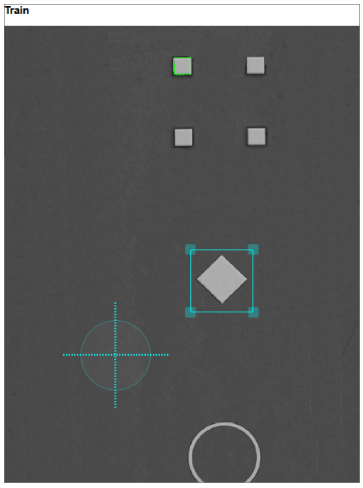
- Click the function key *[Left Mask]*
- The Target and Search screen displays the last stored images of the left mask view.
- If no target has been trained yet, the train screen displays "Untrained".

Grab live image:



- Click the function key *[Grab Live Image]*
  The real image of the left microscope in mask focus position will be stored as train image and displayed.

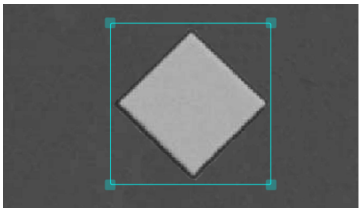
Adjust the bounding box for the train region:



- Pull the handles (little squares) at the edges of the bounding box for the train region and move the box so that the desired alignment target is positioned within train region.
- The box should surround the target closely with some space.



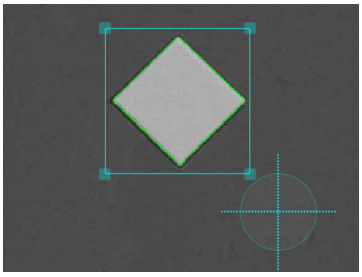
- For better adjustment increase the magnification using the slider.



Train the target model:



- Click the function key *[Train]* to train the target model.



- A graphical feedback („model“) will be given after training.

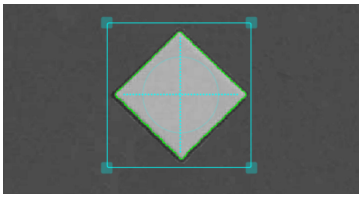
NOTICE!
Do the initial training without selecting the parameter „Edge Threshold“. In this case the software itself determines the optimum value for this parameter.

↳ *Chapter 8.6 “Tips to Create a Good Target Model” on page 150*

Set the origin:



- Click the function key *[Auto Center Origin]*. The software calculates the origin of the trained target model.

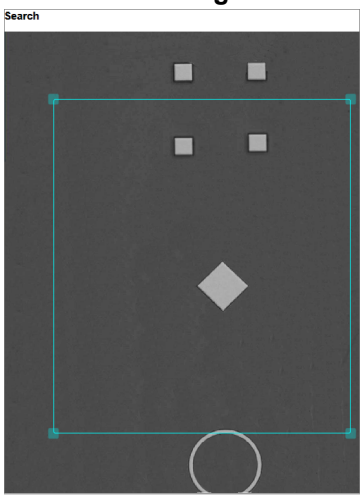


- Auto Center Origin is the most accurate method to define the origin of the model. This increases the alignment accuracy.
- Auto Center Origin is only possible for symmetric targets.

- If the target is not symmetric you have to adjust the origin cross:
  - by drag and drop (clicking and holding the left mouse pressed in the active area of the origin.
  - by editing the origin position in the fields „Origin X Pixels“ and „Origin Y Pixels“.

Training of Search Region

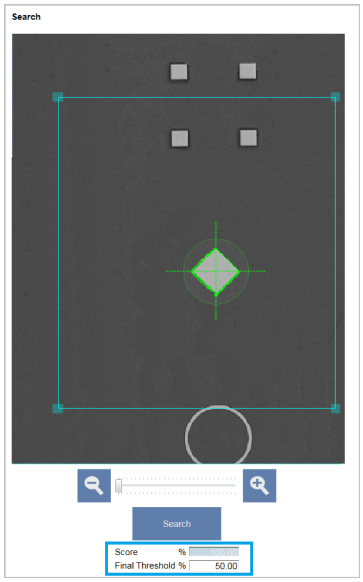
Adjust the bounding box for the search region:



- Pull the bounding box for the search region by its handles and move and adjust it to the desired size and position.
- The search region should be large enough to find the target even if it is badly pre-aligned but small enough to avoid that more than one target model could appear within the box.



- Click the function key *[Search]* to perform a test search to test the quality of pattern recognition.



- A graphical feedback will be given for the search result. And the score is displayed in the field „Score“.
- The score should be well above the defined threshold because it may vary from wafer to wafer.
  - Typical scores of good targets range from 75% to 99%.
  - Typical thresholds range from 50% to 70%.

Save all adjustments:



- Click the function key *[Save]* to save all trained parameters in the current recipe.

Result:

As soon as target model training and test search for the left mask target have been completed successfully select the right mask target and perform target model training and search region training successively.

Next process step: Load chuck and wafer to proceed with wafer target training.

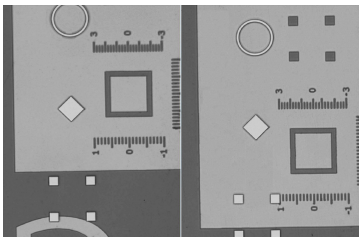
8.3.4 Training of Positions and Views for Wafer Targets

Preconditions:

- Mask Target Training is finished.
- Wafer is loaded.

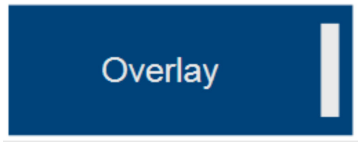
NOTICE!
After training and saving of the mask images the BSA microscopes cannot be moved in X and Y direction.

Starting position:

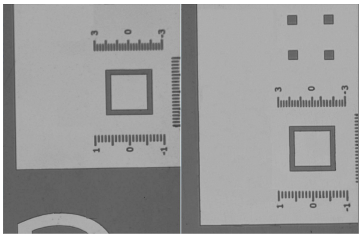


- Once the wafer is loaded the process stops displaying the operational elements for training of positions and views for the wafer targets.
- The screen displays the patterns of the lower side of the wafer.
- The trained mask images are superimposed.

For a better overview for the coarse positioning of the wafer and for adjustment of the focus position of the wafer alignment marks the „Overlay“ function can be switched off.



- Click the function key *[Overlay]*. The LED will be switched off.



- Only the wafer patterns are now visible on the screen.

Adjust focus of microscopes to wafer targets:



- Select joystick mapping for one microscope with one-way toggle key for microscope focus movement:

  [Left BSA Focus] or *[Right BSA Focus]*



- Select desired speed.
- Adjust focus, switch to the other microscope and adjust accordingly.

Pre-align the wafer coarsely in X, Y and Θ:

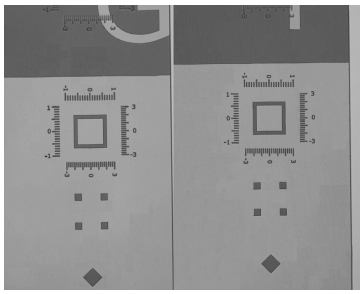


- Select the joystick mapping for stage movement with the one-way toggle key:

  [Stage XYθ]

- Select the desired speed.
- Move the stage until the alignment marks of the wafer are about centric in the corresponding image field.

Result of adjustment:



- Finally both microscopes are adjusted so
  - that the alignment targets of the wafer are focussed and appear approximately in the center of the image field of each microscope.
- The current microscope positions will be stored in the recipe and the microscopes will move to these positions as soon as this recipe is selected.

Save all positions and views:





- Save all adjusted positions and views either in the current recipe with *[Save]* or create a new recipe with *[Save As]*

8.3.5 Training of Wafer Target Model and Search Region

Display and Control Elements

Chapter 8.1.1 “Alignment Training Principle” on page 125

Training of Wafer Target Model

Open target training view:

- Click the Tab [Targets] to get access to the „Train Targets View“

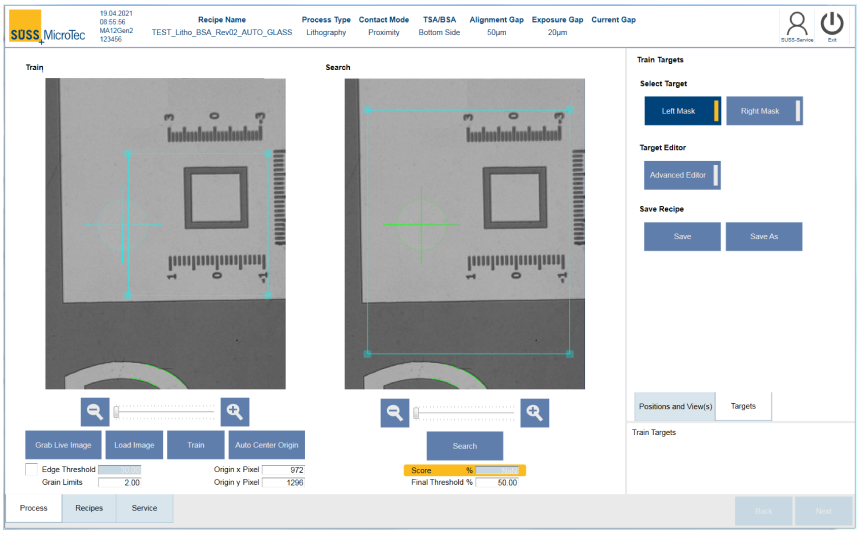


Fig. 8 - 4: Train Targets View

Select the first target view:



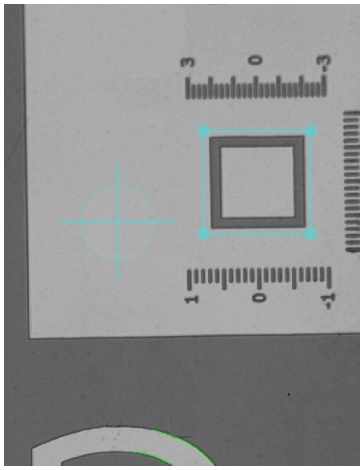
- Click the function key *[Left Wafer]*
- The Target and Search screen displays the last stored images of the left wafer view.

Grab live image:



- Click the function key *[Grab Live Image]*
  The real image of the left microscope in wafer focus position will be stored as train image and displayed.

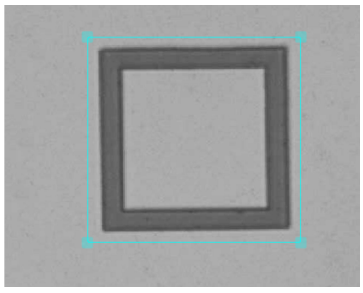
Adjust the bounding box for the train region:



- Pull the handles (little squares) at the edges of the bounding box for the train region and move the box so that the desired alignment target is positioned within train region.
- The box should surround the target closely with some space.



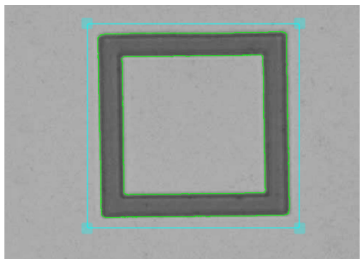
- For better adjustment increase the magnification using the slider.



Train the target model:



- Click the function key *[Train]* to train the target model.



- A graphical feedback („model“) will be given after training.

NOTICE!

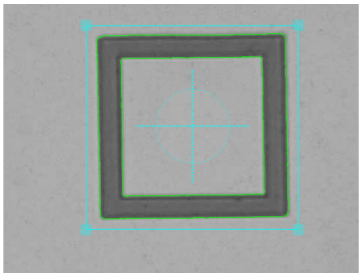
Do the initial training without selecting the parameter „Edge Threshold“. In this case the software itself determines the optimum value for this parameter.

Chapter 8.6 “Tips to Create a Good Target Model” on page 150

Set the origin:



- Click the function key *[Auto Center Origin]*. The software calculates the origin of the trained target model.

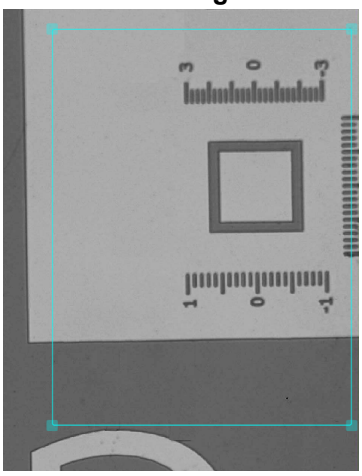


- Auto Center Origin is the most accurate method to define the origin of the model. This increases the alignment accuracy.
- Auto Center Origin is only possible for symmetric targets.

- If the target is not symmetric you have to adjust the origin cross:
  - by drag and drop (clicking and holding the left mouse pressed in the active area of the origin.
  - by editing the origin position in the fields „Origin X Pixels“ and „Origin Y Pixels“.

Training of Search Region

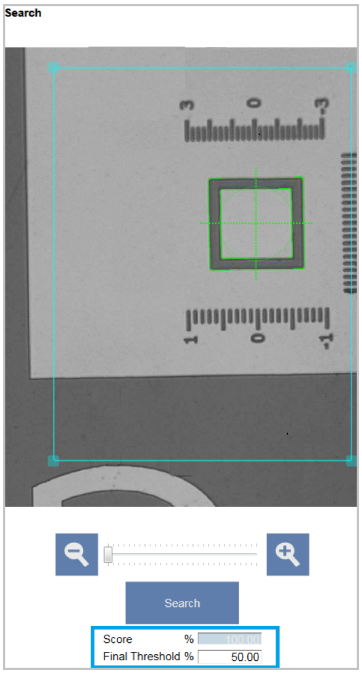
Adjust the bounding box for the search region:



- Pull the bounding box for the search region by its handles and move and adjust it to the desired size and position.
- The search region should be large enough to find the target even if it is badly pre-aligned but small enough to avoid that more than one target model could appear within the box.



- Click the function key *[Search]* to perform a test search to test the quality of pattern recognition.



- A graphical feedback will be given for the search result. And the score is displayed in the field „Score“.
- The score should be well above the defined threshold because it may vary from wafer to wafer.
  - Typical scores of good targets range from 75% to 99%.
  - Typical thresholds range from 50% to 70%.

Save all adjustments:



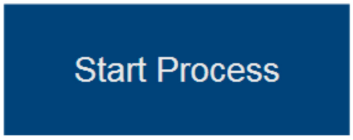
- Click the function key *[Save]* to save all trained parameters in the current recipe.

8.4 Automatic Bottom Side Alignment

Requirements:

- The selected recipe is suitable for bottom side alignment and the parameter Alignment Mode is „Auto“.
- All positions and views are trained.
- All target models, origins and search regions are trained and saved in the recipe.

Start process:



- Click the function key *[Start Process]*
- Proceed with the process until the wafer has reached the alignment gap and the GUI displays the view „Train Positions and Views“

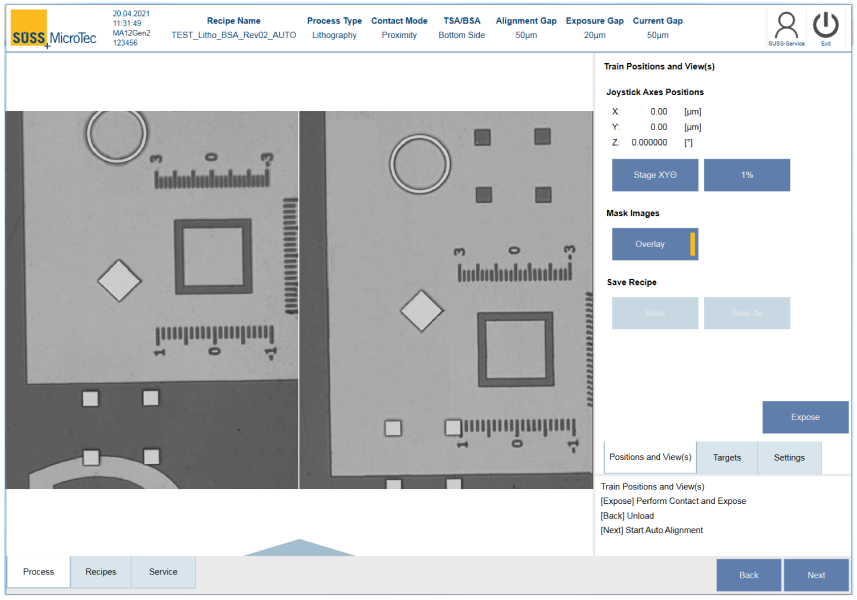


Fig. 8 - 5: Train Position and View(s)

The stored and trained mask targets are super imposed.

- Check whether the alignment targets of the wafer are in the field of view of each microscope.
- If not, pre-align the wafer until the targets appear in the field of view.

Start auto alignment:



- Click the function key [Next]
- The auto alignment cycle starts and the wafer will be aligned to the mask.
- As soon as the required alignment accuracy (defined with the recipe parameter „Auto Alignment Accuracy“) is reached the alignment process will be terminated at the end of the cycle.

If the check box „Do Alignment Check“ in the recipe is checked, the process will be stopped and the GUI displays the left and right microscope images with the aligned wafer.

8.5 Direct Align (DA) Option

"Direct Align" (DA) enables you to check and, if necessary, correct alignment errors in the exposure gap and after the selected contact process has been set up.
DA improves the alignment reliability, accuracy and overlay and because possible de-adjustments during the movement from alignment gap to exposure gap are detected and can be corrected.

Two additional process steps:

During the whole process two additional steps are added:

- After reaching the exposure gap. An additional check of the alignment accuracy is done using the image recognition software.
- If the required alignment accuracy is not reached, the substrate is moved back into the alignment gap and a compensation move is performed.
- Finally the substrate is moved back to the exposure gap.

The option "Direct Align" is available for automatic top side or bottom side alignment processes.

DA Parameters:

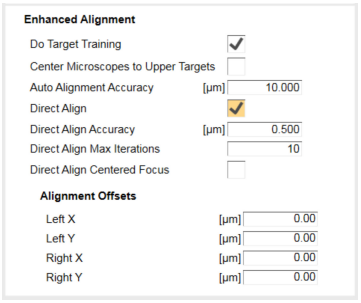


Fig. 8 - 6: DA Parameters

All necessary and programmable parameters can be set in the recipe, tab *"Alignment"*, group *"Enhanced Alignment."*

A detailed description of the recipe parameters for Direct Align can be found in *"Direct Align" on page 56*

Views and Focus Positions:

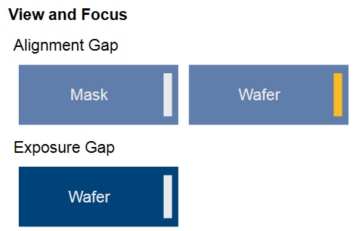


Fig. 8 - 7: Function Keys for Focus Positions

During automatic alignment and direct alignment process different focus positions have to be trained:

- The function key *[Wafer]/ Exposure Gap* is only visible if the check box *"Direct Align"* is selected in the recipe.
  The microscope focus has to be trained so that focus is set to the wafer in exposure gap.
- If additionally the check box *"Direct Align Centered Focus"* is checked, the microscope focus has to be trained so that both mask and wafer are in focus.

The function "Direct Align Centered Focus" is only useful, if the exposure gap is smaller than the depth of focus of the microscopes.

The advantage of the function "Direct Align Centered Focus" is that no refocussing of the microscope from mask to wafer during direct alignment is necessary. Thus errors because of shifting problems of the microscope axes are avoided.

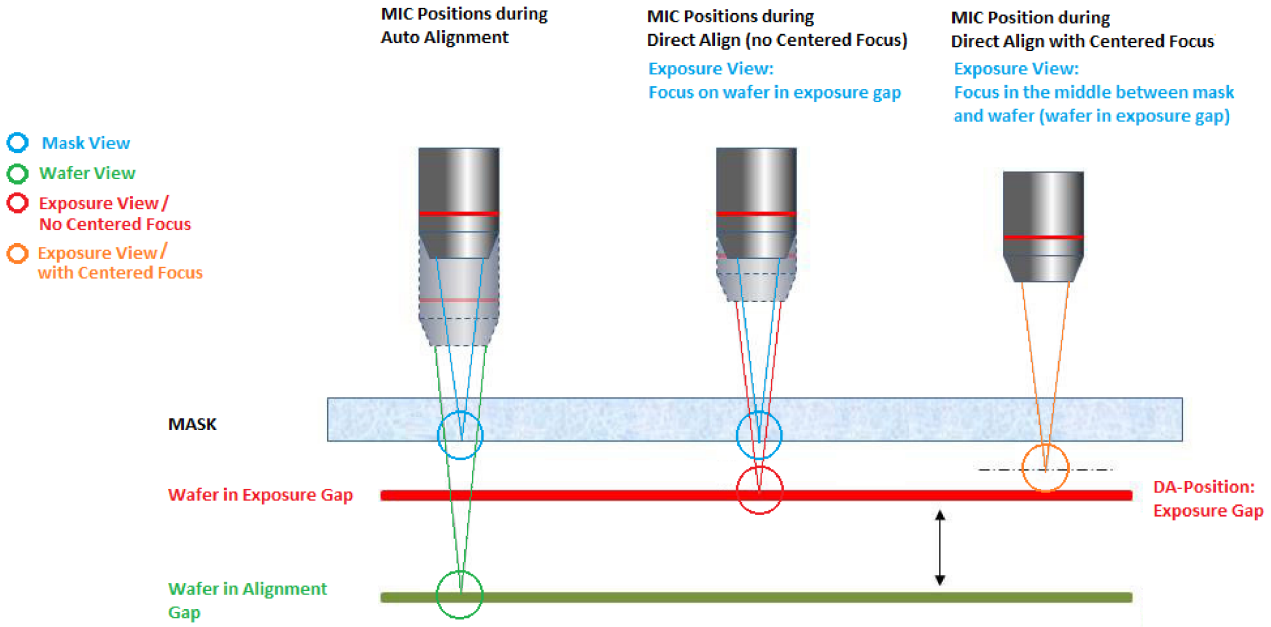


Fig. 8 - 8: View and Focus Positions

View and Focus	MIC Focus Position *No Direct Align*	MIC Focus Position *With Direct Align*	MIC Focus Position *With Direct Align/ Centered Focus*
Mask	Focus on mask targets	Focus on mask targets	Focus on mask targets
Wafer	Focus on wafer targets (wafer in alignment gap)	Focus on wafer targets (wafer in alignment gap)	Focus on wafer targets (wafer in alignment gap)
Exposure Gap Wafer	Not available (not visible in GUI)	Focus on wafer targets (wafer in exposure gap)	Focus in the middle between mask and wafer targets (wafer in exposure gap) Both targets have to be within the depth of focus.

NOTICE!

All focus positions have to be trained in the navigation/dialog frame *"Train Position and View(s)"*

8.6 Tips to Create a Good Target Model

Pattern recognition method:

- A pattern or target is defined as areas of pixels going from dark to light which will define boundaries.
- A continuous boundary between regions of dissimilar pixel values will define the edges of a pattern.
- The software use this edge information when searching for a target.

Graphical feed back:

After target training the software displays a graphical feed back for the target model.
There are some essential characteristics for a good target model.
These are important for a reliable and accurate automatic alignment.

1. **Model edges and real edges shall match with a tolerance below 1 pixel.**

2. **The model‘s edges shall be uninterrupted.**

3. **The model shall consist of large features, it shall not include small features (< 10 pixel).**
   - Small features make it much more sensitive for focus changes.

4. **The model shall only consist of features that are common to all wafers to be aligned.**
   - Features that are unique on a wafer (e.g. a damage) shall not be trained.

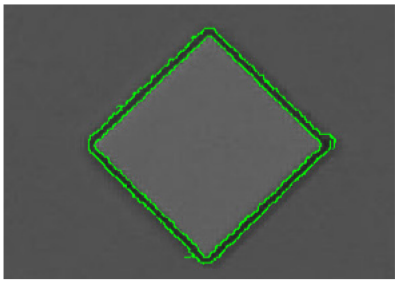
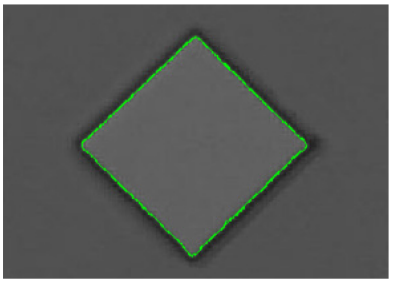
5. **Mask models shall not have double edges.**
   - The shadow of a mask is no feature!

8.6.1 The Parameters "Edge Threshold" and "Grain Limits"

For standard applications the check box for" Edge Threshold" shall remain unticked. In this case the software itself determines optimum values for this parameter.
If a good model cannot obtained in this way the parameter can be varied.

Edge Threshold:

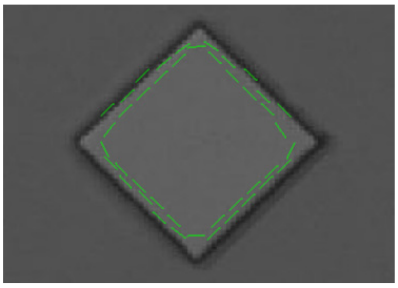
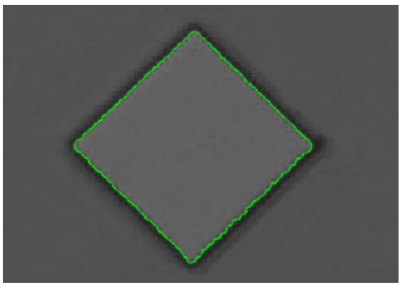
- The edge threshold determines the threshold for detection of the edges of a target model and therefore the visibility of the edges.
- Only pattern instances where the average difference in grey-level values for all of the boundary points exceeds the edge threshold are considered by the software.

Bad Model	Good Model
Edge Threshold - Check Box: Off	Edge Threshold - Check Box: ON Edge Threshold = 20
	

For optimization increase the edge threshold step-by-step until the model becomes incomplete. Then reduce it until it becomes complete again.

Grain Limits:

- The grain limits represent the length of the "edge elements“ of a target model.
- Lower values of the grain limits mean shorter edge elements. They increase the accuracy.
- Higher values of the grain limits mean longer edge elements. They filter noise and have an integrating effect, which is good for low contrast images.

Bad Model	Good Model
Grain Limit = 10,0	Grain Limit = 2,0
	

High grain limits help if images are noisy, have low contrast or a granular background.
Do not set the grain limits higher than necessary because it reduces the accuracy.



Varying and „playing“ with both parameters followed by re-training can help obtaining a good model.

9 CONTACT/ EXPOSURE PROCESSES

- The mask aligner works according to the principle of shadow projection.
- The mask is illuminated over the whole area and the shadow of its structures will be imaged onto the wafer.
- The distance (gap) between mask and wafer determines besides the diffraction reducing optics the possible maximum resolution of the patterns on the wafer.
- The selection of the contact mode and therefore the desired gap between mask and wafer is an essential parameter of each recipe.
- Depending on the selection of the contact mode additional parameters have to be determined individually.

9.1 Proximity

- Exposure in defined gap between mask and wafer.
- Mask and wafer are treated with care, that means higher yield, lower mask wear.
- The distance between mask and wafer is realized with 3 spacers in the mask holder (top substrate holder). Mask and wafer are touched only at these three positions.

9.1.1 Important Recipe Parameters

Exposure Gap:

- determines the possible resolution.
- The smaller the exposure gap the better the resolution but the higher the risk of pollution/ damage of mask and wafer.
- The parameter is located in tab „Exposure“, group „Exposure“
- It is only visible if „Proximity“ is selected.
- Allowed input: 0-1000 [µm]
- The value for the exposure gap has to be smaller than the value for the alignment gap.

WEC:

- = wedge error compensation
- The parameter is located in tab „General“, group „WEC“.
- Reasonable selection is „WEC - Spacer-Top Substrate“ The wedge error compensation is performed with the 3 spacers in the mask holder and guarantees that mask and wafer will not get directly in contact to each other.
    - The selection „WEC - Spacer-Top Substrate“ requires a mask holder with spacers.

9.2 Soft Contact

- For exposure the chuck with the wafer moves in direct contact with the mask.
- The wafer remains fixed with vacuum on the chuck during exposure.
- The Z-axis moves the wafer to a distance of 0 µm to the mask. (This distance is calculated from the Z-axis position after WEC.)
- The pattern resolution is better than with proximity. The risk of pollution/ damage of mask and wafer is higher as with proximity.

9.2.1 Important Parameters

Contact Delay

- Delay time between moving to contact position of mask and wafer and the start of the exposure.
- The parameter is located in tab „Exposure“, group „Contact“
- It is visible if „Soft Contact“ has been selected (and also for Hard Contact ☞ *Chapter 9.3.1 “Important Recipe Parameters” on page 154*)
- The delay time offers that the air between mask and wafer has enough time to escape. This leads to a better contact over the whole area.
- Allowed input: 0-1000 [s]

9.3 Hard Contact

- For exposure the chuck moves in direct contact with the mask.
- The vacuum which holds the wafer on the chuck is switched off.
- Additionally the wafer is pressed against the mask with a nitrogen flow below the wafer.
- The pattern resolution is better than with soft contact. The risk of pollution/ damage of mask and wafer is higher as with soft contact.

9.3.1 Important Recipe Parameters

Contact Delay

- Delay time between moving to contact position of mask and wafer and switch off of vacuum below the wafer.
- The parameter is located in tab „Exposure“, group „Contact“.
- The delay time offers that the air between mask and wafer has enough time to escape. This leads to a better contact over the whole area.
- Allowed input: 0-1000 [s]

Hard Contact Delay

- Delay time between switch-on of nitrogen below the wafer and start of exposure.
- The parameter is located in tab „Exposure“, group „Contact“.

- The delay time offers that the air between mask and wafer has enough time to escape. This leads to a better contact over the whole area.
- Allowed input: 0-1000 [s]

Hard Contact Pressure Maximum

- Upper limit for allowed nitrogen pressure below the wafer.
- The parameter is located in tab „Exposure“, group „Contact“.
- The specified value is set with the pneumatic control „Hard Contact Nitrogen“ *“Hard Contact Nitrogen” on page 17*.
- Allowed input: 0-1000 [mbar]

Hard Contact Pressure Minimum

- Lower limit for allowed nitrogen pressure below the wafer.
- The parameter is located in tab „Exposure“, group „Contact“.
- The specified value is set with the pneumatic control „Hard Contact Nitrogen“ *“Hard Contact Nitrogen” on page 17*.
- Allowed input: 0-1000 [mbar]

9.4 Vacuum Contact

- Buildup of a vacuum chamber that enables the wafer to be pressed against the mask.
- Best possible resolution because of intimate contact between mask and wafer but strong contamination for mask and wafer.
- A special chuck (with an inflatable sealing or angular sealing) is necessary to produce a vacuum chamber.
    - The pressure for the sealing is set with the pneumatic control „Bottom Seal Pressure“ *“Chuck Seal Pressure” on page 17*.
- To build up and to re-open the vacuum chamber a very complex process sequence is necessary.
    - The chamber is evacuated in steps to avoid air bubbles.
    - After exposure the vacuum chamber has to be re-opened carefully and wafer and mask have to be separated from each other with a nitrogen flow.

9.4.1 Important Parameters

Pre Vacuum Delay

- Delay time between switch-on of the pre-vacuum (Pre Vacuum) and switch-on of the main vacuum.
  The pre-vacuum is set with the pneumatic control „Chuck Chamber Prevacuum“ *“Chuck Chamber Prevacuum” on page 17*.

Vacuum Delay

- Delay time between switch-on of the main vacuum and switch-off of the vacuum below the wafer.
- The main vacuum is set with the pneumatic control „Chuck Chamber Vacuum“ *“Chuck Chamber Vacuum” on page 17*.

Wafer/Chuck Release Delay

- Delay time between the switch-off of the vacuum below the wafer and the start of the exposure.

Wafer/Mask Release Delay

- Delay time between nitrogen purge after the exposure for separation of wafer from the mask and the down-moving of the Z-axis for unloading.

9.4.2 Example for a Vacuum Contact Process Sequence

No.	Process Step	Action	Delay	Parameter
	Alignment	Align mask and wafer in AL Gap		
		Click [Next]		
5	Exposure Gap	Machine moves the chuck from AL Gap in to Exposure Gap.		
	AL Check (Check 1)	Visual check of alignment accuracy		
		Click [Next]		
	Contact	Vacuum sealing is inflated.	1 s	
6		Pre-Vacuum for the chamber is switched on.	6 s	Pre Vacuum Delay -->Vacuum decreases SLOWLY.
7		Vacuum in the chamber is switched on.	2 s	Vacuum Delay -->Vacuum decreases FAST
8		Vacuum for the wafer at the chuck is switched off. Air can stream in.		
		Machine is waiting.	3 s	Wafer/Chuck Release Delay
9		Air supply under the wafer is switched off.		
	Contact Check (Check 2)	Visual check of alignment accuracy.		
		Click [Expose]		
	Exposure	Microscopes move to exposure position. Shutter opens for exposure.		

Fig. 9 - 1: Process Steps for Vacuum Contact

Graphical display of the process:

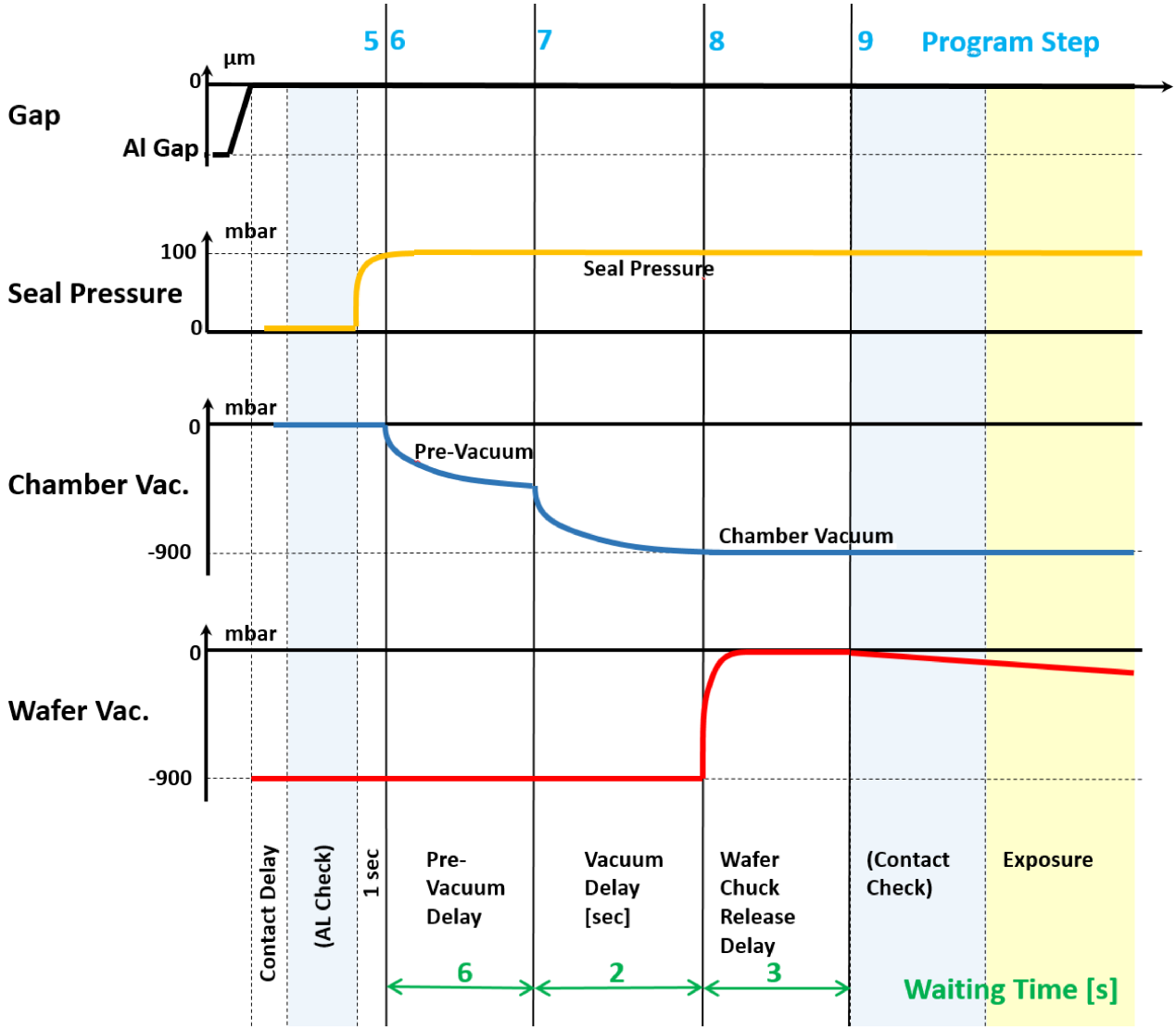


Fig. 9 - 2: Sequence of Vacuum Contact Process

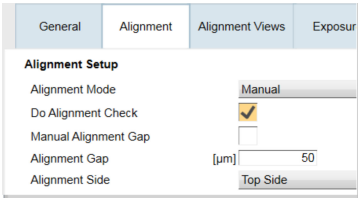
10 ALIGNMENT CHECKS (AL Checks)

To check whether the required alignment accuracy has been kept on its way to the exposure gap and after performing the contact process, their are two positions in the overall process to stop and to check the alignment accuracy:

- **Alignment Check** (= Check 1) in exposure gap
- **Contact Check** (= Check 2) after performing the contact process

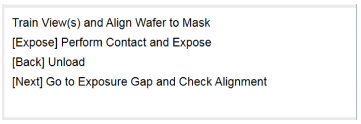
10.1 Select AL Check

Do Alignment Check



- In „Recipe“ view
- In the tab „alignment“ of the selected recipe.
- If the check box is ticked, one or two alignment checks will be performed depending on the selected contact process.

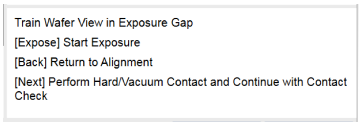
10.2 Alignment Check (Check 1)



- The alignment check 1 is performed for each contact process.

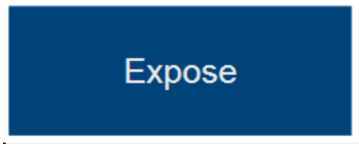


- After clicking the key *[Next]* the Z-axis with the chuck and the wafer moves to the exposure gap.
- Depending on the selected contact process this means:
  - for Proximity: the programmed exposure gap
  - for Soft Contact: the contact position between wafer and mask.
  - for Hard Contact and Vacuum Contact: the contact position between wafer and mask.



10.2.1 Proximity and Soft Contact

- For proximity and soft contact process only the alignment check (Check 1) is available.



- After successful inspection of the alignment accuracy at this stop the exposure can be started with the function key *[Expose]*.

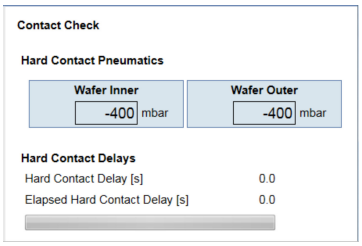
10.3 Contact Check (Check 2)

- This check position is only available for the contact processes „Hard Contact“ or „Vacuum Contact“.

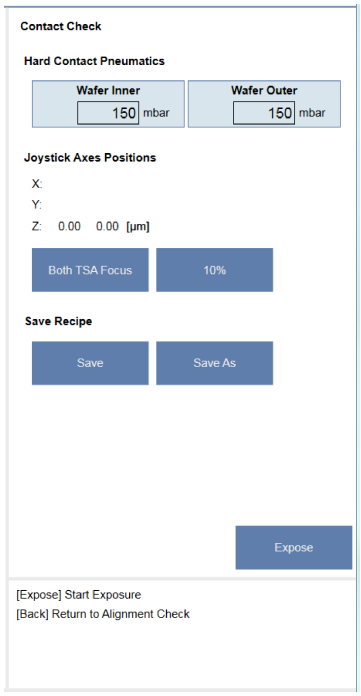


- After clicking the key *[Next]* the selected contact process will be started.

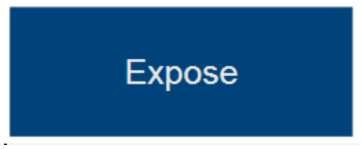
10.3.1 Hard Contact



- During the sequence of the contact process the elapsed time for the programmed hard contact delay is displayed.
- The pressure values used and controlled during hard contact are displayed.

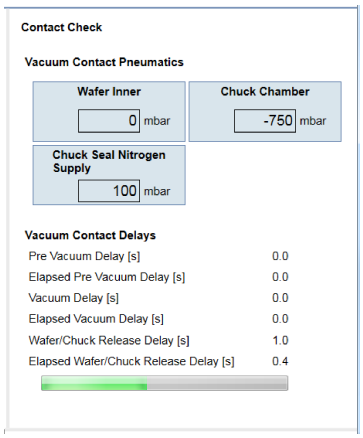


- Once the contact process sequence is terminated the dialog field will display:
  - the controlled pressure values for hard contact.
  - the possible selection for joystick mapping. In this position only the focus of the microscopes can be moved.
  - As soon as the focus position has been changed the keys *[Save]* and *[Save As]* will become active. The changed values can be stored in the current recipe or as a new recipe with new name.

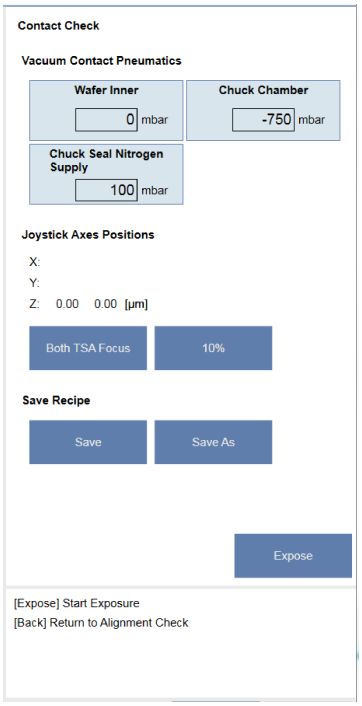


- After successful inspection of the alignment accuracy at the 2 stops the exposure can be started by clicking the function key *[Expose]*.

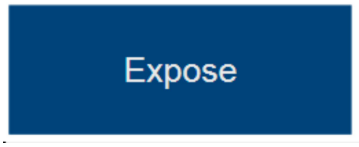
10.3.2 Vacuum Contact



- During the sequence of the contact process the elapsed time for all programmed delays of the vacuum contact process are displayed.
- The pressure values used and controlled during vacuum contact are displayed.



- Once the contact process sequence is terminated the dialog field will display:
  - the controlled pressure values for vacuum contact.
  - the possible selection for joystick mapping. In this position only the focus of the microscopes can be moved.
  - As soon as the focus position has been changed the keys *[Save]* and *[Save As]* will become active. The changed values can be stored in the current recipe or as a new recipe with new name.



- After successful inspection of the alignment accuracy at the 2 stops the exposure can be started by clicking the function key *[Expose]*.

11 EXPOSURE

11.1 Constant Dose

Problem:

Exposure of a substrate with a fixed period of time (exposure mode: Constant Power) carries the risk of fluctuations in exposure intensity from substrate to substrate. Variation of lamp intensity and changes of the shutter times because of temperature and age are the reasons for these fluctuations.
This leads to different exposure results from substrate to substrate and to a loss of quality.

Solution:

The exposure mode „Constant Dose“

- Definition of a total dose (in [mJ/cm²])
- Measurement of the actual light intensity integrated over the time.
- Shutter closing once the dose has been reached.

Result:

- Each substrate will be exposed with the same dose.
- Intensity variations of the lamp will be compensated.

Software Licence necessary!

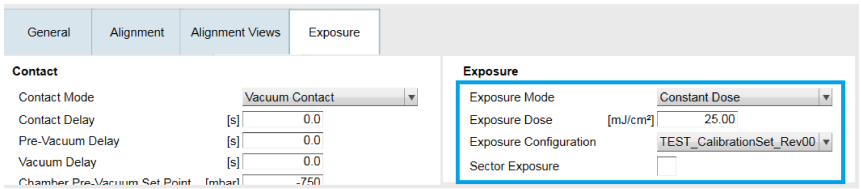
To get access to the exposure mode "Constant Dose" a software licence is necessary that has to be ordered separately.

11.1.1 Select "Constant Dose"

The mode can be selected if the option is installed and activated.

Exposure Mode:

- Select view "Recipe".
- Select tab „Exposure“ in the selected recipe.



- Select the mode „Constant Dose“ in the drop down menu.

Exposure Dose:

- Definition of the total dose for the exposure
- Choose the minimum dose so you avoid exposure times below 2 sec, as the reproducibility becomes worse.
  Possible solution to overcome the problem: Insert gray filter or aperture to reduce intensity

Exposure Configuration:

- For each optics version (e.g. different optics combinations, different apertures, with/without filter) its particular calibration should be performed and stored as individual configuration.
- The suitable optics version has to be selected in the recipe to load and use the right calibration parameters.

NOTICE!

► The dose measurement is performed with a broadband sensor.

► If resist is used which is only sensitive for a small wavelength range (e.g. 365 nm) the dose has to be converted for this resist.

► This dose means a reference point and has to be verified and modified by test exposures.

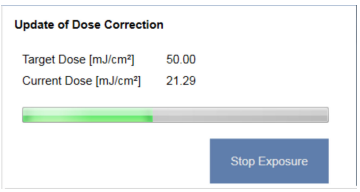
11.1.2 Process Sequence

Requirements:

- The machine is initialized.
- A recipe with exposure mode „Constant Dose“ is selected.

Dose Measurement:

The dose measurement is performed automatically during exposure.



As soon as the exposure step is started (with button [Expose]) and the contact process is finished, the shutter will be opened.

The exposure progress is displayed in the process navigation window.

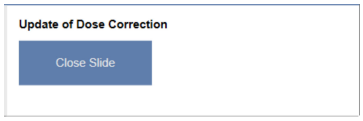
- The dose, defined in the recipe is displayed. (TargetDose)
- The integrated dose progress (CurrentDose) is displayed.
- The shutter will be closed as soon as the TargetDose is reached.

11.1.3 Dose Correction

After process start (button [Start Process]) an automatic correction of the dose will be performed if:

- the machine software has been re-booted.
- the optics has been converted.
- the validity of the dose measurement has been expired.

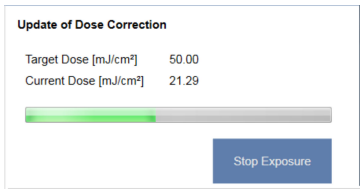
*The "**Dose Correction Expiration Time**" can be set in Service/ Exposure Tab/ Parameter Group.*



- The process navigation window shows that a measurement for dose correction is performed.



- If there is still a substrate on the chuck after process start, the user is requested to remove it.



- As soon as the substrate has been removed and the button *[Next]* has been clicked, the measurement is performed.
- The progress is displayed in the process navigation window.
- The updated value is stored in the recipe.
- The validity of the dose measurement is factory set to 30 minutes.

NOTICE!

If the optics (Constant Dose Calibration Set) defined in the recipe does not match with the optics set by service, an error message will be displayed in the error information line:

Context: Preparing Process
Problem: The Tooling Configuration Does Not Provide the 'Constant Dose Calibration Set' Defined in the Current Recipe.
Solution: Check Configuration or Select a Supported 'Constant Dose Calibration Set' in the Current Recipe.

11.2 Sector Exposure

Sector Exposure provides an additional process to perform test exposures.

Sector Exposure can be used either in "Constant Power" mode or in "Constant Dose" mode.

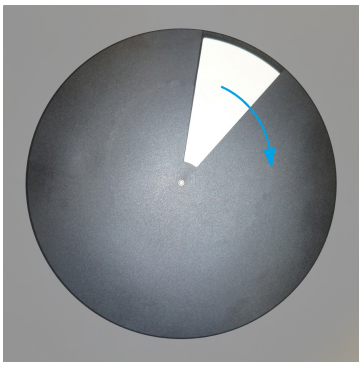
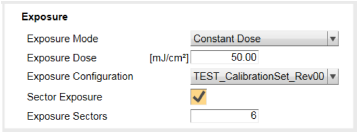


Fig. 11 - 1: Test Exposure Disk

This „test“- exposure mode provides the opportunity to determinate the exposure time during development of new processes of use of new photo resists and to save time and material.

With a special test exposure disk up to 6 sectors with different exposure times can be exposed on a wafer. In the process the wafer remains always in exposure gap.

11.2.1 Select "Sector Exposure"



- Sector Exposure is selected with a check box in tab „Exposure“, group „Exposure“ by ticking the box „Use Sector Exposure“.
- Up to 10 sectors can be programmed.
- Once it is selected the additional parameter „Exposure Sectors“ is displayed:

Exposure Sectors:

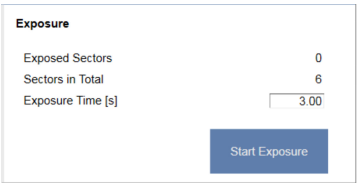
Numeric Input Field

- Allowed values: 2 to10
- Each field can be exposed with a different exposure time.

11.2.2 Process Sequence

Preparation:

- Switch to recipe view.
- Select a recipe and activate „Use Sector Exposure“ and define the desired number of sectors to be exposed in the field „Exposure Sectors“.
- Save the recipe.
- Switch to process view.
- Start the process with the selected recipe.
- Load wafer, move in transport slide and clamp with *[Next]*.
- As soon as the wafer has reached the exposure gap, the process navigation, tab „General“ shows the common operational elements.
- Click the key *[Exposure]*.
- The process navigation frame changes to sector exposure.



- The parameters for the sector exposure are displayed.

Exposed sectors:

- Number of sectors that have been exposed. The counter will be incremented until the programmed number of sectors is reached.

Sectors in total:

- In recipe defined number of sectors which shall be exposed on the wafer.

Exposure time [s]:

- Input field for desired exposure time.
- Each sector can be exposed with an individual exposure time.



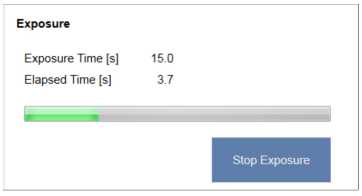
- The user guidance shows:

  Arrange Sector Exposure Test Dial, Define Exposure Time and Close Door.
  [Start Exposure] Start Exposure
  [Next] to Unload Wafer

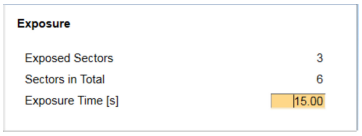
- Define the exposure time for the first sector in input field „Exposure time [s]“.



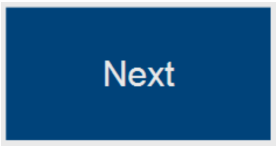
- Click the key *[Start Exposure]*.



- The shutter opens and the exposure takes place.
- Finally the shutter will be closed. The wafer remains in exposure gap.



- Turn the sector disk further to the next sector and input the next exposure time.
- Start the next exposure with *[Start Exposure]*.
- Repeat the sequence until all sectors are exposed.
- Once the last sector is exposed, the Z-axis moves downward and the wafer can be unloaded.



- If the wafer shall be unloaded before the last sector has been exposed, click the key *[Next]* to do so.

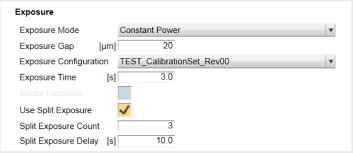
11.3 Split Exposure

Split Exposure provides the opportunity to split the total exposure time into segments.

This option is used to allow outgassing of thick resist and to prevent the wafer surface from becoming too hot.

An additional delay time between the time segments can be programmed.

11.3.1 Select "Split Exposure"



- Split Exposure is selected with a check box in tab "Exposure", group "Exposure" by ticking the box "Use Split Exposure".
- Each exposure time segment has the same exposure time which is defined with the parameter "Exposure Time".
- Once it is selected two additional parameters are displayed:

Split Exposure Count: **Numeric Input Field**

- Allowed values: 0 to 1000
- Number of segments in which the total exposure sequence shall be split.

Split Exposure Delay: **Numeric Input Field**

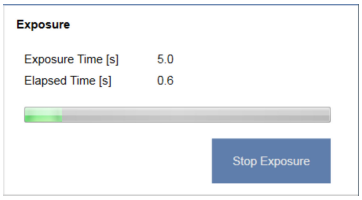
- All input values in [s]
- Allowed values: 0 to 1000
- Waiting time between each exposure segment. Each delay has the same time.

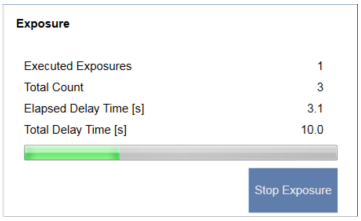
11.3.2 Process Sequence

Preparation:

- Switch to recipe view.
- Select a recipe and activate „Split Exposure“ and define the desired number of time segments for the total exposure time in the field "Split Exposure Count".
- Define the desired waiting time between the segments in the field "Split Exposure Delay".
- Save the recipe.
- Switch to process view.
- Start the process with the selected recipe.
- Load wafer, move in transport slide and clamp with *[Next]*.
- As soon as the wafer has reached the exposure gap, the process navigation, tab „General“ shows the common operational elements.
- Perform all alignment steps.

- Start exposure with the key *[Exposure]*.
- The process navigation frame changes to split exposure.





- The shutter opens for the first exposure segment. The running exposure time is displayed in the process navigation frame.
- As soon as the first exposure segment is finished the shutter will be closed and the process navigation frame displays the running delay time.
- The process navigation frame shows alternatively the running exposure time or the running delay time.
- Once all exposure segments and delay times have been executed the process will be terminated and the wafer can be unloaded.

Executed Exposures:

- Number of split exposure segments that have been already executed.

Total Count:

- Number of split exposure segments that are defined in the recipe.

Elapsed Time [s]:

- Counter for elapsed exposure time

Exposure Time [s]:

- Exposure time per segment that is defined in the recipe. Each segment has the same exposure time.

Elapsed Delay Time [s]:

- Counter for elapsed delay time

Total Delay Time [s]:

- Delay time between the exposure segments that is defined in the recipe. Each delay time has the same amount.

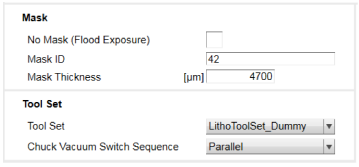
11.4 Flood Exposure

Flood exposure provides a full field exposure of the substrate without a mask.

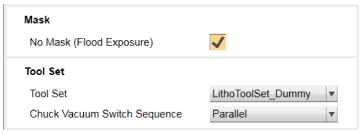
This mode may be used for applications with image reversal resist:

- After a "First Mask" exposure step and post exposure bake, the flood exposure with UV light will cause all previously unexposed areas of photo resist to undergo the chemical reaction to make them soluble to developer.

11.4.1 Select "Flood Exposure"



- Flood Exposure is selected with a check box in tab "General", group "Mask" by ticking the box "No Mask (Flood Exposure).



- Once it is selected the parameters "Mask ID" and "Mask Thickness" disappear, as well as the tabs "Alignment" and "Alignment Views".

- The parameters within the groups "Tool Set" and "Wafer" require correct input.

11.4.2 Process Sequence

Preparation:

- Select a recipe with "Flood Exposure" application or create a new recipe for flood exposure.
- Start the process with the selected recipe.

NOTICE!

If a mask is loaded an error message will be displayed and the request to remove it.
A mask holder is allowed to be loaded.

- Load chuck and substrate
  As soon as both are inside the stage the aligner is ready for exposure.
- Start exposure with the key *[Exposure]*.
  The shutter will be opened and exposure takes place.
- At the end the shutter will be closed.
- The substrate is ready for unloading.

11.5 UV-LED Light Source

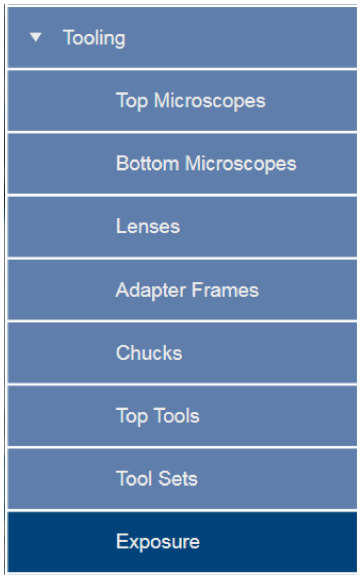
- The LED arrays provide a several wavelengths spectrum:
  - 365 nm (i-line)
  - 405 nm (h-line)
  - 436nm (g-line)
- The different wavelengths can be selected specifically and also adapted individually to a desired intensity. A combination to achieve a broadband illumination is also possible.
- The exposure spectrum can be tailored by software and stored for each process in the standard recipe file.

11.5.1 Service View for UV-LED Light Source

- Click the Service TAB:
  The service view is displayed at the GUI.

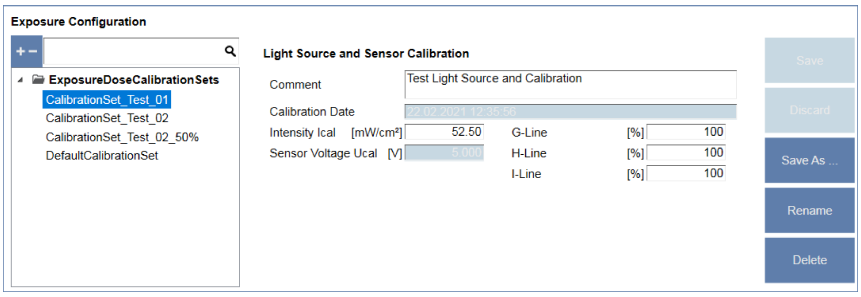


- Click „Tooling“.
  The drop down menu is expanded.



- Click „Exposure“:

- The page for "Exposure Configuration" and their parameters is displayed.



Exposure Configuration:

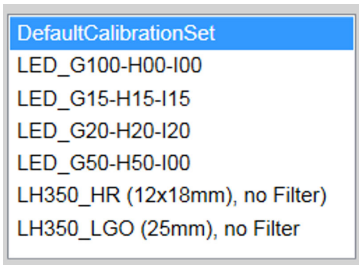
- List of all available configurations
  + default set to create a new configuration.

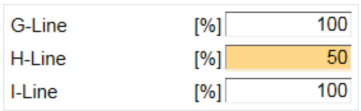
Light Source and Sensor Calibration:

- **G-Line; H-Line; I-Line**
  Input fields for desired current percentage (of total current) of each line that the light source should contain.
- **Comment**
  Input field for comments concerning the light source
- **Calibration Date**
  Display of last performed calibration
- **Intensity Ical**
  Input field for average intensity, measured with an external optometer
- **Sensor Voltage Ucal**
  Display of calibration data for sensor voltage

11.5.2 Creating a New Light Source

- Light source creation can be done in Service View/Tooling/ Page „Exposure“
- You need at least the user rights for „Application“ to create a new light source.
- Select a calibration set from the list. You can either use the default calibration set or any set you have already created.





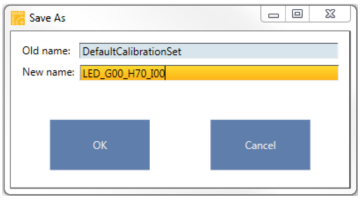
- Type in the desired values for the current percentages that you want to use with the light source.

NOTICE!

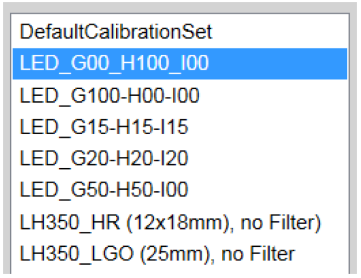
The current has an important influence on the life time of the LEDs. Using the maximum (100%) decreases the life time dramatically.
We recommend using a maximum of 70% and exposure times of at least 2 sec.



- Add a comment, if desired.



- Click the function key *[Save As]*.
- The Save As window opens requesting a new name for the light source.
- Type in the desired name and confirm with *[OK]*



- The name appears now in the list of available light sources.

NOTICE!

The next step has to be a calibration of this new light source.
(See chapter 11.3.2 Calibration of the Constant Dose Sensor)

11.6 First Mask Exposure

Introduction

The "First Mask" mode means the first lithography step where no previous pattern (with alignment targets) is on the substrate.

It depends on the requirements if this first lithography step shall be used without or with alignment.

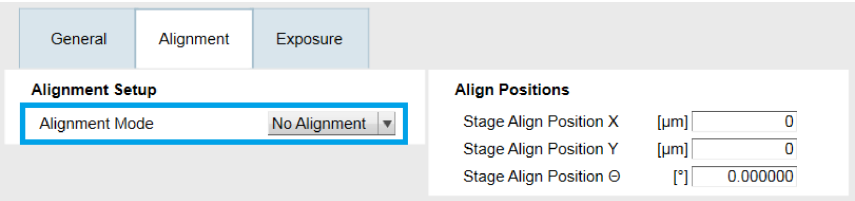
- If you do not need exact pattern positioning on the substrate you may use the "First Mask" mode without alignment.
- If it is important to define the position of the first pattern on the substrate and to do it reproducibly, you may use the "First Mask" mode with alignment to a so called "Golden Wafer".

11.6.1 First Mask without Alignment

First Mask without alignment provides a fast step for initial patterning of a substrate:

- No alignment step is performed.
- The process does not stop between substrate loading and exposure.

Preparation:



1. Create or use a recipe with the "Alignment Setup" parameter "Alignment Mode" set to --> No Alignment.

➡ The Tab "Alignment Views" disappears.
All other parameters in group "Alignment Setup" disappear.
In group "Align positions" only the "**Stage** Align Positions" are displayed.

2. Set all "Stage Align Positions to **"0"**.

➡ This setting ensures that the stage is in a center position and the mask is centererd to the substrate.

3. Load mask and start process.

4. After loading the substrate into the stage, the process runs automatically until the substrate is exposed and can be unloaded.

12 THE BOND ALIGN PROCESS

The MA/BA Gen4 can also be used as a tool for bond alignment. The process provides manual or automatic alignment from wafer to wafer and subsequent bonding of substrates.

The system can be ordered especially as bond alignment tool (BA Gen4) or as a combination of mask aligner and bond aligner (MA/BA Gen4).

Switching between the two processes is simple and can be performed quickly due to the modular concept of the machine.

12.1 Components for the Bond Align Process

If the machine is exclusively used for bond alignment, the components lamp house/ mirror house and lamp power supply are not present.

The bond aligner is equipped with BSA microscopes for alignment of lower side of the top substrate to lower side of the bottom substrate.

The heart of the bond aligner consists of:

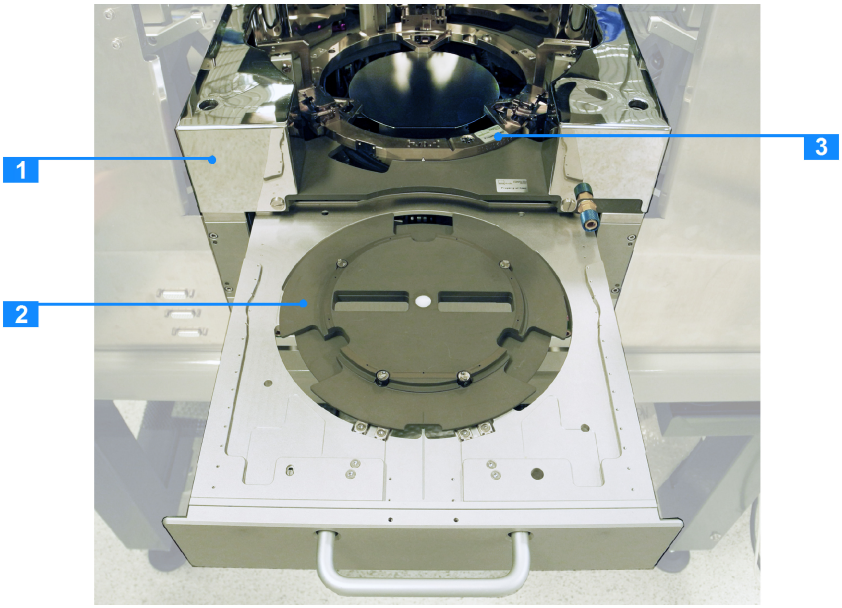


Fig. 12 - 1: Bond Alignment Components

1	**Alignment stage with bond adapter frame**
2	**Bond chuck**
3	**Bond transport fixture**

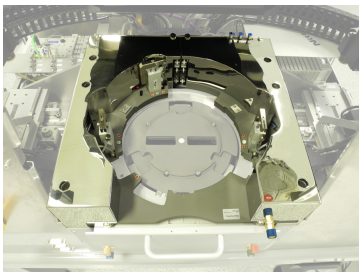
12.1.1 Bond Adapter Frame

The tool set for the bond alignment process requires a special adapter frame. The frame has an individual identification code for definition and control of the bond alignment process requirements.

The frame is able to support top tool identification.

Mounting/ removing of the adapter frame on top of the alignment stage can be easily performed with 4 screw bolts.

For adapter frame exchange it is necessary to switch off all valves supporting the top tool. This is done with the key *[All Adapter Valves Off]* which is accessible in dialog frame *"Change Tools"*.



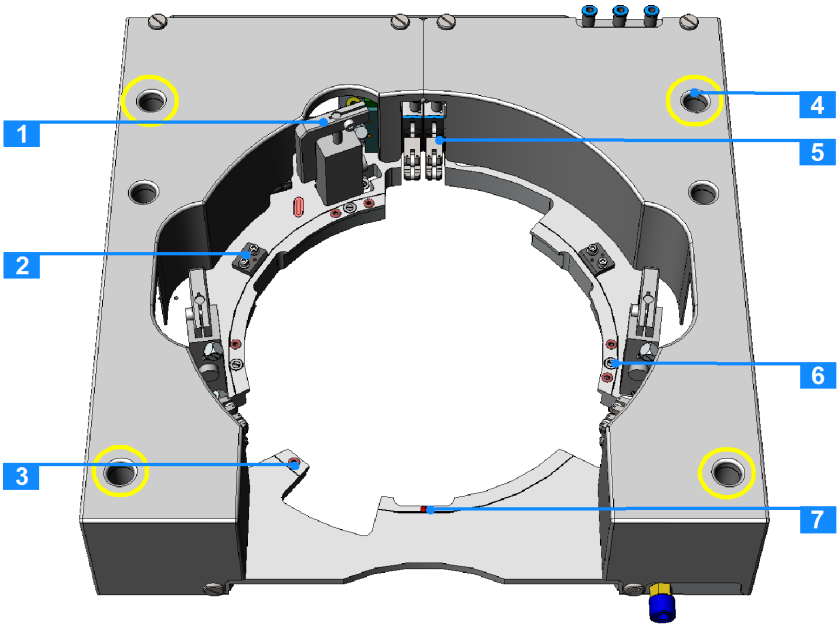


Fig. 12 - 2: Bond Adapter Frame

1	**Fixture clamping (3x)**
2	**Fixture positioning limit stops (2x)**
3	**Vacuum connections for substrate via fixture (6x)**
4	**Fixation screws for bond adapter frame in stage (4x; yellow circles)**
5	**Drives for fixture clamping/ spacer mechanics**
6	**Fixture posts (3x)**
7	**Fixture positioning pin**

12.1.2 Bond Transport Fixture

The transport fixture is housed in the recess of the adapter frame. The fixture is used to hold the substrates within the alignment stage and to transport the aligned substrate stack to the bonder.

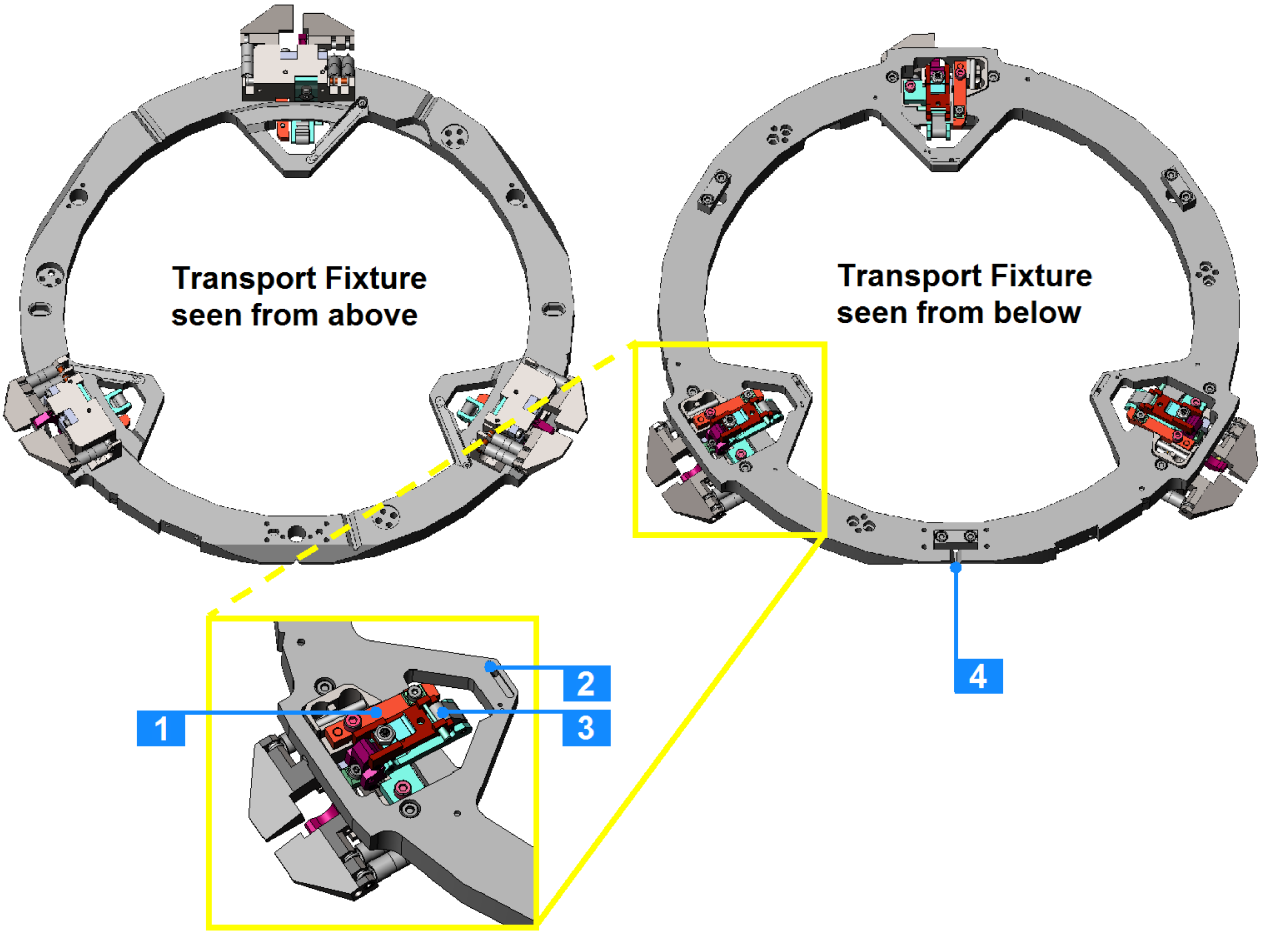


Fig. 12 - 3: Bond Transport Fixture

1	Spacer flag (3x)
2	Substrate vacuum area (3x)
3	Substrate clamp (3x)
4	Notch for positioning pin at bond adapter frame

12.1.3 Bond Chuck

The chuck is primarily used to load the substrates into the alignment stage and to hold the substrate for transfer to the fixture and during alignment.

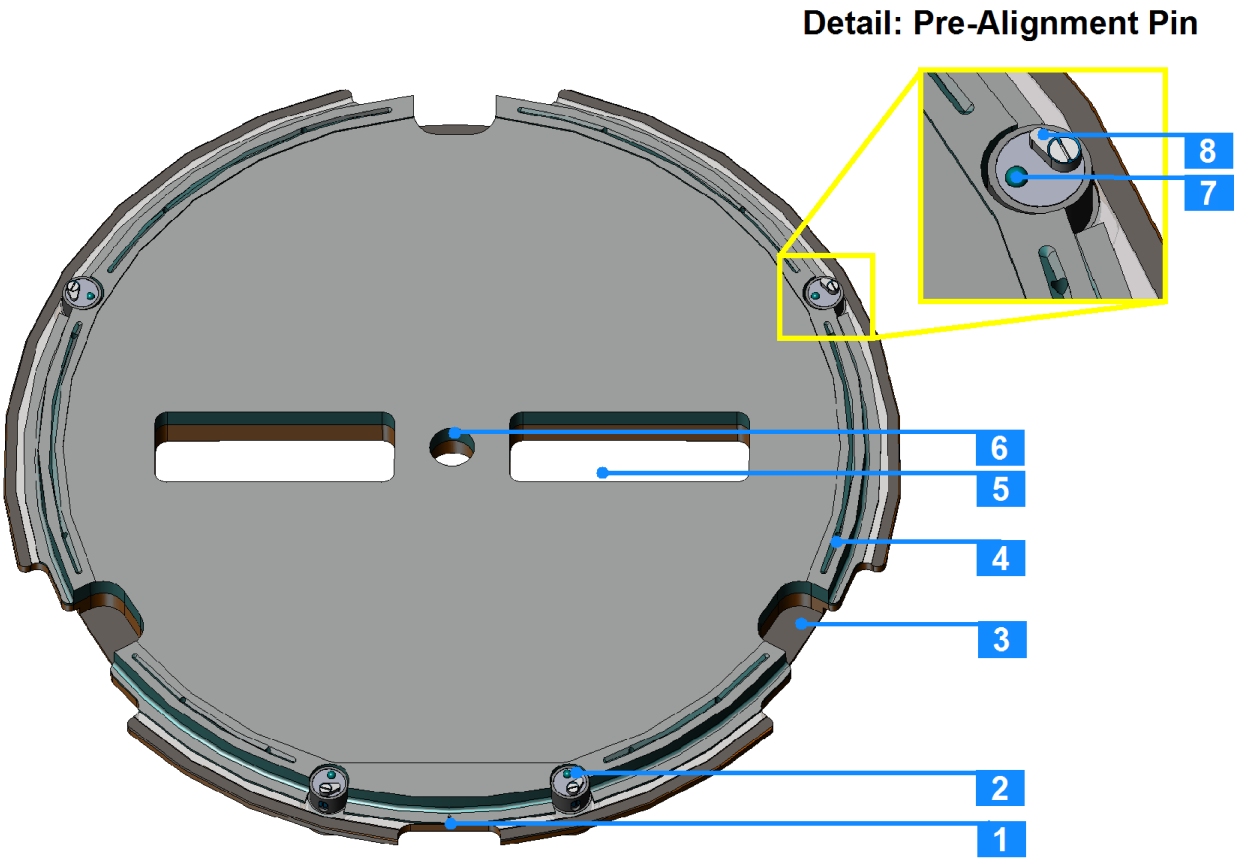


Fig. 12 - 4: Bond Chuck

1	**Marking for position in transport slide**	5	**Window for BSA-microscope**
2	**Pre-alignment pin**	6	**Adjustable center pin**
3	**Cut-out for substrate clamping of fixture**	7	**Steel ball**
4	**Vacuum channel for substrate fixation**	8	**Swivel-mounted alignment pin**

The pre-alignment pins of the chuck keep up the position of the substrate during its transport into the alignment stage.

They have to be adjusted to the individual customer's substrate dimensions (especially the flat):

- Put your substrate onto the chuck
- Loosen the screws of the swivel-mounted alignment pins
- Adjust the pins to your convenience and fix them with the screws.

12.2 Graphical User Interface in Bond Alignment Process

Some additional parameters and the tab *"Bond Alignment"* are present in recipe view if the process type **Bond Alignment** is selected.

Instead of "Mask" and "Wafer" the process substrates are named "Top Substrate" and "Bottom Substrate".

12.2.1 Parameters of the Tab *"General"* in Bond Align Recipe

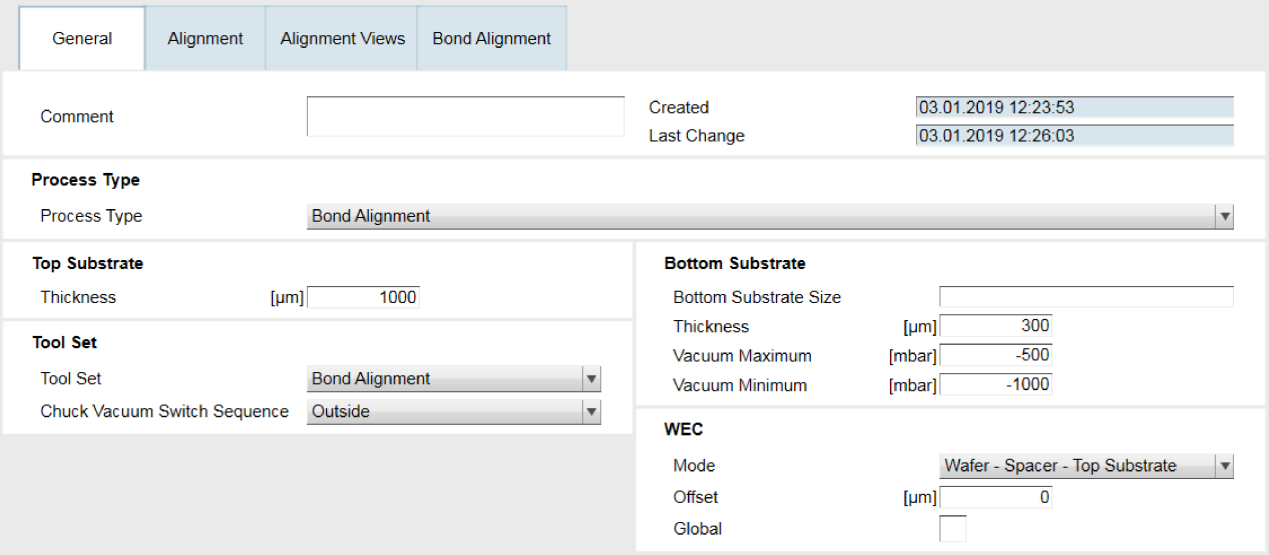


Fig. 12 - 5: Tab "General" in Bond Align Recipe

The selected *"Process Type"* has to be *"Bond Alignment"*.

Top Substrate

Thickness

Numeric Input Field

- All input values in [µm]
- Allowed values: 0 to 17.700
- The thickness of the top substrate can be entered via keyboard.
- The thickness specification is necessary to calculate the travel distance which the Z-axis moves fast until the speed is slowed down. This optimizes the throughput.
  If the thickness is set too high throughput will be decreased. If it is set too low an error may occur.

Bottom Substrate

Thickness

Numeric Input Field

- All input values in [µm]
- Allowed values: 0 to 17.700
- The thickness of the bottom substrate can be entered via keyboard.
- The thickness specification is necessary to calculate the travel distance which the Z-axis moves fast until the speed is slowed down. This optimizes the throughput.
  If the thickness is set too high throughput will be decreased. If it is set too low an error may occur.

Vacuum Minimum

Numeric Input Field

- All input values in [mbar]
- Allowed values: -1000 to 0
- Lower tolerance limit for substrate vacuum.
- If the value falls below the limit an error message will be displayed.

Vacuum Maximum

Numeric Input Field

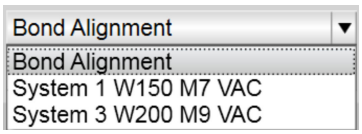
- All input values in [mbar]
- Allowed values: -1000 to 0
- Upper tolerance limit for substrate vacuum
- If exceeding the limit an error message will be displayed.

Tool Set

The group *"Tool Set"* defines parameters of the tool set components. The tool set determines the *"Process Type"* in which the MA/BA Gen4 works.

Tool Set

Drop Down Menu



- Selection of all available tool sets. Definition of the tool set is done in service view.
- The tool set has to be suitable for the selected *"Process Type"*. This is controlled by the software with individual identification codes. An error will be displayed if the components are not valid for bond alignment.
- Each tool set following components and conditions are assigned to:
  - Allowed top substrate load mode
  - Used adapter --> adapter frame has to support "bond alignment"
  - Used top tool --> top tool has to be a "fixture"
  - Used chuck

Chuck Vacuum Switch Sequence

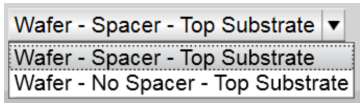


Drop Down Menu

- A selection in this menu is only possible if the tool set includes a special chuck (combination chuck for use with 2 substrate sizes).
- The combination chuck uses 2 independent vacuum circuits:
  - **Inside**
  - **Outside**
- In this menu you can choose whether only one of both shall be used (Inside/ Outside)
  - **Parallel**
- If a chuck has only one vacuum circuit (standard) *"Inside"* is automatically selected. The other options cannot be selected (crossed out).

WEC

WEC Mode



Drop Down Menu

- You can select if the wedge error compensation is performed in contact or if spacers between top and bottom substrate shall be used so set the parallelism.

  - Wafer - Spacer - Top Substrate
    Wedge error compensation with spacers in top tool
  - Wafer - No Spacer - Top Substrate
    Wedge error compensation in contact

NOTICE!
For wedge error compensation with spacers a top tool (fixture) with spacers has to be used.

WEC Offset

Numeric Input Field

- All input values in [µm]
- Allowed values: 0 to 1000
- Entry of a value greater than „0“ means that this value is added to the alignment gap and the contact position defined in the recipe.
  - Example:
    A WEC offset of 10 µm increases the alignment gap and the contact position about 10 µm.
- The entry of a value greater than „0“ can be necessary because of several reasons e.g.:
  - If one substrate is coated with a soft resist or glue the spacers could be pressed into the coating. This would lead to an alignment gap that is in reality smaller than the defined gap of the recipe.
  - During wedge error compensation a bending of the top substrate may take place which also leads to a smaller alignment gap.

NOTICE!

To measure the real distance between top and bottom substrate during the different process steps (wedge error compensation, alignment gap) it is recommended to check it from time to time with a suitable measuring device (e.g. Heidenhain).
This is also reasonable during development of new processes.

12.2.2 Parameters of the Tab *"Alignment"* in Bond Align Recipe

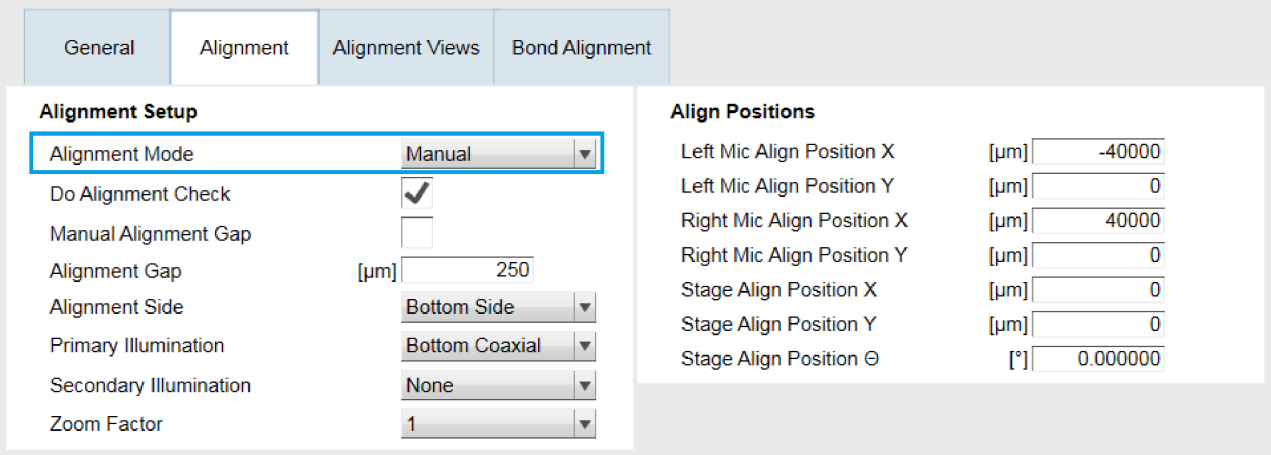


Fig. 12 - 6: Tab "Alignment" in Recipe View: Mode "Manual"

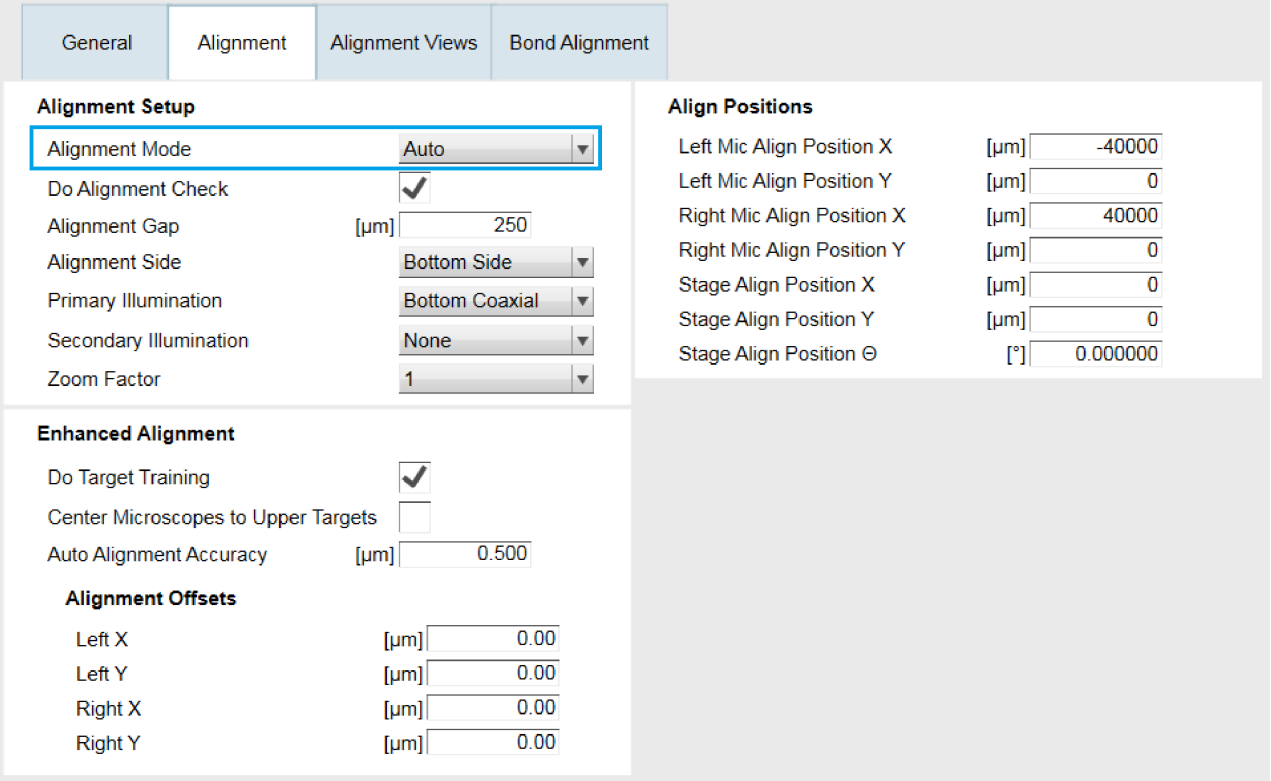


Fig. 12 - 7: Tab "Alignment" in Recipe View: Mode "Auto"

Most of the parameters are identical to the lithography process parameters.

Details see ↳ *Chapter 2.5.3 "Parameters of the Tab "Alignment"" on page 52*.

Some exceptions and restrictions are valid for the bond alignment process:

Alignment Gap

Numeric Input Field

- All input values in [µm]
- Allowed values: 0 to 1500
- Definition of alignment gap between top substrate and bottom substrate

If the parameter *"Clamping Mode"* in the recipe tab *"Bond Alignment"* is set to *"With Spacers"*, the minimum allowed alignment gap must be set to [Spacer Thickness + 31 µm]. Otherwise an error message will be displayed.

- The alignment mode "No Alignment" is not available for bond alignment.
- The check box *"Single Alignment Microscope"* is not available because this option cannot be used with BSA-microscopes.
- The only available "Alignment Side" is **Bottom Side.**
  In the bond alignment process the machine only works with bottom side microsopes. Top side microscopes cannot be used because of mechanical restrictions due to the bond align adapter frame.

12.2.3 Parameters of the Tab *"Alignment Views"* in Bond Align Recipe

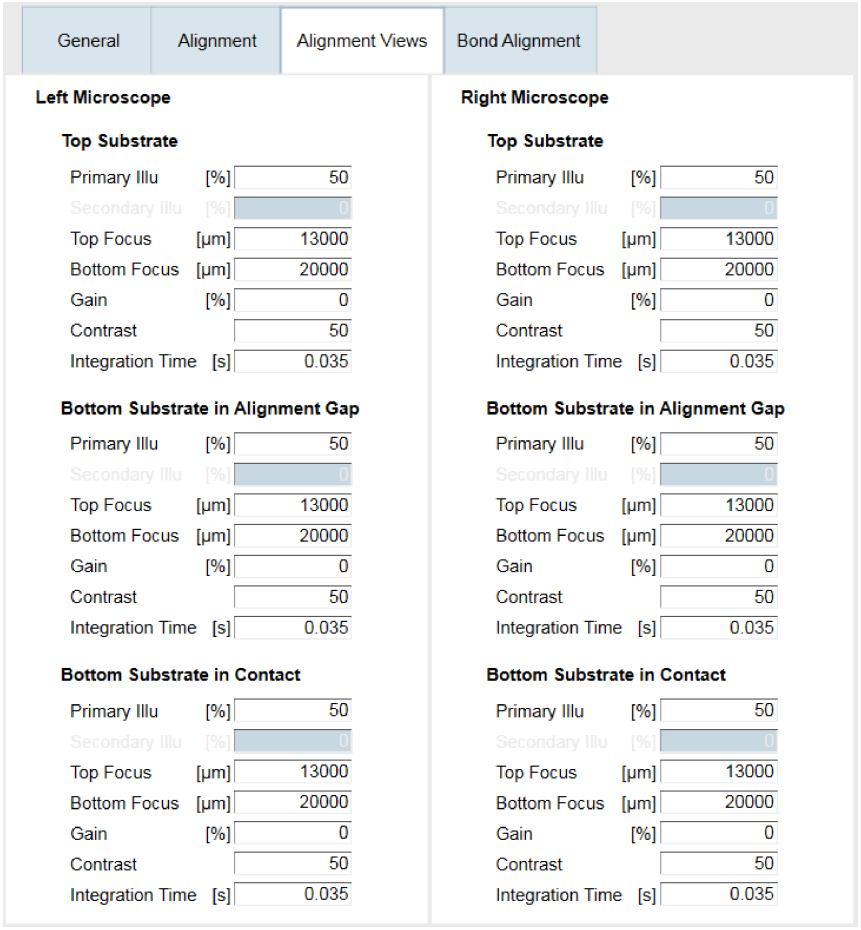


Fig. 12 - 8: Tab "Alignment Views" in Recipe View

All parameters of the tab *"Alignment Views"* refer to the corresponding focus position of left or right microscope

Details see ↳ *Chapter 2.5.4 "Parameters of the Tab "Alignment Views"" on page 57*

In "Bond Align" process only the naming of the focus positions is different:

Mask ➔ Top Substrate
Wafer ➔ Bottom Substrate
Wafer in Exposure Gap➔ Bottom Substrate in Contact

12.2.4 Parameters in Tab *"Bond Alignment"* in Bond Align Recipe

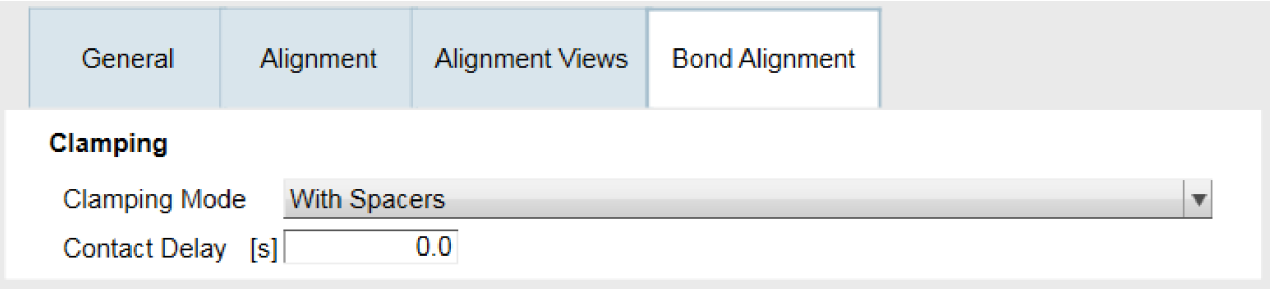
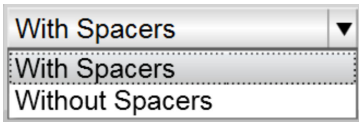


Fig. 12 - 9: Tab "Bond Alignment" in Recipe View

Clamping Mode



Drop Down Menu

Two clamping modes are available:

- **With Spacers**
  - The flags which are used as spacers during WEC, will remain between the two substrates.
  - The alignment gap has to be at least the spacer thickness + 30 µm to ensure that the spacers will not touch the upper substrate during alignment.
  - After alignment upper and lower substrate are moved in contact with spacers in between.
  - Finally the substrate stack is clamped.

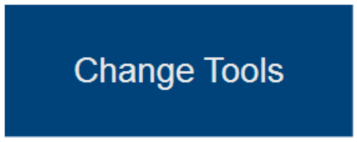
- **Without Spacers**
  - After WEC with spacers, the lower substrate is moved down into clearing distance and the spacers are removed.
  - Then the lower substrate is moved back into the alignment gap.
  - After alignment upper and lower substrate are moved into direct contact to eachother.
  - Finally the substrate stack is clamped.

Contact Delay

Numeric Input Field

- All input values in [s]
- Allowed values: 0 to 300
- Delay after Z-axis has been moved into contact position and before clamping of the substrate stack is performed.

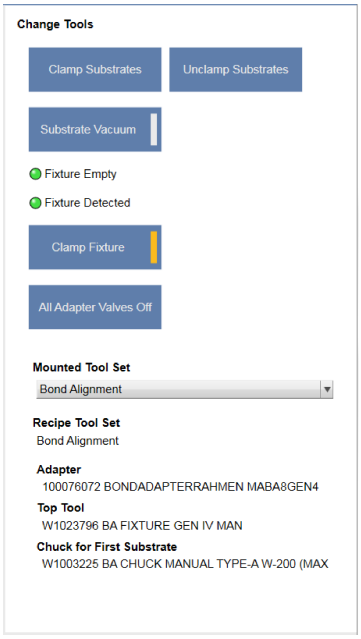
12.2.5 Dialog Frame *“Change Tools”* in Bond Align Mode



Function Key

- As soon as the function key, displayed in the dialog frame of the start screen is clicked, the view will be switched to the dialog frame *“Change Tools”*.

Change Tools



Dialog Frame

- The user guidance shows in this view that:
  - the substrates can be clamped or unclamped.
  - substrate vacuum can be switched on and off.
  - the fixture can be clamped.
  - all adapter valves can be switched off.
  - with*[Next]* you can return to the start screen.

- Two sensor displays (LEDs) show:
  - whether the fixture is empty or not (*“Fixture Empty”*).
  - whether a fixture is detected (*“Fixture Detected”*).
  - Sensor display "red": fixture is not empty.
  - Sensor display "gray“: no fixture.
  - Sensor display "green“: fixture is empty/ fixture detected.

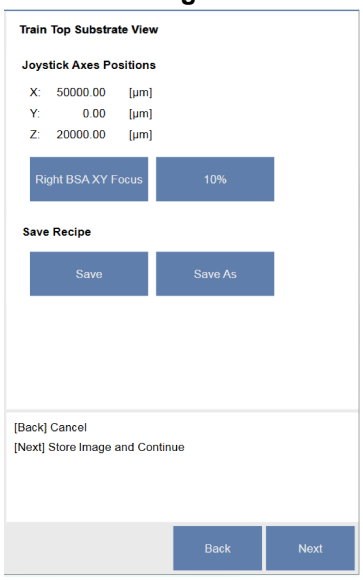
- With the drop down menu *“Mounted Tool Set”* the currently used tool set can be selected.
- The information below shows the tool set of the currently selected recipe *“Recipe Tool Set”*, consisting of:
  - Adapter Frame
  - Top Tool
  - Chuck

NOTICE!

If *“Mounted Tool Set”* and *“Recipe Tool Set”* are not identical, an error will be displayed on the start screen.

12.2.6 Dialog Frame *"Train Top Substrate View"* in Bond Align Mode

TrainTop Substrate View for Manual Alignment



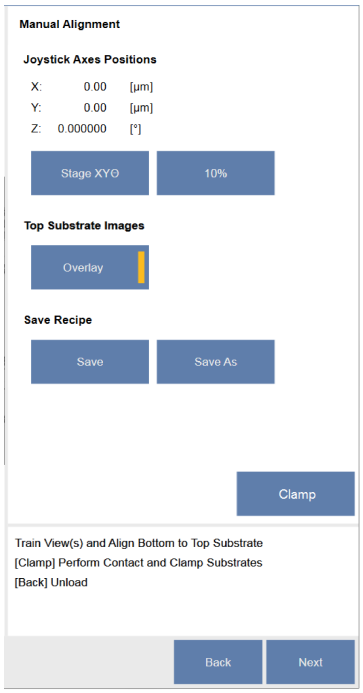
Dialog Frame

- The dialog frame, shows in this view that:
  - the joystick axes can be assigned to *[Left BSA XY Focus]* and *[Right BSA XY Focus]*.
  - the joystick speed can be adapted to different speeds (e.g 10%, Single Step, 100%).
  - the changes can be saved either in the currently used recipe with *[Save]* or in a new recipe with *[Save As]*.

- The user guidance displays:
  - **"[Back] Cancel"**
  - **"[Next] Store Image and Continue"**

12.2.7 Dialog Frame *"Manual Alignment"* in Bond Align Mode

Manual Alignment



Dialog Frame

- The dialog frame shows in this view that:
  - the joystick axes can be assigned to *[Stage XYΘ]*, *[Left BSA Focus]*, *[Right BSA Focus]* and *[Both BSA Focus]*.
  - the joystick speed can be adapted to different speeds (e.g 10%, Single Step, 100%).
  - with the function key *[Overlay]*the "grabbed" images of the top substrate can be overlain the live images of the bottom substrate
  - the changes can be saved either in the currently used recipe with *[Save]* or in a new recipe with *[Save As]*.
  - with the function key *[Clamp]* the substrate stack can be clamped.

- The user guidance displays:
  - **"Train View(s) and Align Bottom to Top Substrate"**
  - **"[Clamp] Perform Contact and Clamp Substrates"**
  - **"[Back] Unload"**
  - **"[Next] Perform Contact and Check Alignment"** *

* This instruction and also the function key *[Next]* are only present if check box *"Do Alignment Check"* is checked.

12.2.8 Dialog Frame *"Train Positions and Views"* in Bond Auto Align Mode

Train Positions and Views for Auto Alignment



Dialog Frame

- The dialog frame shows in this view that:
  - the joystick axes can be assigned to *[Stage XYΘ]*, *[Left BSA Focus]*, *[Right BSA Focus]* and *[Both BSA Focus]*.
  - the joystick speed can be adapted to different speeds (e.g 10%, Single Step, 100%).
  - with the function key *[Overlay]* the "grabbed" images of the top substrate can be overlain the live images of the bottom substrate.
  - the changes can be saved either in the currently used recipe with *[Save]* or in a new recipe with *[Save As]*.
  - with the function key *[Clamp]* the substrate stack can be clamped immediately and will be prepared for unload.

- The tab *"Target"* gives access to the target training of left/right bottom substrate targets.
- The tab *"Settings"* gives access to input alignment offsets and auto alignment accuracy.

- The user guidance displays:
  - **"Train Positions and View(s)"**
  - **"[Clamp] Perform Contact and Clamp Substrates"**
  - **"[Back] Unload"**
  - **"[Next] Start Auto Alignment"**

12.3 Bond Align Process Sequence

12.3.1 Prepare Process

After switching on and initializing the machine (details see *Chapter 4 “POWER-ON and PROCESS PREPARATION” on page 82*) select a recipe which is suitable for bond align process.

- Process Type: 'Bond Alignment'
- Tool Set: 'Bond Alignment'
- WEC Mode: Select with or without spacers
- Alignment Setup: Select Manual or Auto
- Clamping: Select with or without spacers

If the mounted tool set does not correspond with the selected tool set change tool set (see *Chapter 2.4.2 “Dialog Frame “Change Tools”” on page 39*

Load Fixture

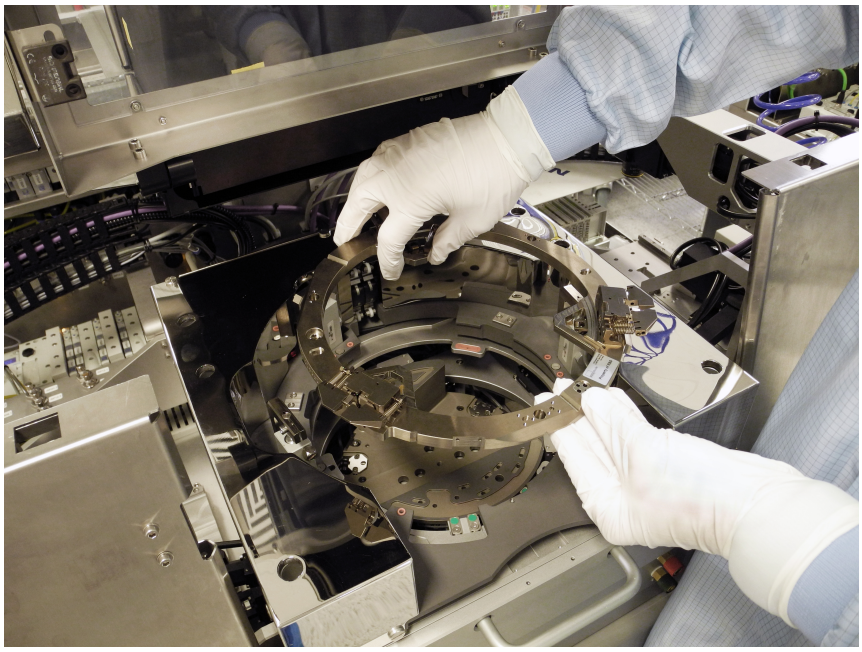


Fig. 12 - 10: Load Bond Fixture

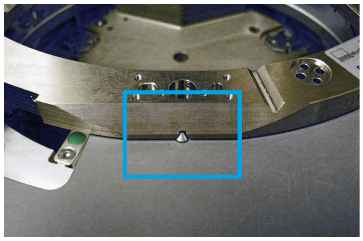
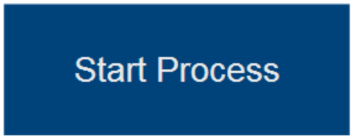


Fig. 12 - 11: Fixture adjusted

- Load the bond fixture into the bond adapter.
- For right orientation adjust the bond fixture with its notch to the pin at the bond adapter (see Fig.11-11).)

12.3.2 Start Bond Align Process



- Click the function key *[Start Process]*
- The dialog frame shows: **Load Fixure**.
  The fixture is clamped in the bond adapter and is fixed in a defined position.

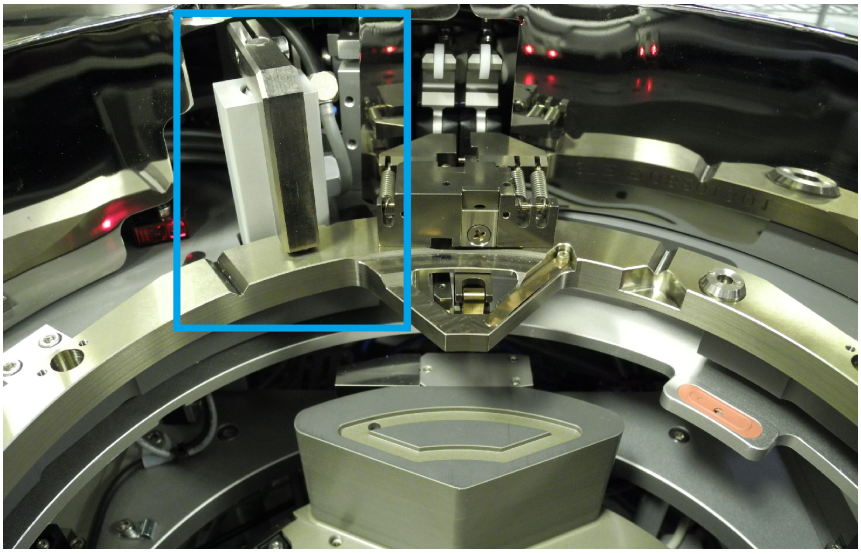
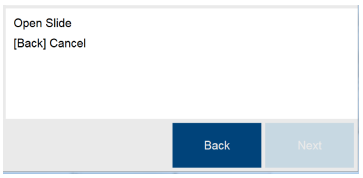


Fig. 12 - 12: Detail: Fixture clamped in bond adapter

- The process for the selected recipe is started.
- Finally the dialog frame shows: **Load**

12.3.3 Load Top Substrate

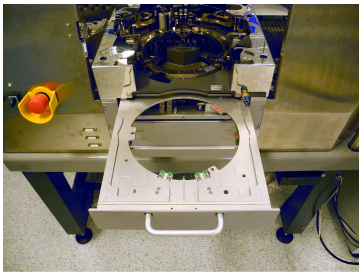
Load Substrate



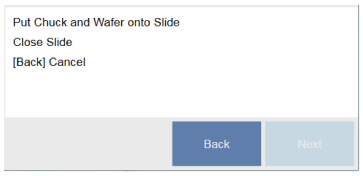
1. Open transport slide (pull forwards).

- After process start the user guidance shows:

  „Open Slide“
  „[Back] Cancel“



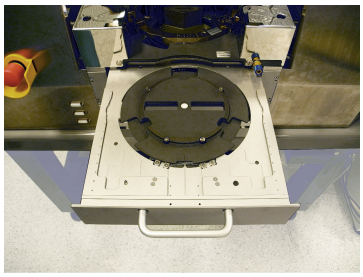
- Pull transport slide with handle forward.



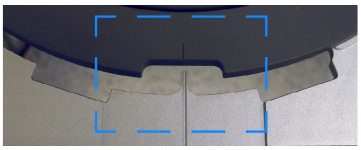
2. Load chuck and substrate onto the transport slide.

- The user guidance shows:

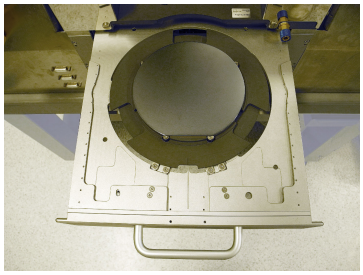
  „Put Chuck and Wafer onto Slide“
  „Close Slide“
  „[Back] Cancel“



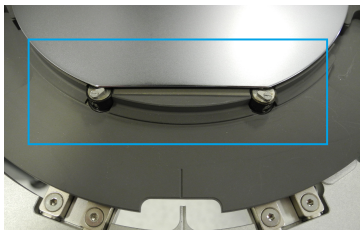
- Load the chuck on the transport slide.



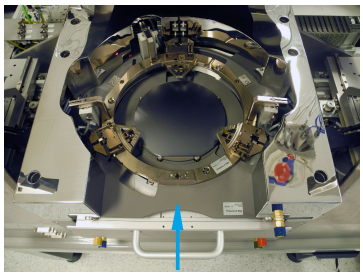
- Take care that the marking on the chuck is adjusted to the marking of the transport slide.



- Put the top substrate upside down onto the chuck.



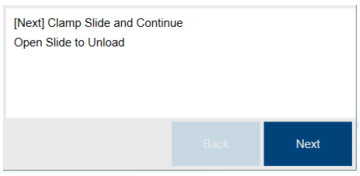
- Take care to load the substrate exactly onto the chuck with flat towards the operator.



3. Close transport slide (push backwards).

- Push transport slide with handle backwards.

  Be sure to move the slide all the way back to the stop.



4. Clamp transport slide.

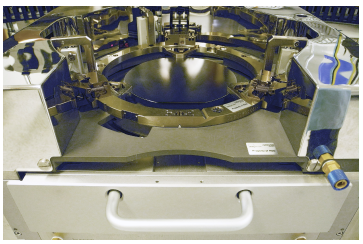
- The user guidance shows:

  „[Next] Clamp Slide and Continue“
  „Open Slide to Unload“



- Click function key *[Next]*

  Clamping of the transport slide is activated.
- Once the transport slide is clamped, the Z-axis moves chuck and substrate upward.



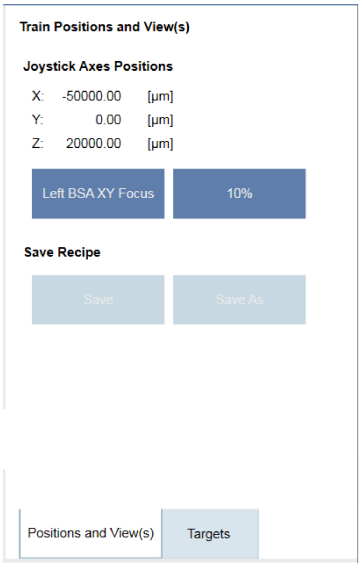
- The substrate will be transfered to the fixture and fixed with vacuum.
- Then the Z-axis moves downward.

12.3.4 Prepare for Alignment

Depending on the selected alignment mode, different views will be presented in the dialog frame.

Auto Alignment Mode

Train Positions and Views

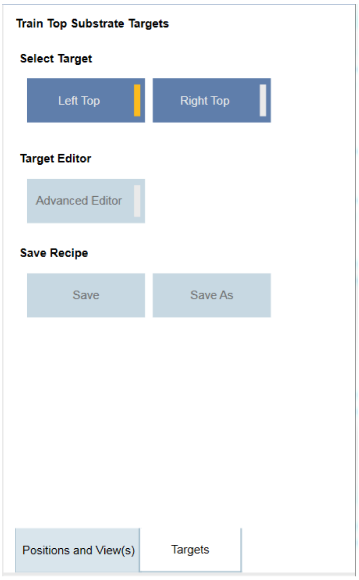


The dialog frame **Train Position and View(s)** displays the "Positions and View(s)" view for BSA alignment.

- Train positions and views for left and right BSA-microscopes according to mask training.

  Details see *Chapter 8.3.2 “Training of Positions and Views for Mask Targets” on page 136*

Train Top Substrate Targets



Open target training view:

- Click the Tab [Targets] to get access to the "Train Top Substrate Targets" view.



- Train each target for *[Left Top]* and *[Right Top]* according to "Mask Target Model Training".

  Details see *Chapter 8.3.3 “Training of Mask Target Model and Search Region” on page 137*

- Go back to the Tab [Positions and View(s)]



- Click *[Next]* to store the images.
- A test seach of the top targets is performed.

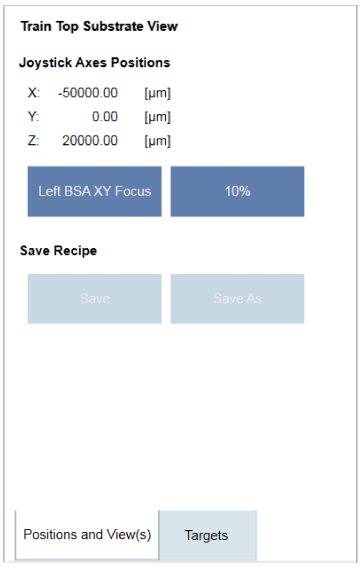
- The user guidance shows:

  „Open Slide“
  „[Back] Cancel“

Proceed with loading the bottom substrate.

Manual Alignment Mode

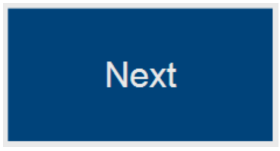
Train Top Substrate View



The dialog frame **Train Top Substrate View** displays the view of each microsope for BSA-alignment.

- Adjust the view (X,Y and Focus) for each left and right BSA-microscope .

  Details see *Chapter 8.3.2 “Training of Positions and Views for Mask Targets” on page 136*



- Click *[Next]* to store the images.

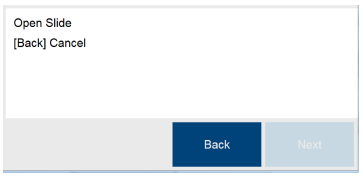
- The user guidance shows:

  „Open Slide“
  „[Back] Cancel“

Proceed with loading the bottom substrate.

12.3.5 Load Bottom Substrate

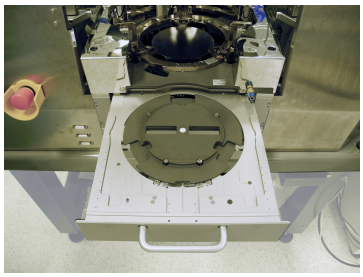
Load Substrate



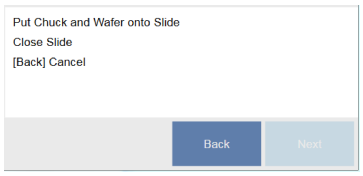
1. Open transport slide (pull forwards).

- The user guidance shows:

  „Open Slide“
  „[Back] Cancel“



- Pull transport slide with handle forward.

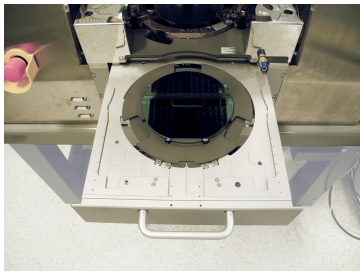


2. Load the bottom substrate onto the transport slide.

- The user guidance shows:

  „Put Chuck and Wafer onto Slide“
  „Close Slide“
  „[Back] Cancel“

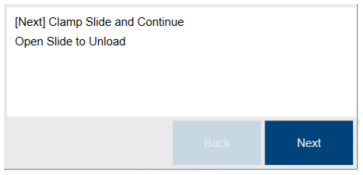
- Put the bottom substrate onto the chuck.



3. Close transport slide (push backward).

- Push transport slide with handle backward.

  Be sure to move the slide all the way back to the stop.



4. Clamp transport slide.

- The user guidance shows:

  „[Next] Clamp Slide and Continue“
  „Open Slide to Unload“



- Click function key *[Next]*

  Clamping of the transport slide is activated.
- Once the transport slide is clamped, the Z-axis moves chuck and substrate upward.
- Wedge error compensation between top and bottom substrate takes place and the bottom substrate is moved to alignment gap.
  Depending on the selected clamping mode, the spacers are removed or stay between top and bottom substrate.
  Details see ↳ *Further information on page 184*

12.3.6 Align Substrates

Depending on the selected alignment mode, different views will be presented in the navigation/dialog frame.

Auto Alignment Mode

Train Positions and Views

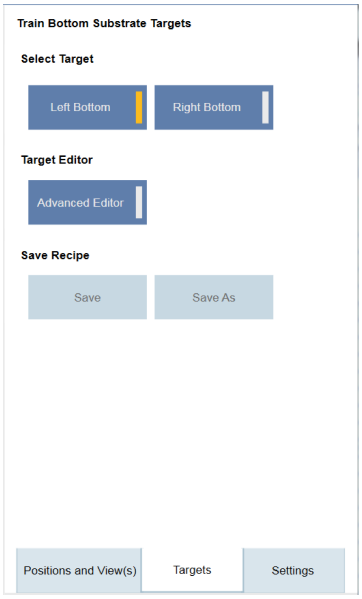


The navigation/dialog frame **Train Position and View(s)** displays the "Positions and View(s)" view for BSA-alignment.

- Train focus positions of the BSA-microscopes and prealign bottom substrate target positions according to BSA-training of bottom substrate.

  Details see *Chapter 8.3.4 “Training of Positions and Views for Wafer Targets” on page 141*

Train Bottom Substrate Targets



Open target training view:

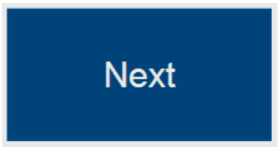
- Click the Tab [Targets] to get access to the "Train Bottom Substrate Targets" view.



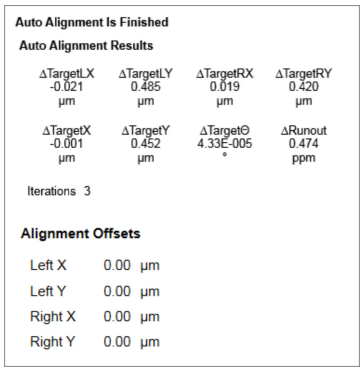
- Train each target for *[Left Bottom]* and *[Right Bottom]* according to "Wafer Target Model Training".

  Details see *Chapter 8.3.5 “Training of Wafer Target Model and Search Region” on page 143*

- Go back to the Tab [Positions and View(s)]



- Click the function key *[Next]* to start Auto Alignment.



- Auto Alignment is performed and when finished all alignment data are displayed in the navigation/dialog frame.
- Top and bottom substrate are still in alignment gap.



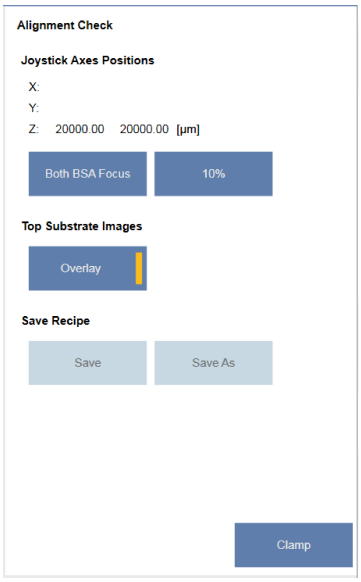
- The user guidance shows:

  „[Clamp] Perform Contact and Clamp Substrate“
  „[Next] Perform Contact and Check Alignment" *
  „[Back] Return to Auto Alignment Training“

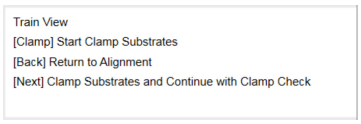
  * This instruction and the function key *[Next]* are only present if in the process recipe the check box *“Do Alignment Check”* is checked.



- Click the function key *[Next]*.

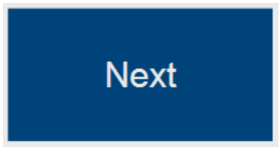


- The bottom substrate is moved into contact with the top substrate, depending on the selected contact mode with or without spacers in between.
- The navigation/dialog frame displays the "Alignment Check". (Only if check box *“Do Alignment Check”* is checked in the process recipe.)

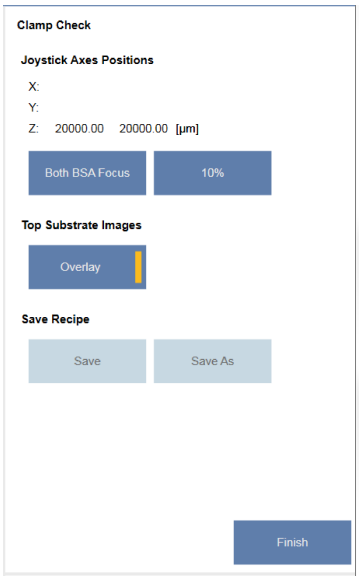


- The user guidance shows:

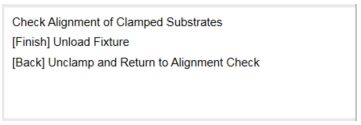
  „Train View"
  „[Clamp] Start Clamp Substrate“
  „[Back] Return to Alignment“
  „[Next] Clamp Substrates and Continue with Clamp Check"
- You may adjust the focus positions of the BSA-microscopes for this contact position with the toggle button and save them in the recipe.
- You may start the clamping sequence with *[Clamp]*.
- If alignment was not sufficient click *[Back]* to return to the alignment step.



- Click the function key *[Next]*.
- The clamping sequence starts to clamp the substrate stack in the fixture.



- The sequence stops at the "Clamp Check" to enable checking the alignment after the clamping. (Only if check box *“Do Alignment Check”* is checked in the process recipe.)



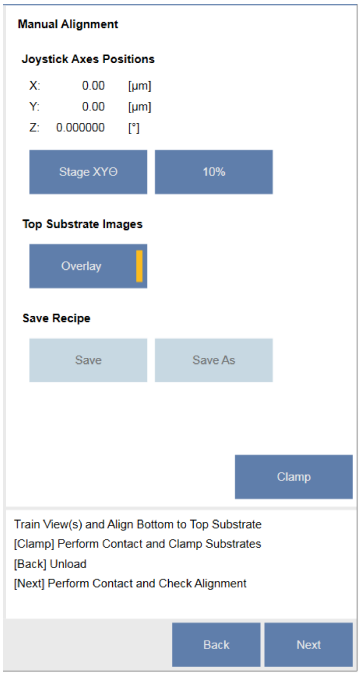
- The user guidance shows:

  „Check Alignment of Clamped Substrate"
  „[Finish] Unload Fixture“
  „[Back] Unclamp and Return to Alignment Check“

- You may finally check the alignment before unloading the substrate stack with the fixture.
- If alignment is not sufficient click *[Back]* to unclamp and to return to the alignment check.

Manual Alignment Mode

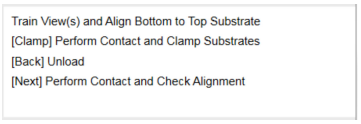
Manual Alignment



The navigation/dialog frame **Manual Alignment** displays all function keys that are necessary to perform manual alignment..

- Train focus positions of the BSA-microscopes and align bottom to top substrate according to manual BSA-alignment.

  Details see ↳ *Chapter 7.3.6 “Align Substrate to Mask” on page 115*.



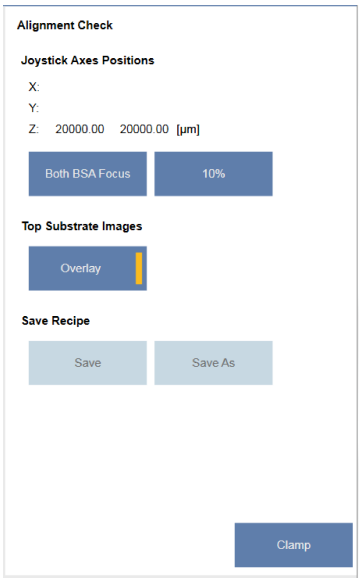
- The user guidance shows:

  „Train View(s) and Align Bottom to Top Substrate"
  „[Clamp] Perform Contact and Clamp Substrates“
  „[Back]Unload“
  „[Next] Perform Contact and Check Alignment" *

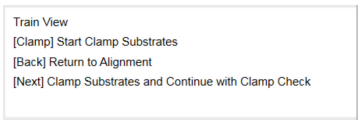
  * This instruction and the function key *[Next]* are only present if in the process recipe the check box *“Do Alignment Check”* is checked.



- Click the function key *[Next]*.



- The bottom substrate is moved to contact position and the navigation/ dialog frame *"Alignment Check"* is displayed.
  (Only if check box *"Do Alignment Check"* is checked in the process recipe.)
- If necessary re-adjust focus.

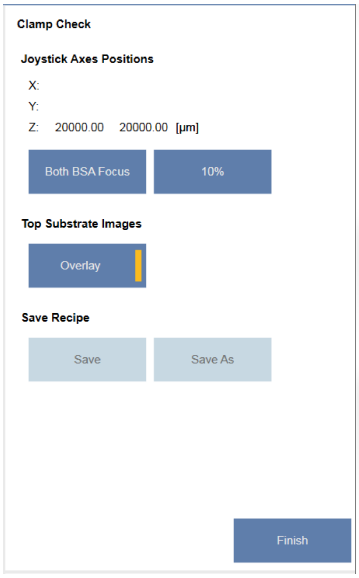


- The user guidance shows:

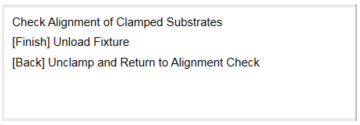
  „Train View"
  „[Clamp] Start Clamp Substrates"
  „[Back] Return to Alignment"
  „[Next] Clamp Substrates and Continue with Clamp Check"



- Click the function key *[Next]*.



- Clamping is performed and the navigation/ dialog frame *"Clamp Check"* is displayed.
  (Only if check box *"Do Alignment Check"* is checked in the process recipe.)
- If necessary re-adjust focus.



- The user guidance shows:

  „Check Alignment of Clamped Substrates"
  „[Finish] Unload Fixture“
  „[Back] Unclamp and Return to Alignment Check“
- You may finally check the alignment before unloading the substrate stack with the fixture.
- If alignment is not sufficient click *[Back]* to unclamp and to return to the alignment check.

12.3.7 Unload Fixture



- Finally click the function key *[Finish]*.

- The clamping sequence will be terminated and the fixture clamping in the adapter frame will be released.
- The fixture with the substrate stack is ready for unload.

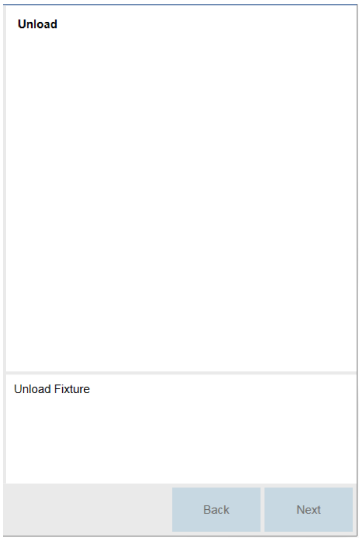


Fig. 12 - 13: 37_Unload-UnloadFixture

- The navigation/dialog frame shows "Unload"
- The user guidance shows:

  "**Unload Fixture**".



Fig. 12 - 14: Remove Fixture with Clamped Substrate Stack

- Unload the fixture from the adapter frame.

Fixture with Substrate Stack:

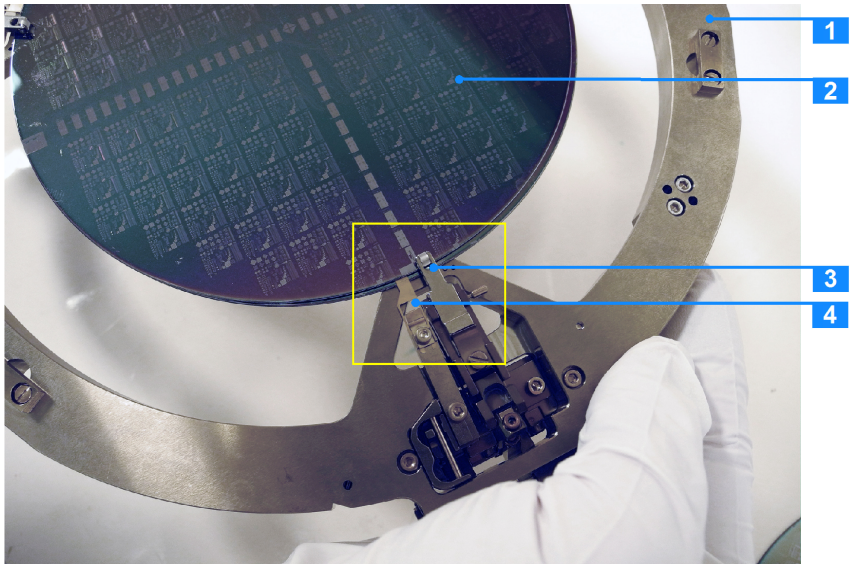
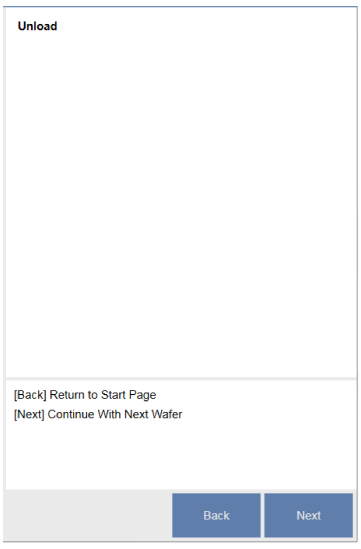


Fig. 12 - 15: Detail of Substrate Stack in Fixture

1	**Fixture (seen from below)**
2	**Substrate Stack**
3	**Clamping Mechanism**
4	**Spacer between Top and Bottom Substrate**

As soon as the fixture has been removed from the adapter frame the function keys *[Back]* and *[Next]* become operable.



- The user guidance shows:

  „[Next] Continue With Next Wafer"
  „[Back] Return to Start Page“

- Click *[Next]* to load a fixture and process the next substrates.
- Click *[Back]* to return to start screen.

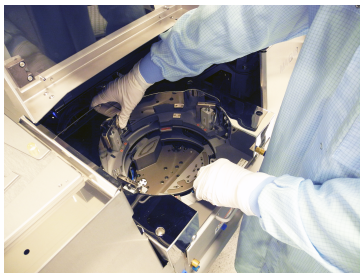
12.4 Tooling Exchange

To switch from mask aligner mode to bond align mode an exchange of 3 components is necessary:

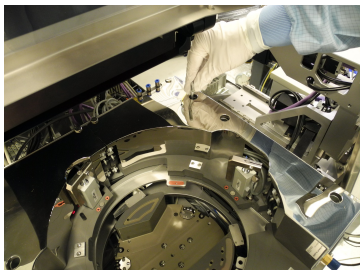
- Bond adapter frame
- Bond transport fixture
- Bond chuck

Exchange Procedure:

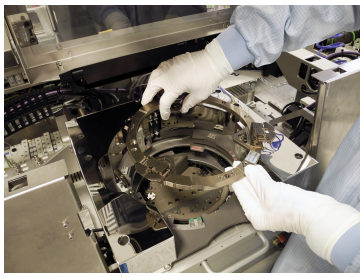
1. Unscrew the 4 mounting screws of the mask adapter frame.
2. Remove the mask adapter frame from the stage.



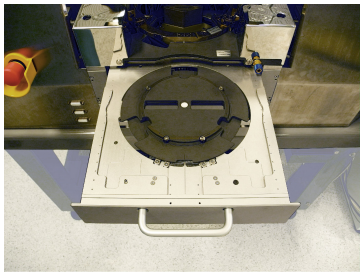
3. Load the bond adapter frame onto the stage.



4. Tighten the 4 screws of the adapter frame to fix it on the alignment stage.



5. Load the bond fixture into the bond adapter frame.
6. After process start the fixture will be clamped in the adapter frame.



7. The bond chuck can be loaded.

13 IMPRINT PROCESSES

Special substrate conditions such as uneven or warped wafers, materials like glass, sapphire, II-V compounds and challenging structure properties such as high aspect ratios, small feature sizes or non-periodic structures, place high demands on imprint processes and equipment. The variety of parameters to be selected during the imprint process offer the flexibility to cover a wide range of applications.

13.1 Graphical User Interface - GUI for Imprint Processes

13.1.1 Parameters of the Tab *"General"* in Imprint Recipe

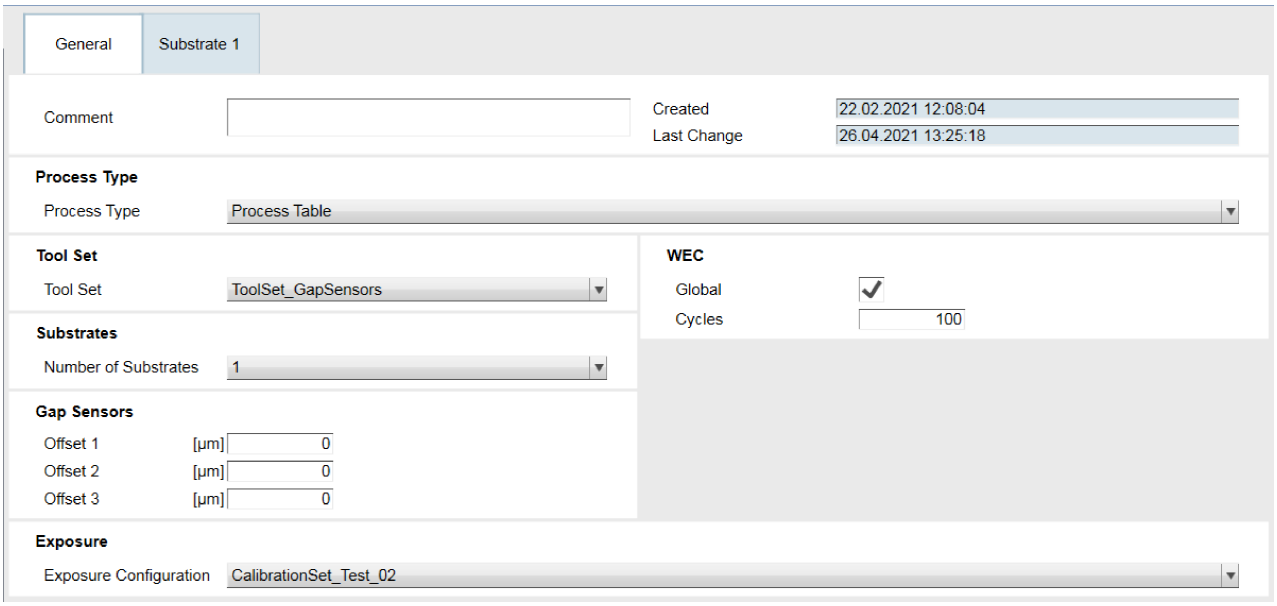


Fig. 13 - 1: "General" in Imprint Recipe

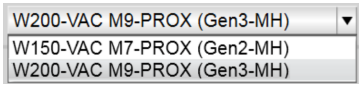
The selected *"Process Type"* has to be *"Process Table"*.

Tool Set

The group *"Tool Set"* defines parameters of the tool set components. The tool set determines the *"Process Type"* in which the MA/BA Gen4 works.

Tool Set

Drop Down Menu



- Selection of all available tool sets. Definition of the tool set is done in service view.
- The tool set has to be suitable for the selected *"Process Type"*. This is controlled by the software with individual identification codes. An error will be displayed if the components are not valid for the required process type.
- Each tool set following components and conditions are assigned to:
  - Allowed top substrate load mode
  - Used adapter --> adapter frame has to be a mask holder adapter
  - Used top tool --> top tool has to be a mask holder or a special imprint top tool
  - Used chuck
  - Minimum allowed gap measurement position (for active gap setting)

Substrates

The group *"Substrate"* defines the number of substrates which shall be processed within one process cycle.
The drop down menu shows only "1" within this software version.

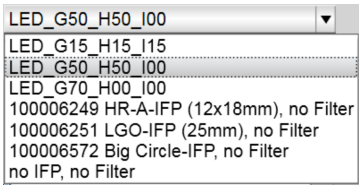
In future up to 3 substrates shall be able to be selected to enable a stacking process.

Exposure

The group *"Exposure"* defines the parameters of the exposure optics for the UV-lamp houses or the individual UV-LED combinations for the UV-LED light source.

Exposure Configuration

Drop Down Menu



- Selection of all available exposure configurations. Definition of the configuration is done in service view.
- The exposure configuration has to be suitable for the built in lamp house/ light source .
- If the mask aligner is equipped with a UV-LED light source, the individually created combination of the LEDs can be selected with this drop down menu. *Chapter 11.5.2 "Creating a New Light Source" on page 171*

13.1.2 Parameters of the Tab *"Process Settings"* in Imprint Recipe

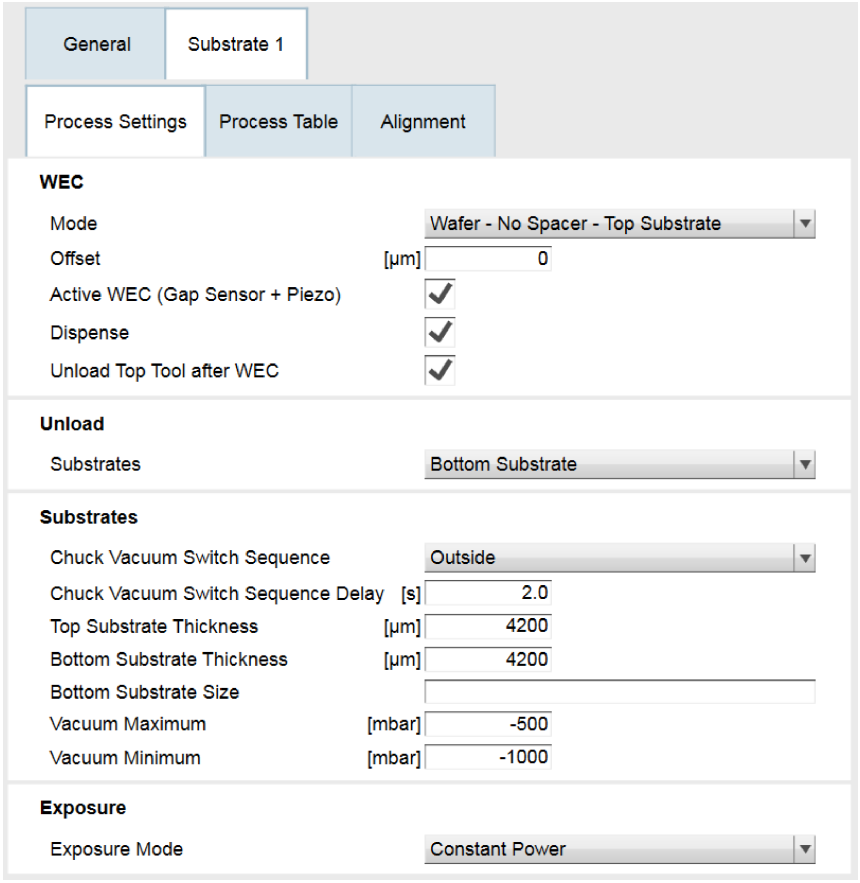
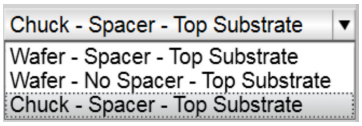


Fig. 13 - 2: "Process Settings" in Imprint Recipe

WEC

Mode



Drop Down Menu

- You can select if the wedge error compensation is performed in contact, if spacers between mask and substrate shall be used to set the parallelism or if you use the non-contact gap setting mode.
-
  - **Wafer - Spacer - Top Substrate**
    Wedge error compensation with spacers in mask holder
  - **Wafer - No Spacer - Top Substrate**
    Wedge error compensation in contact
  - **Chuck - Spacer - Top Substrate**
    Wedge error compensation for non-contact gap setting.

WEC Offset

Numeric Input Field

- All input values in [µm]
- Allowed values: -1000 to 1000
- Entry of a value greater than „0“ means that this value is added to the alignment gap defined in the recipe.
  - Example:
    A WEC offset of 10 µm increases the alignment gap about 10 µm.
- The entry of a value greater than „0“ can be necessary because of several reasons e.g.:
  - If a very soft photo resist is used the spacers could be pressed into the resist. This would lead to a alignment gap that is in reality smaller than the defined gap of the recipe.
  - During wedge error compensation a mask bending may take place which also leads to a smaller alignment gap.

NOTICE!

To measure the real distance between mask and wafer during the different process steps (wedge error compensation, alignment gap, exposure gap) it is recommended to check it from time to time with a suitable measuring device (e.g. Heidenhain).
This is also reasonable during development of new processes.

Active WEC (Gap Sensor + Piezo)

Check Box

- if checked, active gap setting is enabled.
- the actual gap between lower and upper substrate is measured by gap sensors.
- Fine positioning of lower to upper substrate is performed by piezos.
- For a detailed description of the active gap setting see *Chapter 13.2 “Active Gap Setting” on page 214*

Dispense

Check Box

- if checked, the process stops after WEC and the lower substrate can be moved out for dispense.

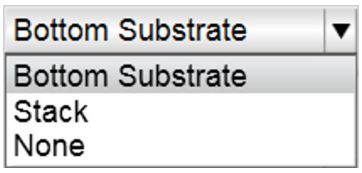
Unload Top Tool after WEC

Check Box

- This check box is only visible if the check box *“Dispense”* is checked.
- This option is only available for special toolings.
- If checked, the top tool with upper substrate can be removed to dispense a droplet onto the upper substrate.

Unload

Substrates



Drop Down Menu

Select what to be unloaded at the end of the process.

- **Bottom Substrate**
  Only the lower substrate is unloaded, the upper substrate remains on the upper tooling.
- **Stack**
  The stacked substrates (upper and lower) are unloaded together.
- **None**
  Both substrates remain in the machine after end of process.

Substrates

Chuck Vacuum Switch Sequence



Drop Down Menu

- A selection in this menu is only possible if the tool set includes a special chuck (combination chuck for use with 2 substrate sizes).
- The combination chuck uses 2 independent vacuum circuits:
  - **Inside**
  - **Outside**
- In this menu you can choose whether only one of both shall be used (Inside/ Outside)
  - **Parallel**
- If a chuck has only one vacuum circuit (standard) automatically „Inside“ is selected. The other options cannot be selected (crossed out).

Chuck Vacuum Switch Sequence Delay

Numeric Input Field

- All values in [s]
- Allowed values: 0 - 100

Top Substrate Thickness

Numeric Input Field

- All input values in [µm]
- Allowed values: 0 to 17.700
- The thickness of the top substrate can be entered via keyboard.
- The thickness specification is necessary to calculate the travel distance which the z-axis moves fast until the speed is slowed down. This optimizes the throughput.
  If the thickness is set too high throughput will be decreased. If it is set too low an error may occur.

Bottom Substrate Thickness

Numeric Input Field

- All input values in [µm]
- Allowed values: 0 to 17.700
- The thickness of the bottom substrate can be entered via keyboard.
- The thickness specification is necessary to calculate the travel distance which the z-axis moves fast until the speed is slowed down. This optimizes the throughput.
  If the thickness is set too high throughput will be decreased. If it is set too low an error may occur.

Bottom Substrate Size

Text Field

- Maximum allowed characters: 30
- The field usually is empty but the information can be added by the customer.
- When the field is filled in, the information will be added to the quality date file.

Vacuum Maximum

Numeric Input Field

- All input values in [mbar]
- Allowed values: -1000 to 0
- Maximum vacuum to fix the substrate on the chuck

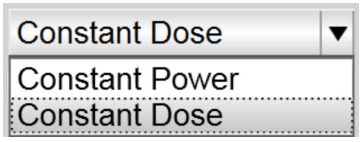
Vacuum Minimum

Numeric Input Field

- All input values in [mbar]
- Allowed values: -1000 to 0
- Minimum value for vacuum to fix the substrate on the chuck.
- An error message is displayed if the value is not reached.

Exposure

Exposure Mode



Drop Down Menu

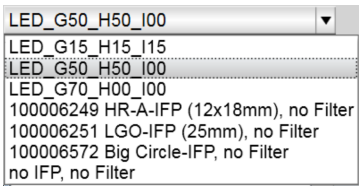
- shows all available exposure modes

Constant Power	The exposure time is defined and the electric power will remain constant during the exposure time period.
Constant Dose	The desired exposure dose is defined. with a sensor in the exposure optical path the dose is measured during exposure. The shutter is kept open until the defined does is reached. Fluctuation of intensity can be equalized with this method. A licence isnecessary to use this mode. This mode is not valid for UV curing (flood expo-sure)

Exposure

The group *"Exposure"* defines the parameters of the exposure optics for the UV-lamp houses or the individual UV-LED combinations for the UV-LED light source.

Exposure Configuration



Drop Down Menu

- Selection of all available exposure configurations. Definition of the configuration is done in service view.
- The exposure configuration has to be suitable for the built in lamp house/ light source .
- If the aligner is equipped with a UV-LED light source, the individually created combination of the LEDs can be selected with this drop down menu. *Chapter 11.5.2 "Creating a New Light Source" on page 171*
- If the aligner is equipped with a UV-LED curing source the created intensity levels can be selected with this drop down menu.

13.1.3 Parameters of the Tab *"Process Table"* in Imprint Recipe

General | Substrate 1

Process Settings | Process Table | Alignment

		Step 1	Step 2	Step 3	Step 4	Step 5	Step 6	Step 7	Step 8
Movement									
Mode		Stage-Z	Stage-Z	Stage-Z	Stage-Z	Stage-Z	Stage-Z	Stage-Z	Stage-Z
Gap	[µm]	2500	2200	500	100	500	400	2000	2500
Speed	[µm/s]	500.0	100.0	25.0	10.0	5.0	50.0	50.0	50.0
Maximum Force	[N]	10.0	10.0	10.0	10.0	10.0	0.0	0.0	0.0
Minimum Force	[N]	0.0	0.0	0.0	0.0	10.0	0.0	0.0	0.0
Timeout	[s]	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
Pneumatics	Select								
Top Substrate Outer Vacuum		✓	✓	✓	✓	✓	✓	✓	✓
Top Substrate Inner Vacuum		✓							✓
Top Substrate Inner Nitrogen			✓	✓	✓	✓	✓	✓	
Top Substrate Inner Atmosphere									
Chuck Chamber Pre Vacuum									
Chuck Chamber Vacuum									
Chuck Chamber Nitrogen									
Chuck Seal									
Chuck Purge In									
Wafer Inner Nitrogen									
Wafer Outer Nitrogen									
Wafer Outer Vacuum		✓	✓	✓	✓	✓	✓	✓	✓
Wafer Inner Vacuum		✓	✓	✓	✓	✓	✓	✓	✓
Wafer Inner Atmosphere									
Wafer Outer Atmosphere									
Chuck Purge Out									
General									
Delay	[s]	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
Do Alignment			✓	✓	✓				
Auto Align Accuracy	[µm]	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500
Exposure									
Exposure Time	[s]	0.0	0.0	0.0	10.0	90.0	0.0	0.0	0.0

Fig. 13 - 3: "Process Table" in Imprint Recipe

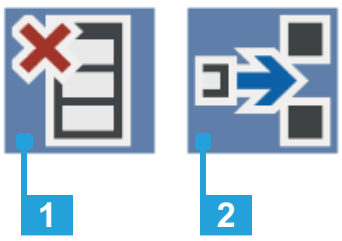


Fig. 13 - 4: Delete/Add Buttons

On top of each process step two buttons are displayed:

- **1** - delete the current step
- **2** - add an additional step after the current step

Movement

Mode

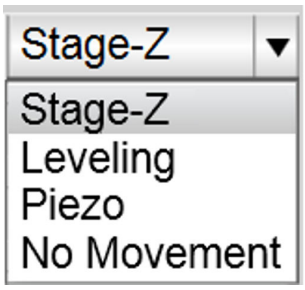


Fig. 13 - 5: Movement Mode

Drop Down Menu

- You can select how and whether the movement of the chuck during the process steps is performed.
-
  - **Stage-Z**
    Z-axis is used for movement
  - **Leveling**
    The measuring probes measure the current distances and the piezos use the results to position the chuck parallel to the stamp surface.
  - **Piezo**
    Piezos are used for movement (max. range: 80 µm).
    Use Piezo for wedge offset compensation or if high forces at the end of a process are required!
  - **No Movement**
    No movement is performed during the process step.
    If your process needs a step without any motion.
    (e.g. during curing it may come to a shrinking of process material but you do not want to compensate it with a movement)

Gap

Numeric Input Field

- All input values in [µm]
- Allowed values have to be within following rule:
  Pre Transfer Position + Chuck Thickness + Bottom Substrate Thickness + Top Substrate Thickness + Gap ≤ Top Tool Mounting Position.
- Input field to define the gap between upper (stamp) and lower substrate for each step.
- The gap of the each subsequent process step should always become smaller until the final exposure gap is reached. Otherwise the coating of the lower substrate may be damaged.
- For the last process step (for unloading) the gap should become equal to the transfer position to allow substrate unloading.

Speed

Numeric Input Field

- All input values in [µm/s]
- Allowed values: 0 to *"Maximum Speed"* set for *"Stage-Z"* on Service page.
- Defines the speed for the Z-axis.
- During Start and Unload it is recommended setting the speed to a high value (1000 - 1500 µm/s) to keep the overall process time as short as possible.
- As soon as upper and lower substrate may get into contact a slow speed (~ 5-20 µm/s) is recommended to avoid shifting or creation of air bubbles between the substrates.

Maximum Force

Numeric Input Field

- All input values in [N]
- Allowed values: 0 to 1000

- Input field to apply extra force to reach a programmed gap.
- If the speed of the Z-axis does not produce sufficient pressure between substrate and stamp, additional force can be applied.
- If set to „0“ no extra force is applied and the force is not detected by the force sensor
- A force sensor in the WEC head can detect the force, applied between upper and lower substrate during movement to a programmed gap.
- To activate the sensor a force >0 has to be set.

Minimum Force

Numeric Input Field

- All input values in [N]
- Allowed values: 0 to 800
- *“Minimum Force”* must be smaller or equal to *“Maximum Force”*

Timeout

Numeric Input Field

- All input values in [s]
- Allowed values: value has to be greater than 0.
- Maximum allowed time to perform one step.
  If exceeded an error message will be displayed and the user can choose how to proceed.

Pneumatics

List of all available valves during each process step

Check Boxes

Valve Name	Description	Note
Top Substrate Outer Vacuum	Vacuum to fix the top substrate at the top tool	
Top Substrate Inner Vacuum	Vacuum to fix the inner substrate area	
Top Substrate Inner Nitrogen	Pressure to slightly arch the inner stamp area.	
Top Substrate Inner Atmosphere		
Chuck Chamber Pre Vacuum	Pre-vacuum to build up a vacuum chamber	
Chuck Chamber Vacuum	Main vacuum to build up a vacuum chamber	
Chuck Chamber Nitrogen	Nitrogen to purge the chamber to avoid oxygen	
Chuck Seal	CDA to blow up the sealing in the chuck to create a chamber which can be evacuated	
Chuck Purge In	Nitrogen purge to release the vacuum in the vacuum chamber	
Wafer Inner Nitrogen	Nitrogen purge under the inner wafer area to perform hard contact	
Wafer Outer Nitrogen	Nitrogen purge under the outer wafer area to perform hard contact	
Wafer Outer Vacuum	Outer vacuum to fix the wafer on the chuck	

Valve Name	Description	Note
Wafer Inner Vacuum	Inner vacuum to fix the wafer on the chuck	
Wafer Inner Atmosphere	Releases the chuck vacuum in the inner wafer area	
Wafer Outer Atmosphere	Releases the chuck vacuum in the outer wafer area	
Chuck Purge Out	CDA for chuck purge	

- All input values in [s]
- Allowed values: value has to be greater than 0.
- Maximum allowed time to perform one step.
  If exceeded an error message will be displayed and the user can choose how to proceed.

13.1.4 Parameters of the Tab *"Alignment"* in Imprint Recipe

All main parameters are described in detail in *Chapter 2.5.3 "Parameters of the Tab "Alignment"" on page 52*.

Only the differences are descibed within this chapter:

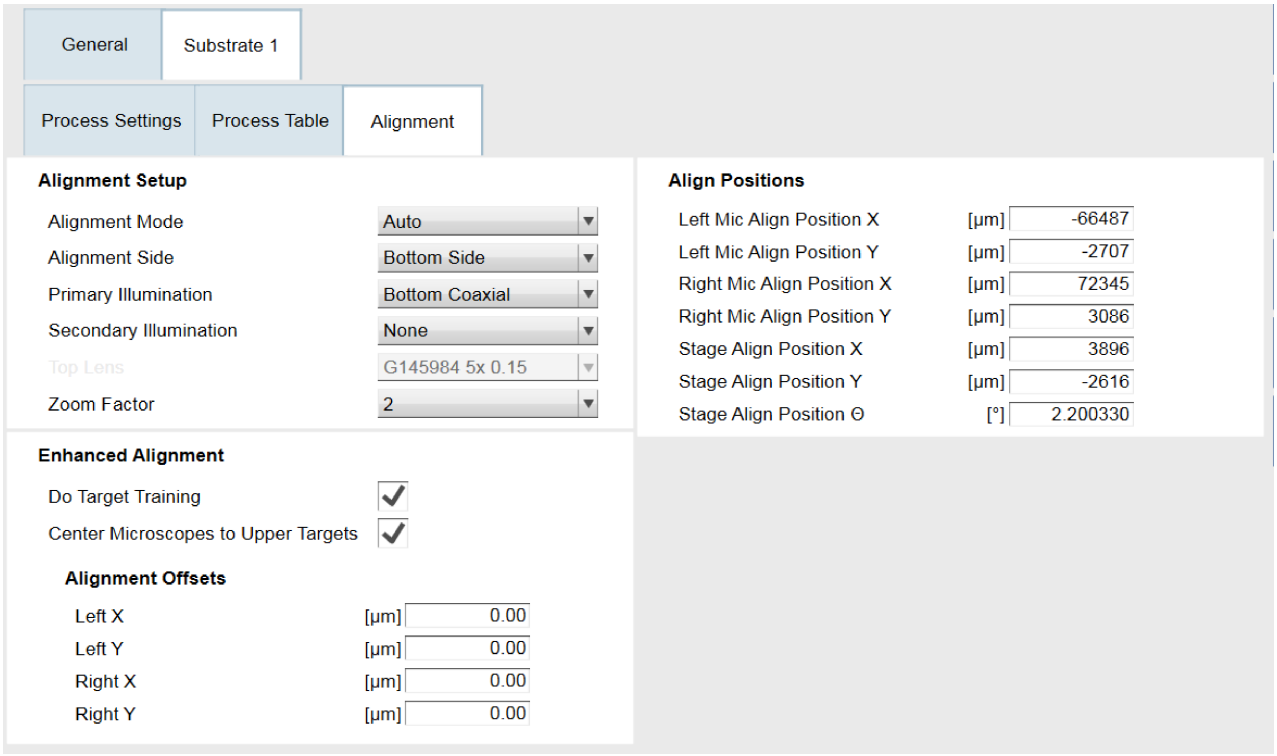


Fig. 13 - 6: Tab "Alignment" in Recipe View for Process Table

Alignment Mode



Drop Down Menu

- Selection of all available alignment modes
  - **Manual:** Manual alignment with joystick
  - **Auto:** Auto Alignment

Center Microscope to Upper Targets



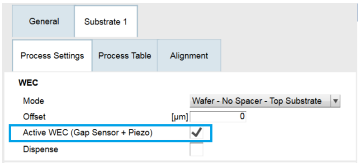
Check Box

- If checked the microscopes are moved to position the mask targets into the center of the field of view.
  - During the automatic alignment the mask targets are searched.
  - Once detected, the microscopes are positioned so that the targets are in the center of the image field.
  - The image quality is better in the center and mechanical inaccuracies are compensated.

13.2 Active Gap Setting

The mask aligner/ imprint tool provides an active WEC system that employs piezo-electric linear actors, a highly accurate gap measurement system and a force detector.
This enables the continuous control of the gap between upper and lower substrate. For imprint processes this is a necessary option because typical materials are compressible and therefore the gap may become less than defined in the recipe and parallelism between upper and lower substrate can not be guaranteed during the process.

Activation of Active Gap Setting:



The use of Active Gap Setting can be set in the recipe:

- Tab: Substrate/ Tab: Process Settings/ Group: WEC
  ➔ Check box: Active WEC (Gap Sensor + Piezo)

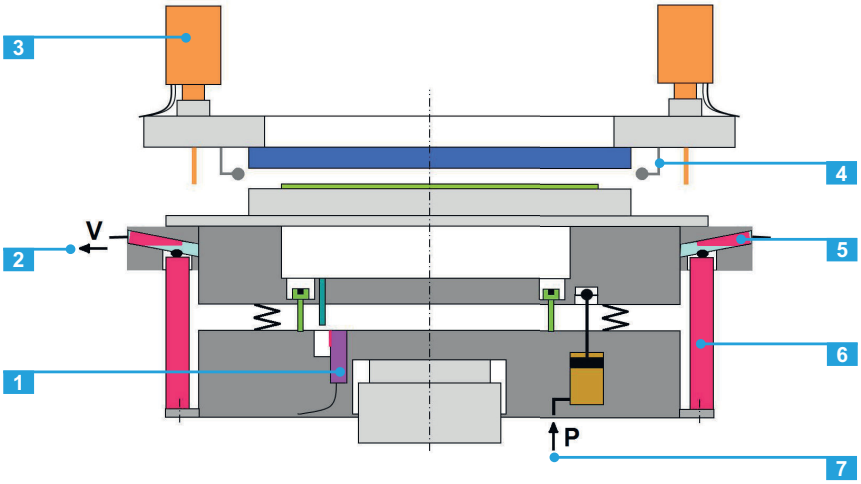
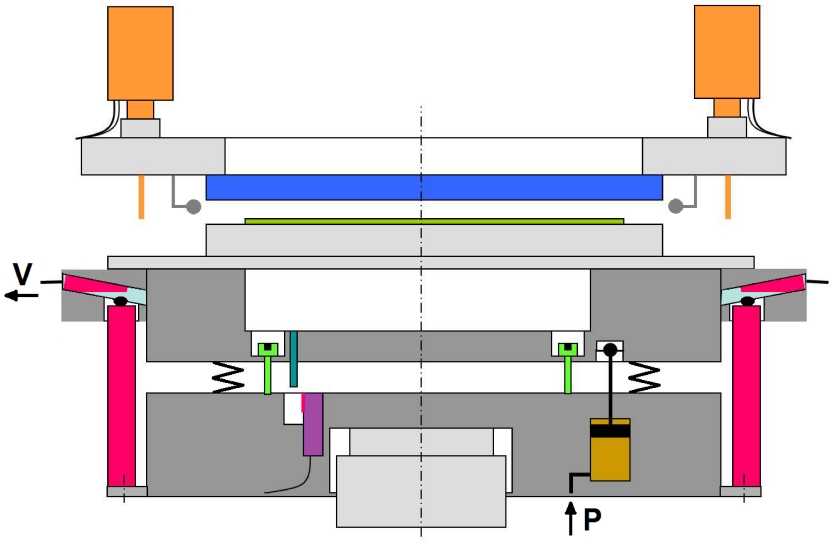


Fig. 13 - 7: WEC-Head with Active Gap Setting

1	WEC sensor
2	Vacuum/ Pressure supply (to rectract wedges by vacuum)
3	Measuring probe (3x)
4	Spacers (3x)
5	Wedges (3x)
6	Piezo element (3x)
7	Vacuum/ Pressure supply (WEC pressure support)

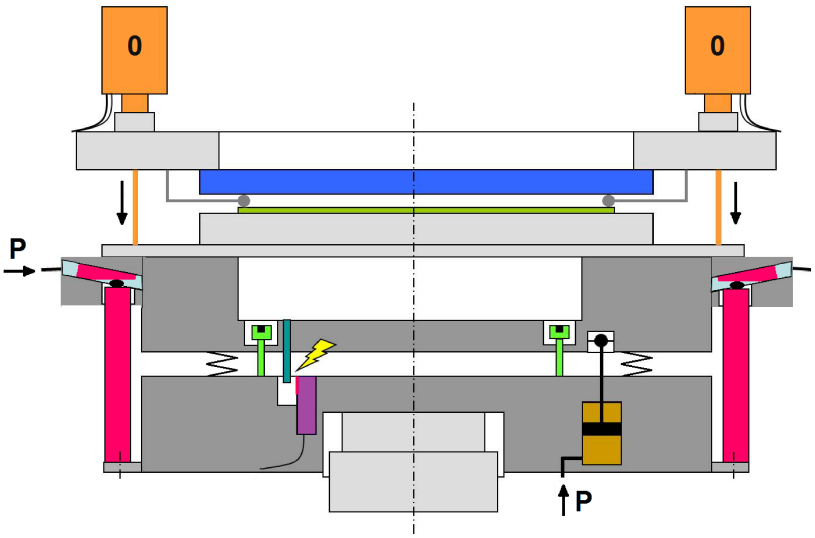
13.2.1 WEC-Sequence

1. Basic Position



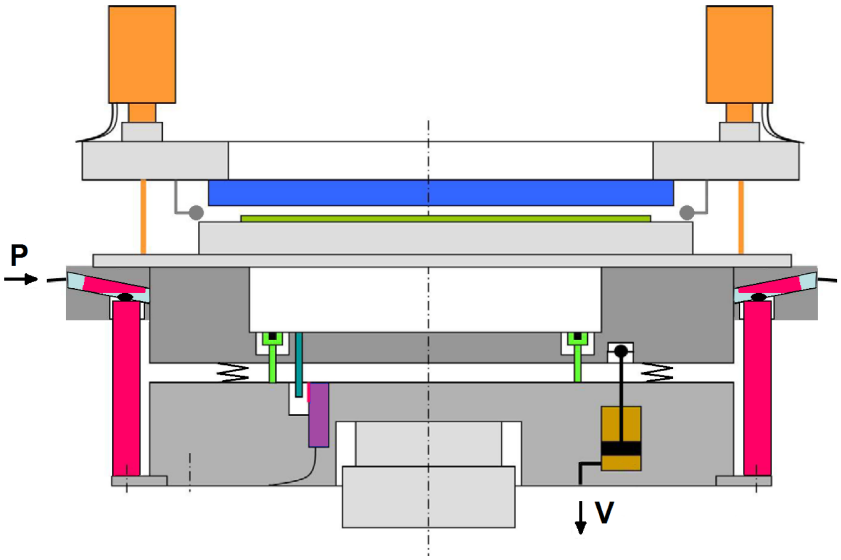
- WEC head is in home position and can move freely.
- Wedges and spacers are retracted.
- Measuring probes are in waiting position.

2. During WEC



- Spacers move in between upper and lower substrate.
- Measuring probe sensor tips move into contact with the chuck.
- Z-axis moves up until the WEC sensor is triggered.
  - In this position the wedges are moved in, to provide mechanical contact between WEC head and piezo elements.
  - The WEC head is fixed in this position.
  - The measuring probes are referenced to the chuck position.
  - The gap between upper and lower substrate at this position is defined by the diameter of the spacer balls (= 3000 µm)
- From now on the gap between upper and lower substrate can be continuously controlled by the measuring sensors and can be adjusted by the piezo elements.

3. Move to Defined Gap



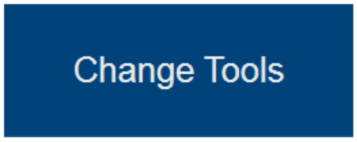
- The Z-axis moves the WEC head into the clearing distance.
- The spacers are moved out.
- TheZ-axis moves the WEC head with the chuck and the substrate into the gap, defined in the recipe.
- If *"Active WEC"* is selected the actual gap is measured and if necessary the piezo elements will adjust the gap to ensure parallelism between upper and lower substrate.

13.3 Imprint Process Sequence

13.3.1 Imprint - Prepare Process

- Load a recipe, suitable for imprint processes.
- The recipe parameter *"Process Type"* has to be **"Process Table"**.
- The tool set in the recipe must match with the mounted tool set and must be suitable for imprint processes.

Load Top Substrate:



- Click the function key *[Change Tools]* and load the top substrate. Details see: ↬ *Chapter 2.4.2 "Dialog Frame "Change Tools"" on page 39*

Start Process:

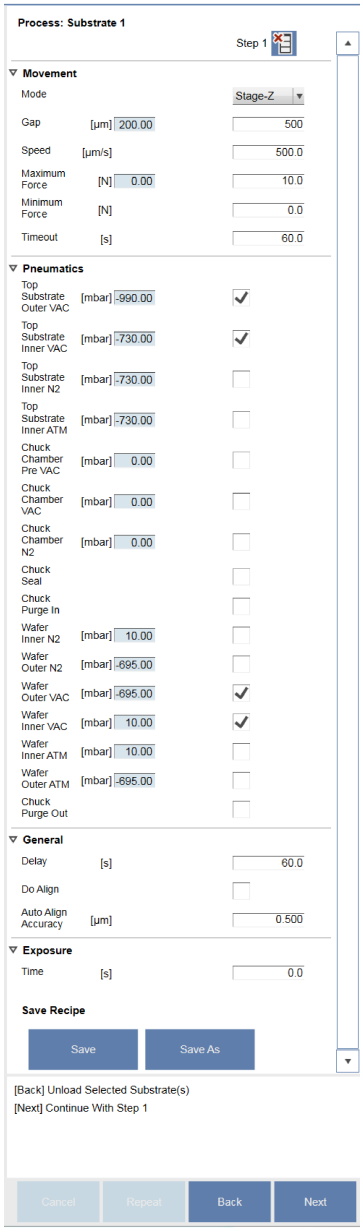


- Click the function key *[Start Process]* to start the process with the selected recipe.

13.3.2 Imprint - Start Process

- Load "Substrate 1".
- Wedge Error Compensation is performed and the process stops **before Step 1** of the imprint process table:
- The dialog frame shows: **Process: Substrate 1**

Preparation for Step 1:



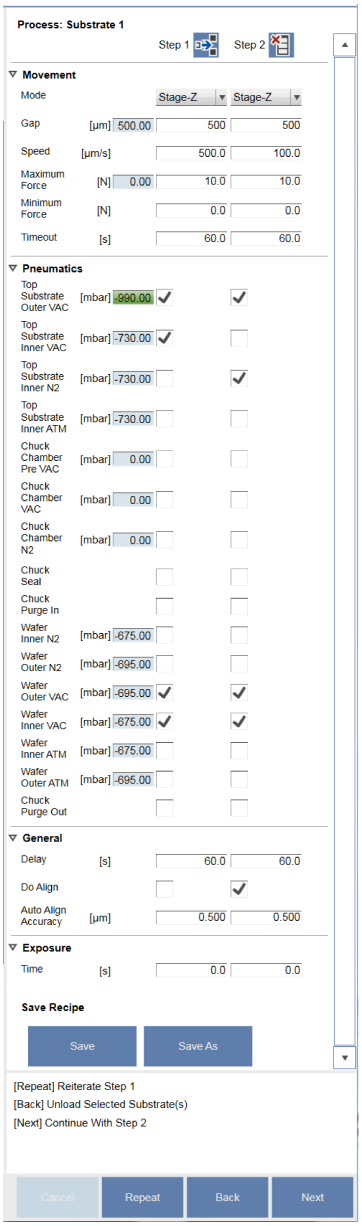
- All parameters of Step 1 of the process are displayed.
- Every group can be expanded or folded in.
- Every parameter can be edited and saved in the current recipe with *[Save]* or within a new recipe with *[Save As]*.
- The actual parameters are displayed.
- It is also possible to skip (delete) Step 1

If everything is ok:



- Click *[Next]* to continue with Step 1.

Preparation for next Steps:



- After successful execution of Step 1, Step 2 is displayed and ready to be executed.
- You can repeat Step 1 with function key *[Repeat]*.
- You can delete Step 2.
- You can change the parameters and save the changes.
- The dialog frame always displays 2 step at a time, the last executed step and the next step.

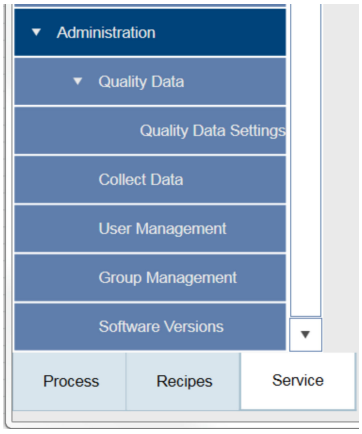
Proceed with each step until the whole process table is processed.

Finally unload the substrate(s).

14 DIAGNOSTICS

If quality problems in the manufacturing process occur, diagnostics is an effective tool to identify weaknesses and errors in the process and to eliminate them effectively.

In order to be able to understand errors or losses in the yield, it makes sense to save data over a defined period of time and to get to the bottom of it in the event of a problem.



To get access to this tool:

- Click the tab *"Service"* to get access to the service views.
- Expand the drop down menu *[Administration]*.

NOTICE!
The user role "Operator" can only view and export the quality data.
To make changes at least the user role "Application" is necessary.

14.1 Quality Data

14.1.1 Quality Data Settings

In case you want to individualize your quality data and to include/ exclude data you can do this in the view "Quality Data Settings".

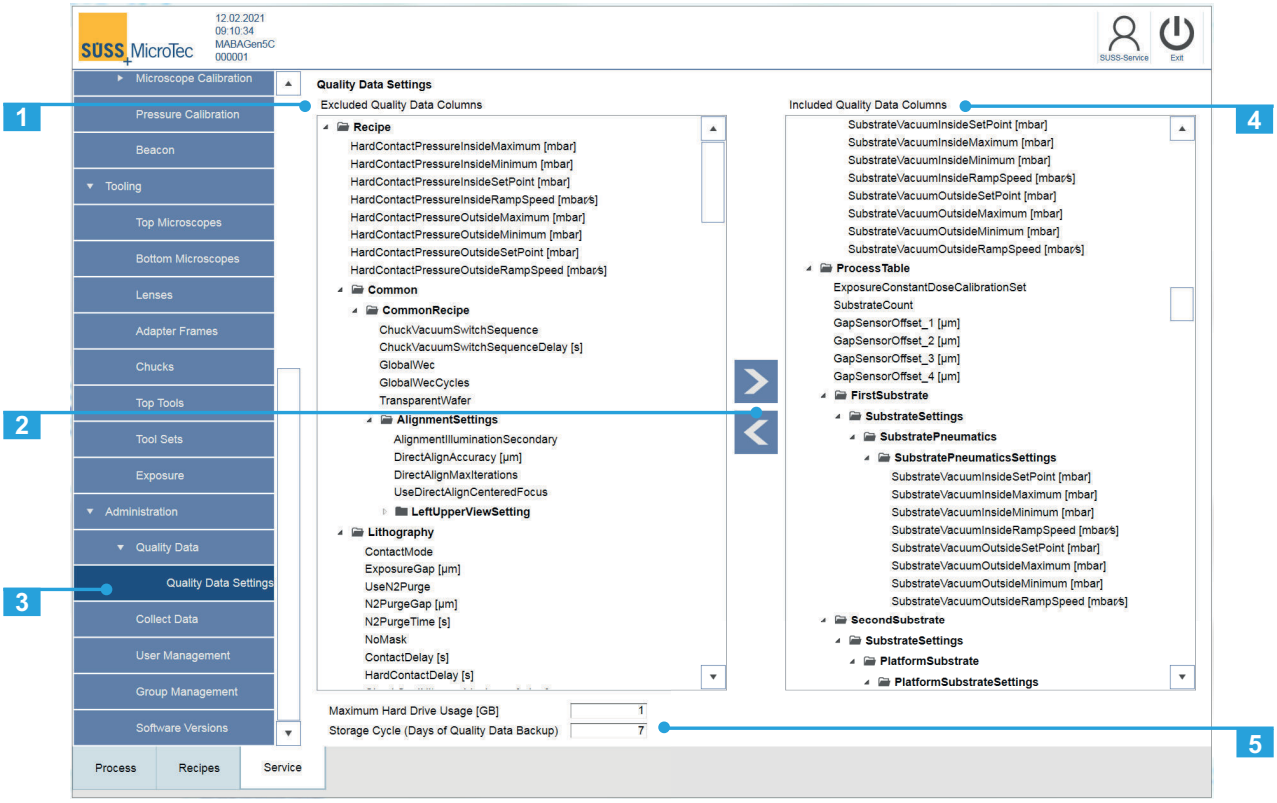


Fig. 14 - 1: Quality Data Settings View

1	**Excluded Quality Data**
2	**View for Quality Data Settings**
3	**Arrows for Selection of Data**
4	**Included Quality Data**
5	**Additional Parameter Fields**

Initially all available data are listed in the "Included Quality Data Columns."

- All recipe data are organized in folders which correspond to the respective recipe pages and groups.
- The Process folder includes all parameters which are created during the process.



If you want to select a folder or a single parameter and move it from one column to the other you can do it using the corresponding arrow.

- Click the desired folder or parameter in the column.
- Then click with the corresponding arrow to move it to the other column.
- The parameter is moved. Additionally the folder where it was organized is created in the other column.
- If you click a folder, all parameters that are included in this folder are moved to the other column.

In this way you can customize the quality data to your needs.

Maximum Hard Drive Usage [GB]	1
Storage Cycle (Days of Quality Data Backup)	7

- The parameter *“Maximum Hard Drive Usage [GB]”* limits the use of the hard drive space to a defined maximum amount.
- The parameter *“Storage Cycle (Days of Quality Backup)”* defines the duration of the storage of the quality data. The data will be over-written after this predefined time.

14.1.2 Quality Data View

To view all data click the menu item *“Quality Data ”*.

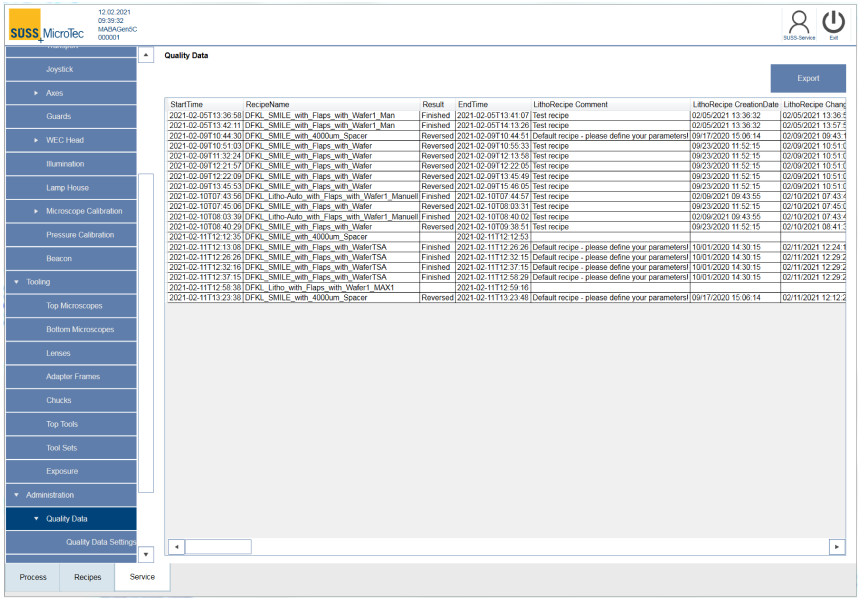


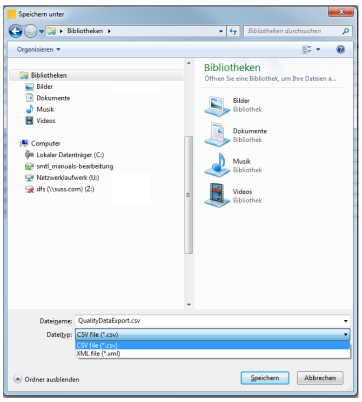
Fig. 14 - 2: List of all selected quality data

In this view you can only see all data which are currently selected for export.
And you can export these data.

Export Data:



- Click the function key *[Export]*.



- The windows explorer is opened and all data can be saved within your desired location.
- The predefined name of the file is "QualityDataExport".
- The predefined file type is "CSV file" (*.csv)
- You can change the file name and also switch to the file type "XML file" (*xml).

14.2 Collect Data

"Collect Data" provides an effective tool for diagnostic in case of quality and performance problems.

The collected data can be sent to our service department and help to analyze and eliminate problems and facilitate troubleshooting.

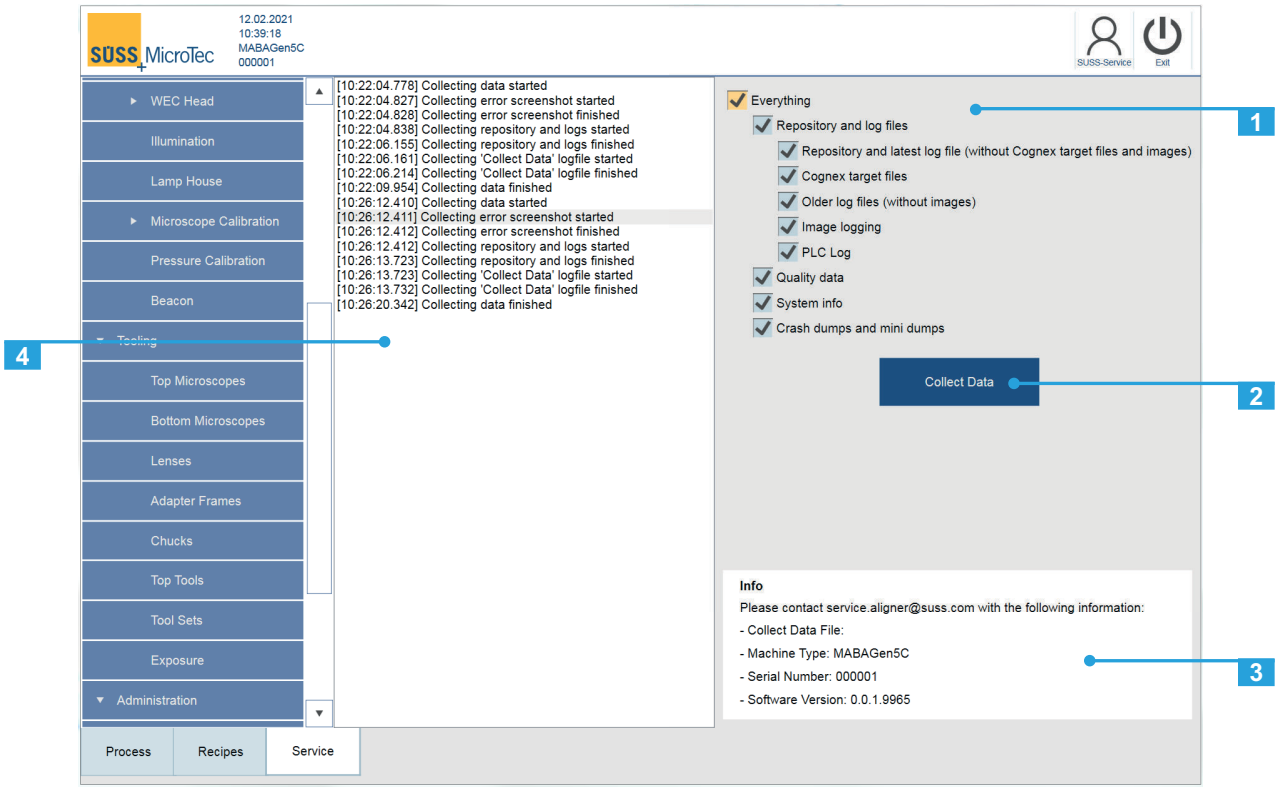
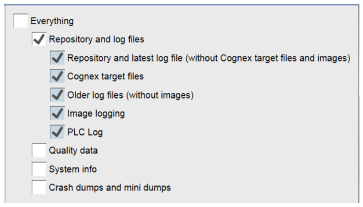


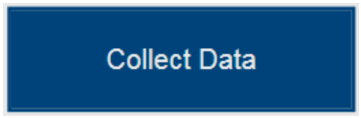
Fig. 14 - 3: Collect Data View

1	**Check list for data collection**	**3**	**Required service information**
2	**Function key to start data collection**	**4**	**List of collected data log**

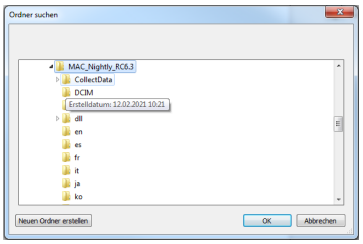
Check List:



- Selection of data to be collected.
- Click the check box *[Everything]* to check all check boxes and collect all available data.
- Click individual check boxes to select your individual need for collected data.



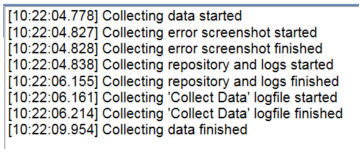
- Click the function key *[Collect Data]* to start the data logging.



► A sub-window opens to select the folder for Collect Data saving. A new folder can also be created.

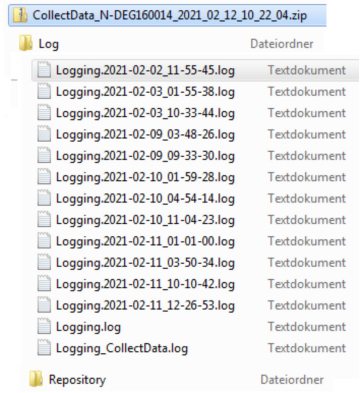
► Click *[OK]* to start data collecting.

List of Data Logging:



- Logging list after start of data collection.

Stored Data:



- The selected folder contains a zip-file with all collected data.



► Send this ZIP-File together with all other required information to SUSS Service.

15 MAINTENANCE

15.1 General Maintenance



CAUTION!

Danger of Machine Damage!

Only trained personnel is allowed to perform maintenance work at the MA/BA Gen4 and if detailed knowledge of operation and service of the machine is available.



DANGER!

High Voltage! Risk of Death by Electric Shock!

Always set the machine to a save condition.
If there is any doubt about safety requirements, completely de-energize the machine.



DANGER!

Risk of Injury by Moveable Machine Parts!

Always set the machine to a save condition.
Read and understand all warnings in the safety chapters of the machine documentation.

- Regular maintenance improves the overall performance of the machine.
- Always take care of unusual noise.
- Always take care of changes in operation and process results.
- Nonobservance can lead to machine damage.



The functions in the service view (TAB „Service“) are only accessible for the user roles „Service“ or „SUSS-Service“.

Recommended SUSS Service:

- To keep the machine in perfect running order it is recommended that a SUSS service technician should inspect the system completely every 2 or 3 years.
- If the machine is used for full time production (i.e. 3 shifts), the inspection is recommended every 6 months.
- This inspection will include a full test of WEC-functionality and re-adjustment of WEC-system.

15.1.1 Daily Visual Inspection

Chuck and Mask Holder

- Check for dust and residues especially photo resist or substrate fragments.
- Inspect for scratches and sign of wear at an early stage. The use of damaged chucks and mask holders lead to a loss of performance of the mask aligner.
- The inflatable vacuum sealing of the chucks are very sensitive for damage by broken substrate pieces. Always check the sealings carefully for damage.



CAUTION!

Risk of Injury because of Wafer Fragments!

Avoid contact with your skin and always wear gloves and use tweezers to remove fragments from the machine.

15.1.2 Test Run

- Load test wafer and test mask.
- Select a standard process and run it.

Check: if all major subassemblies are working properly:

- Manipulators
- Alignment stage movement
- Mirror house movement
- Microscope movement

15.1.3 Safety System Check

At regular intervals (at least monthly) check the interlock systems.

- Activate the EMO to de-energize the machine, lamp and power supply.
- With lamp off and CIC in stand-by, test:
  - lamp house door interlock
  - interlock for optics cover
  - interlock for lamp socket cooling, by reducing the cooling flow or switching of the CDA supply.

15.1.4 Check of WEC-Head

If a Heidenhain measurement set is available, parallelism should be checked from time to time. Procedure details are described in the manual of the Heidenhain set.

NOTICE!

When using WEC with measuring probes, the WEC pressure must be higher than with WEC without measuring probes.

15.2 Lamp Power Supply

15.2.1 CPC350 Lamp Power Supply

Power Supply Information

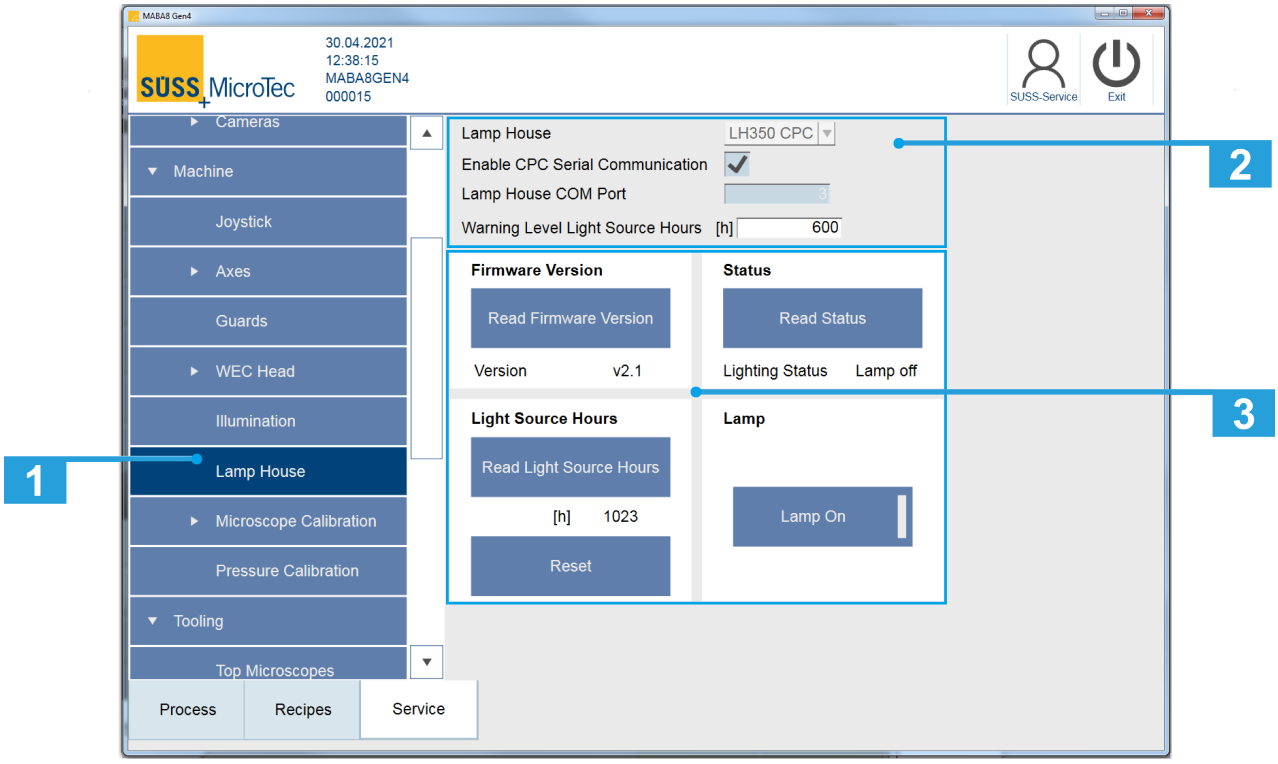


Fig. 15 - 1: Service View: Lamp House - CPC350

1	**Service View "Lamp House"**	3	**Function Keys for Status and Lamp**
2	**Power Supply/Lamp House Information**		

In the tab ***"Service"*** you have access to the service view ***"Lamp House"***.

Power Supply/Lamp House Information:

Common information is displayed on top of the view:

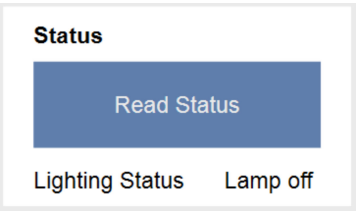
- Power supply, actually used
- Selected serial communication (only info, setting is done in configuration)
- Number of used Com Port
- Numeric input field for warning level of maximum light source hours. The number of maximum hours depends on the used lamp/ light source. (Details see in the corresponding lamp data sheet)

Function Keys:



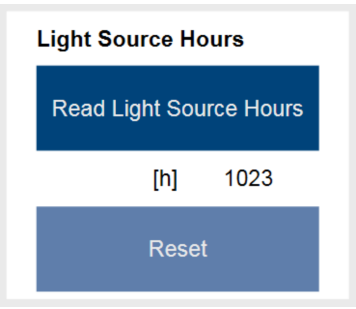
Firmware Version

- Click the function key *[Read Firmware Version]* to update the version display.
- The current firmware version may be helpful in case of service work.



Status

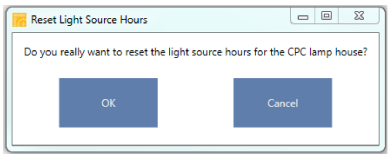
- Click the function key *[Read Status]* to check whether the light is on or off.
- The current status is displayed below the function key.



Light Source Hours

- Click the function key *[Light Source Hours]* to update the current number of operating hours of the light source.
- The current status is displayed below the function key.
- Click the function key *[Reset]* to reset the display. This is typically done if the lamp is exchanged and before a new lamp is started.

In this case a warning is displayed:



NOTICE!

If you confirm the warning, the operating hours are reset to zero. If reset of the counter and lamp exchange are not synchronized, the lamp hour counter will not display the correct value which can cause severe damage.



Lamp

- Click the function key *[Lamp On]* to switch the lamp on or off.
- The current status is displayed with the "LED" in the function key and in the status of the light.

Lamp Power Information

In the tab ***"Service"*** you have access to the service view ***"Exposure"***.

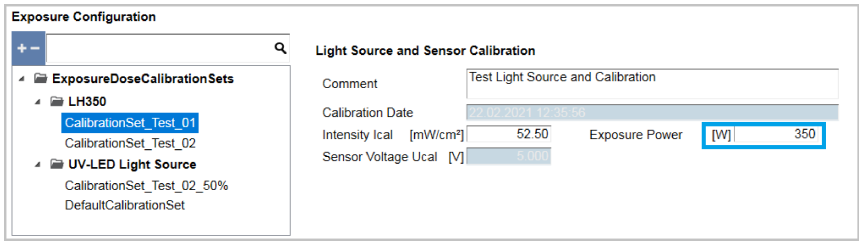


Fig. 15 - 2: Lamp Power Information and Adjustment

Lamp Power Information:

For each ***Exposure Configuration*** the current valid ***Exposure Power*** is displayed (*see blue square*):

- The exposure power should be set according to the lamp specification.
- Lower power than the value specified by the manufacturer should only be used if very low intensities are necessary to avoid too short exposure times. It is recommended to use a neutral filter to reduce the intensity.
- Do not set higher wattages than the value specified by the manufacturer to avoid shortening the life of the lamp.

At least the user role "Service" is necessary to be allowed to change the lamp power!

15.3 Maintenance of Lamp and Light

The proper function of the exposure lamp and the optimum intensity and uniformity of the light in the exposure area are requirements for a successful process result. Therefore intensity and uniformity have to be checked on a regular basis and the lamp has to be exchanged du to given intervals (specified by the supplier).



WARNING!

Risk of Eye Damage!

Invisible, high energy UV light may damage eyes or skin.

- ► Never use the machine without covers.
- ► When performing light uniformity adjustments always wear UV-protective glasses and cover your skin.
- ► Be especially careful with almost invisible UV radiation of UV-B and UV-C.



WARNING!

Risk of Burns!

The lamp and its surrounding are extremely hot - even after switched off the lamp.

- ► Do not touch the components.
- ► Wait until the surface has been cooled down below 40°C.
- ► Always wear heat resistant gloves.



WARNING!

Risk of Explosion!

UV lamps are highly pressurized. They can explode if mistreated causing serious injuries by fragments.

- ► Touch only when wearing face shield and gloves.
- ► Avoid rude handling.
- ► If not in use store it in its original box.

Protective equipment:
- Face Shield
- Safety Gloves
- UV-Safety Goggles



Details concerning hazards and safe use and handling of the lamp you find in the safety-/installation manual of the corresponding mask aligner.

15.3.1 Intensity and Uniformity Check



WARNING!

Danger of Damage of Eyes and Skin!

UV light is harmful for eyes and skin.

- ► Respect the section „Radiation Hazards“ in the safety instructions of the corresponding documentation.

- Measure the light intensity at different places of the substrate with a light measuring probe.
- Insert a special light measuring plate in the mask holder frame.



All functions for light measurement are done in the dialog frame *“Light Measurement”*.

To open this dialog frame click the function key *[Light Measurement]* at the start page of the GUI.
(Details see: *Chapter 2.4.3 “Dialog Frame "Light Measurement"” on page 41*)

Calculate the light uniformity:

- Insert the highest (H) and the lowest (L) value of all measured values into following formula:

$$\text{Uniformity (\%)} = [(H-L) / (H+L)] \times 100$$

H [mW/cm²] = Intensity, highest value
L [mW/cm²] = Intensity, lowest value

- Once the calculated value of the uniformity lies within the given limits, calibrate the power supply.



A detailed description you find in the manual of the lamp power supply.

15.4 Lamp Exchange in Lamp House LH350

15.4.1 Exchange Procedure in LH350

NOTICE!

Reset Light Source Hours

Do not forget to reset the light source hours after replacing the lamp!
See *Further information on page 229* for details.

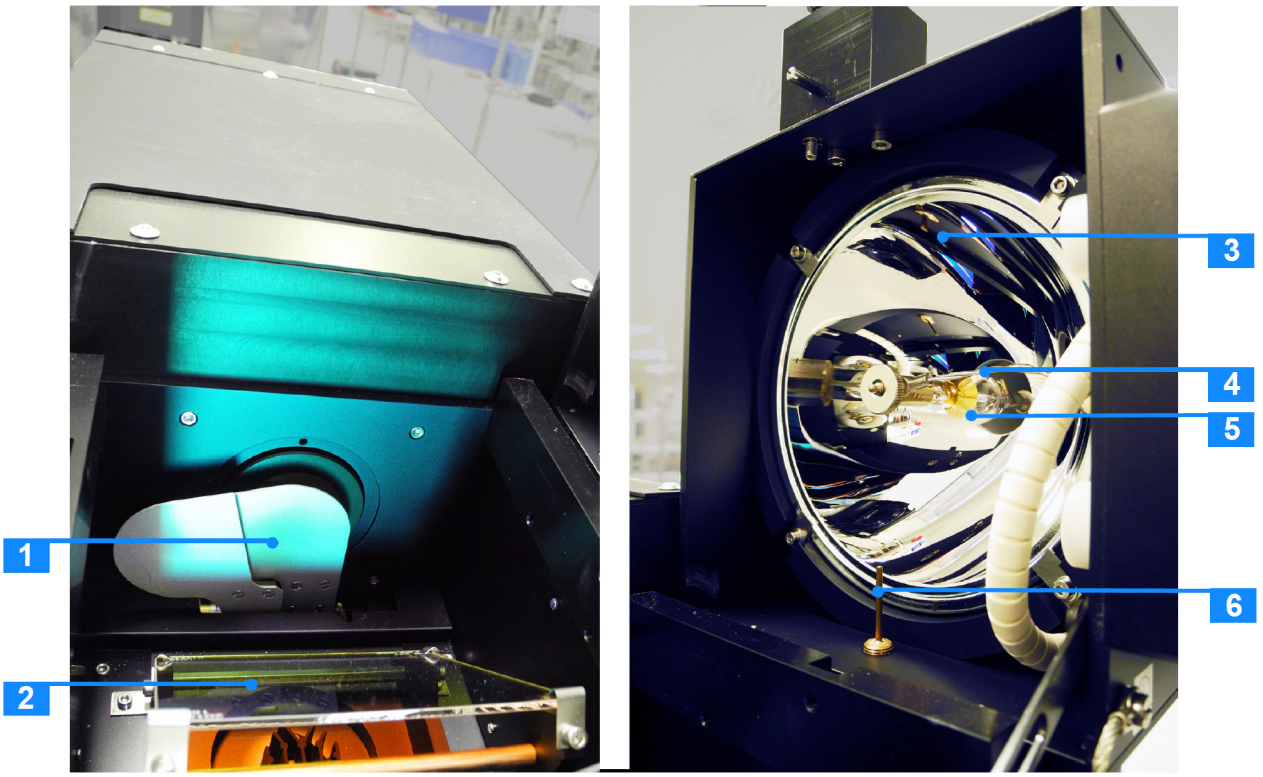


Fig. 15 - 3: LH350-Inside View

1	**Shutter**	4	**Connection Cable/Anode (+) of the Lamp**
2	**Cold Light Mirror**	5	**Exposure Lamp**
3	**Ellipsoid Mirror**	6	**Cooling Nozzle for the Lamp Socket**

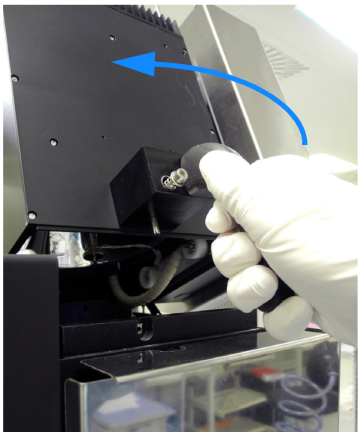
Exchange Procedure

1. Switch off the mask aligner.
2. Switch off the exposure lamp and remove the electric supply.

NOTICE!
Before opening the lamp house wait at least 20 min. until the lamp house and the lamp are cooled down.



3. Loosen the safety screw at the lamp house side (see blue circle).



4. Tilt the upper lamp house with the lever backward (see blue arrow).
5. Cover the cold light mirror with a lint free tissue to prevent it from contamination.
6. Remove the connecting cable from the anode of the lamp.
7. Unscrew the lamp from the upper socket and remove it from the lamp house.
8. Take the new lamp from the transport box and remove the knurled nuts (they are not used).
9. Take the lamp at its positive (engraved) end and screw the negative (not engraved) end into the lamp socket. Depending on the lamp an adapter between lamp socket and lamp my be required.

> **NOTICE!**
> HgXe lamps (500W) have a reverse polarity!

10. Close the lamp house and lock it with the screw.
11. Store the used lamp carefully in the original manufacturer‘s box and dispose it according to manufacturer‘s rules.

15.4.2 Lamp Adjustment

Manipulators for adjustment:

They are located at the upper front part of the lamp house.

- With the manipulators the position of the lamp in the ellipsoid mirror can be adjusted in X-, Y- and Z-direction.
- Goal is to reach a uniform light distribution with high intensity over the whole exposure plane.

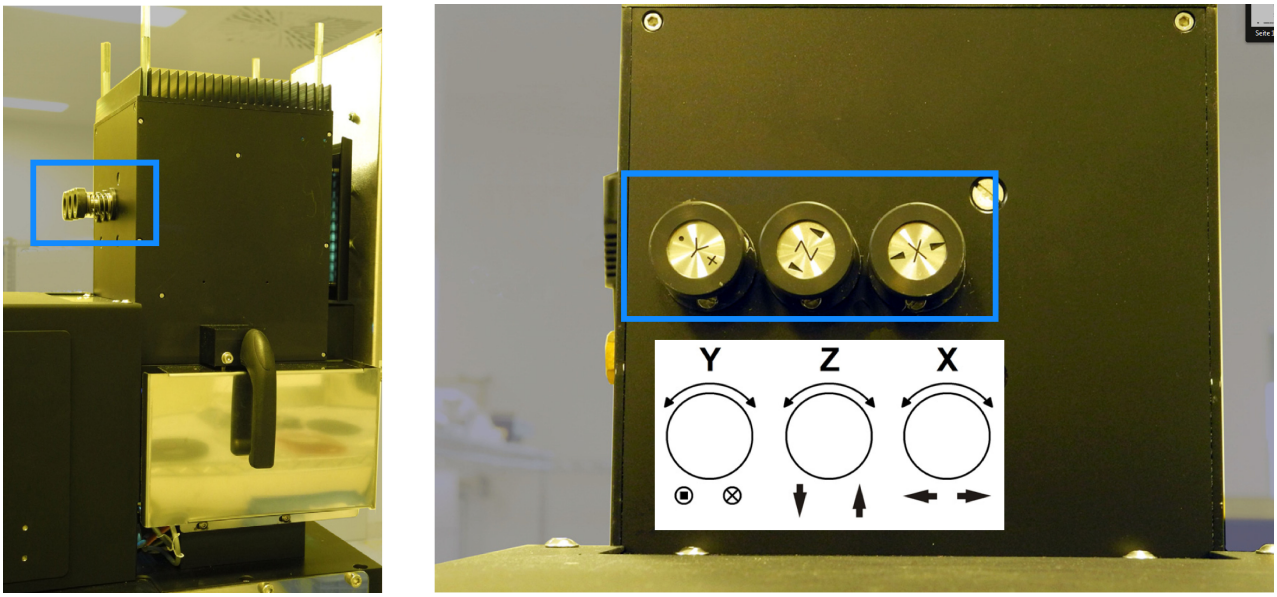


Fig. 15 - 4: LH350 - Lamp Manipulators

Necessary tools:

- Light measurement device (e.g. UV-Optometer)
- Suitable measurement probes for wavelengths 405 nm, 365 nm, 320 nm or 240 nm,
- Light measurement plate to be put on the chuck

Preliminary work:

The adjustment of the lamp is performed in idle mode of the lamp power supply.

- After lamp exchange the correct cooling of the lamp house and the lamp has to be checked and re-adjusted if necessary.

Details for cooling adjustment see *Chapter 15.4.3 “Control of Lamp Cooling” on page 236*ff.

1. Switch on the mask aligner.
2. Switch on UV-light source at the machine.
   - Working with the power supply CPC350 the lamp has to be switched on with the function key *[Lamp On]* in the navigation-/ dialog frame "Light Measurement".
   - Working with the power supply CIC1200 only the power supply is switched on. The lamp has to be ignited via CIC1200.
3. Wait at least 15 minutes until the lamp has been stabilized.
4. Put the light measurement plate onto the chuck.
5. Put the suitable light measurement probe on the plate.

Adjustment Sequence:

1. Move the X-, Y- and Z-adjustment to find the point of highest intensity. For this put the light measurement probe in the center of the measurement plate.
2. Move the sensor alternately to the left and right edge of the illuminated area and adjust the lamp with X-adjustment until both positions show the same intensity.
3. Move the sensor alternately to the rear and the front edge of the illuminated area until both positions show the same intensity.
4. Check the vertical adjustment (Z-adjustment) for maximum intensity.

NOTICE!
The Z-adjustment must only be used to set the intensity of the exposure lamp to its HIGHEST value. Reducing the intensity with the Z-adjustment of the lamp leads to a temperature increase in the lamp house and may lead to lamp explosion.

NOTICE!
If using the MO-Optics (standard optics in the MA/BA Gen4) only the Z-adjustment is used to reach maximum intensity.
Do NOT use X- or Y-adjustments.

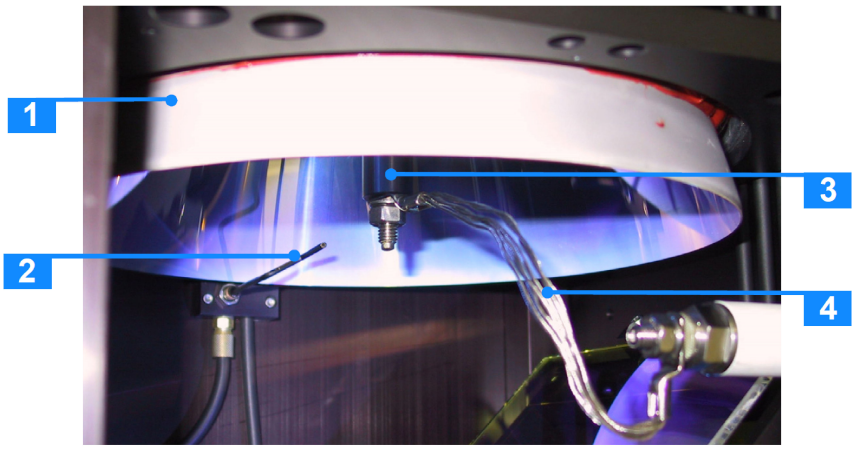
15.4.3 Control of Lamp Cooling

Cooling of the lamp house and the lamp socket is controlled continuously by a flow meter -BP33.1 (below the lamp house).

- Re-adjustment of the flow meter /air pressure has to be performed as soon as any part of the cooling system has been exchanged.
- Only qualified personnel is allowed to perform the adjustment.

Detailed cooling data for the lamp and the lamp house can be found in the safety and installation manual of the MA/BA Gen4 (chapter 2.7.1).

15.4.4 Adjustment of the Cooling Nozzle for the Lamp Socket



1	**Ellipsoid Mirror**
2	**Cooling Nozzle for the Lamp Socket**
3	**Lamp Socket**
4	**Connection Cable**

Each exchange of an optics component (ellipsoid mirror, cold light mirror, lamp) requires a check and a possible re-adjustment of the cooling nozzle for the lamp socket cooling.

The cooling nozzle and the cooling flow of the CDA must reach exactly the lamp socket. Otherwise there exists the danger of a lamp explosion.

15.4.5 Exhaust for HgXe 500 W Lamp

Control in Exhaust Tube of the Lamp House

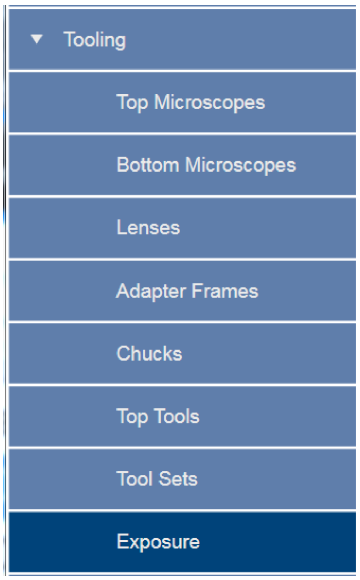
For the HgXe 500 W lamps the exhaust has to be adjusted during in house installation using the local exhaust facilities.

The exact adjustment data can be found in can be found in the safety and installation manual of the MA/BA Gen4 (chapter 2.7.1).

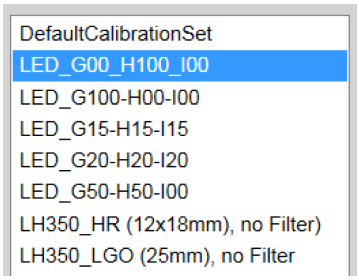
15.5 "Constant Dose" Maintenance Work

- The „Constant Dose“ system consists of a sensor which is located in the vertical tube just above the front lens and very narrow to the exposure area.
- The sensor itself is maintenance-free.
- If any modifications or changes in optics configuration have been done, the constant dose calibration should be renewed.

15.5.1 Loading of Current Calibration Parameters after Optics Change



- Click the Service TAB: The service view is displayed at the GUI.
- Click „Tooling“. The drop down list expands.
- Click „Exposure“ The page for Exposure Configurations and Parameters is displayed.



- Select the current valid optics configuration from the drop-down menu „Calibration Set“.

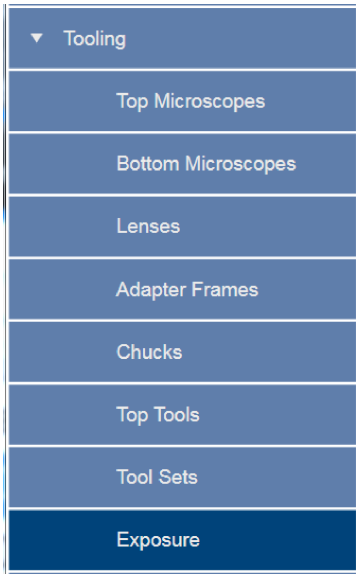
The selected calibration set has to match with the calibration set of the current recipe. Otherwise an error message will be displayed when the process is started.

15.5.2 Calibration of Constant Dose Sensor

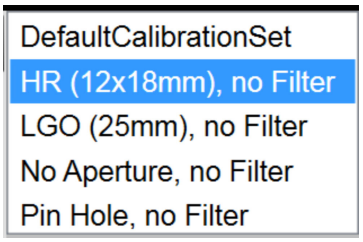
Recommendations:

- Setting of a „Calibration Set“ for each optics configuration (e.g. for different filter or aperture combinations).
  Calibration interval: weekly
- Avoid exposure times below 2 sec, as the reproducibility becomes worse. Solution: Insert gray filter or aperture to reduce intensity.
- Minimum intensity for constant dose sensor: 1 mW/cm² (internal amplifier adjustment: 1)

Load current calibration data:

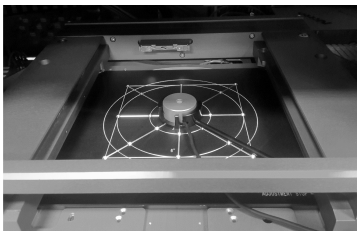


- Click Service-TAB.
  The service view is displayed at the GUI.
- Click on „Tooling“ at the arrow to drop down and display the lower pages
- Click on page „Exposure“. The calibration and parameter page is displayed.



- Select the valid Exposure Configuration from the list top left and click on it.
- The corresponding calibration data will be loaded and displayed.

Perform an external UV-measurement:

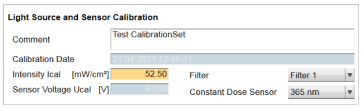


- Equip an external UV-optometer (e.g. SUSS PN. G207355) with a sensor „405“ or with a sensor "365".
- Adjust the integration time at the optometer to 1 sec.
- Put a measurement plate (PN. G300409) onto the chuck and position the sensor on the center.

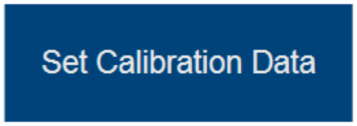


- Click on the button *[UV Light On]*. All doors have to be closed (LEDs are green).
- The shutter opens.





- Watch the display „Light Sensor Average“. A stable value is reached after approx. 3 sec.
- Read the external optometer. Average the values over some seconds.
- Write this optometer value in the input field „Intensity Ical“



- Click on the button *[Set Calibration Data]*.





- Save the current optics configuration with the button *[Save]*.
- Alternatively create a new optics configuration with button *[Save As]*.

NOTICE!

If the value „Light Sensor Average“ is larger than 9.5 Volt, the sensor delivers too much voltage and the control goes into saturation. The calibration is incorrect.

► Reduce the sensor amplification.

NOTICE!

If the value „Light Sensor Average“ is smaller than 0.1 Volt, the sensor delivers insufficient voltage. The constant dose control does not work correctly because of the noise component.

► Increase the sensor amplification.

Details for changing the sensor amplification can be found in the service manual.

15.6 Cleaning of Optical Components



CAUTION!

Risk of Damage of Optical Components!

- ► When cleaning any optical surface, the surface quality could be damaged heavily if improper method or material is used.
- ► Do not touch optical surfaces with rough material or with bare skin!
- ► Use only solvents and methods as recommended below.
- ► NEVER use aggressive solvents like acetone.
- ► Never soak optical components in solvents for an extended time.
  Adhesive compounds could be dissolved and coatings could be destroyed.



WARNING!

Risk of Fire by Highly Flammable Solvents!

- ► Isopropyl alcohol (IPA), Petroleum Ether and many other solvents are highly flammable.
- ► Use of such solvents is only allowed in a well-ventilated area, with ignition sources removed.
- ► Moreover, also cloth soaked with flammable solvent has a potential for self-ignition.

- Deposit used soaked tissues according to local safety regulations.
- Use of flammable solvents is restricted to adequately trained personnel.
- Warnings of the SDS (Safety Data Sheet) must be understand and respected.

Results of contamination:

- Resolution is degrading visibly.
- Light intensity is decreasing.
- Contamination on optical components can be detected.

Possible reasons:

- Contaminations in gas media or process solutions.
- Other process relevant contaminations

Type of cleaning:

- Depending on the kind of contamination it is possible to blow them off or to wash them with a suitable solution.
- The cleaning has to be performed very carefully, as most of the optical components (mirrors, lenses) are covered with high-quality coatings.

15.6.1 Cleaning Materials

Latex Laboratory Gloves:

- Protective gloves should always be used, whenever solvents are applied.
- Moreover, use of gloves will prevent direct touching of optical components, which would result in new contamination.

Dry Cleaning:

- To blow off dust.
- Use only filtered, dry nitrogen gas or extremely clean compressed air (CDA).
- Apply through an anti-static nozzle.

Flushing:

- For final flushing after wet removal of deposits, apply always DI-water.
- It removes also smears produced by solvents.
- Remove remaining water droplets without residue by a nitrogen blow.

Detergent Solution:

- A mild soap, e.g. dish washing liquid in a 1% dilution with DI-water.
- Do not use perfumed, alkaline or colored dish washing products.

Solvent:

- Isopropyl alcohol (IPA) is acceptable.
- For obstinate contaminations (e.g. resin) Petroleum Ether (30/40) can be used.
- Never use acetone.



NOTICE!

This special light benzine can be supplied by chemical suppliers as Carl Roth (www.carl-roth.de)
Attend the much higher flammability compared to ordinary gasoline!

Cloth:

- Avoid wiping with cloth, because any wiping can cause fine scratches in optical coatings
- If unavoidable for removing of persistent contaminations use only dust- and lint-free tissues.
- Soak the tissue with solvent and apply only by wiping with a gentle, figure eight motion or by dipping off gently.

- For removal of small local contamination spots as well as for wiping very small lenses the lens tissue should be twisted around a swab.
- Do not use any plastic cloths or plastic swab stems for cleaning. Plastics could be dissolved by alcohol and produce a smear coating on the optical components

15.6.2 Preparation for Cleaning of Optical Components

- Provide a clean laboratory table.
- Provide a nitrogen blower with antistatic nozzle.
- Prepare wash bottles with DI-water, detergent solution and solvent.
- Prepare empty bowls for collecting the liquids.
- Prepare submersion bowls filled with DI-water, detergent solution and solvent.
- Supply gentle, clean cloths as described above.
- Prepare a box with a lid for safe collection of solvent soaked cloths (to prevent from self ignition).

15.6.3 Cleaning Procedure

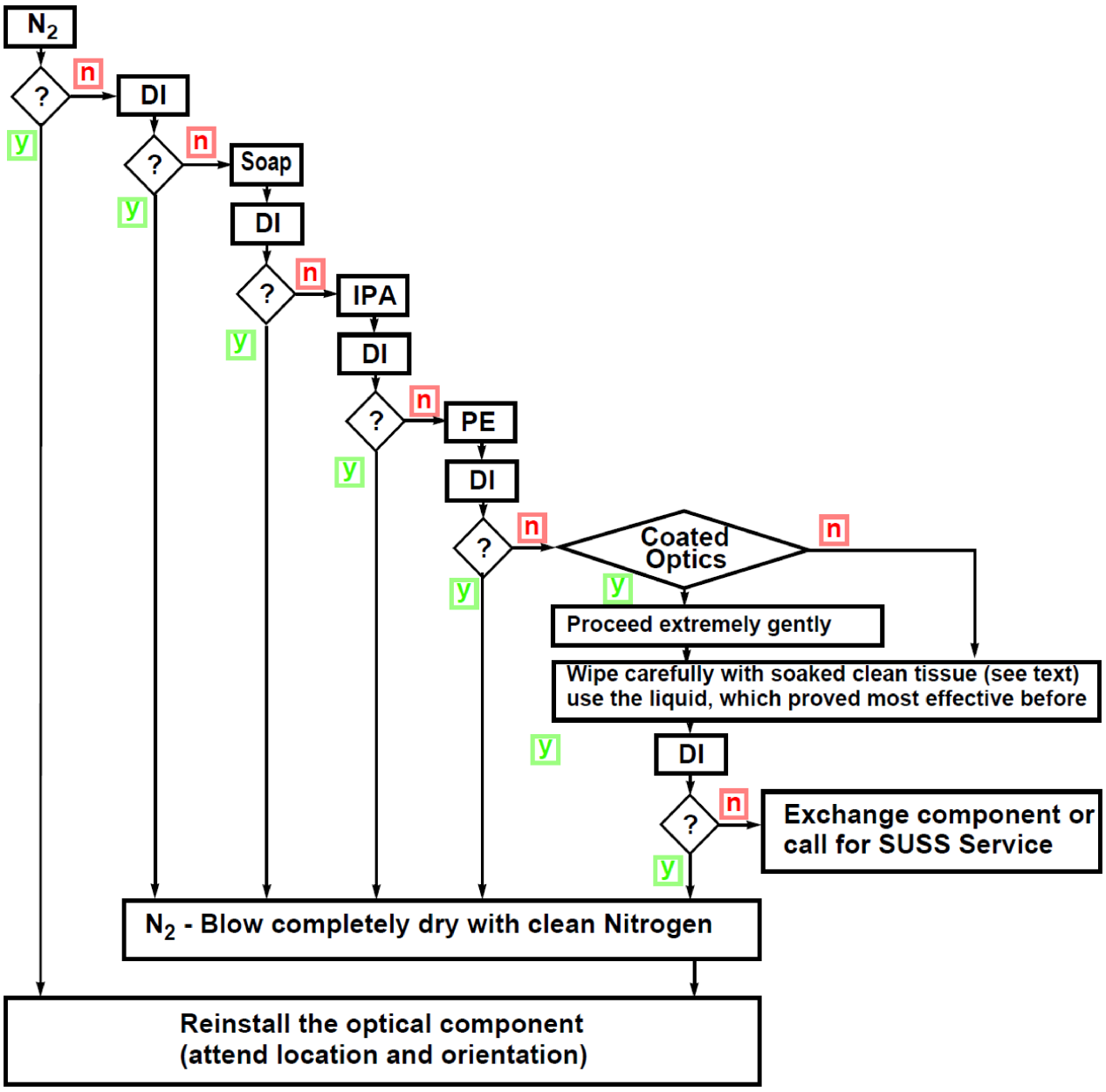
1. Remove the optical component, which has to be cleaned from the machine.
2. Note the orientation and exact location for later reinstallation.
3. Do wet cleaning, as appropriate: Rinse of the liquid over the optical surface or submerse the optical component into the clean liquid.
4. Remove fingerprints or droplets as soon as they appear in soap water.
5. See the flow diagram below for detailed cleaning procedure recommendation.
6. For extreme contaminations use petroleum ether additionally to IPA.



NOTICE!

Solvent consumption should be kept to a reasonable minimum for environmental and safety reasons.

Recommended Cleaning Procedure for Optical Components



Legend of Cleaning Procedure:

N2	Blow off dust (or droplets) with nitrogen
y/n	Check if surface is clean (y=yes, clean; n=no, not clean)
DI	Rinse or submerge with DI water (as appropriate for the component)
Soap	Rinse or submerge with detergent (1% in DI water)
IPA	Rinse or submerge with isopropanol alcohol
PE	Clean with petroleum ether (special light benzine)

- If a treatment step has been nearly successful, but one cannot be satisfied completely by the result, repeat this step, prior to trying the next treatment step or solvent type.
- When a cleaning procedure proved to be successful at an individual machine or production line, use always the same procedure and solvent when the optics of the identical machine needs cleaning again.
- In case of doubt contact SUSS Service in advance.

15.6.4 Safe Clean-Up after Use of Solvents

- Do not mix different liquids.
- Cap each bin (bottle, bowl, can) securely.
- Restore all unused inventory to its safe-keeping.
- Dispose each used cleaning liquid according to company or local waste rules and regulations.
- Dispose soaked cloths accordingly.

CC. SAFETY DATA SHEETS (SDS)

1 Greases

- Uniflor 8322 (formerly Fluoroether 857a)
- Leica 310
- Leica 410
- Isoflex NBU 15
- Isoflex NCA 15
- Rheolube 365

2 Gases

- Ozone

3 Solvents and Liquids

- Isopropanol (2-Propanol)
- Acetone
- Ethylene Glycol

4 Other Materials

- GaAs
- Silicon

5 Lamps

- High Pressure UV-Lamps
- Mercury
- Mercurysorb

NOTE!

SDS instructions can change caused by additional insight.

Always make sure, that the newest version of suppliers SDS is available!

Process-specific hazardous material may also be used. Related Safety Data Sheets mus be provided by the user.

MATERIAL SAFETY DATA SHEET

UNIFLOR 8322

According to EC Directive 2001/58/EC

1. Chemical and company identification

Name of chemical (Product name)	**UNIFLOR 8322**
Manufacturer	Nye Lubricants
Address	12 Howland Road
Division	Fairhaven, Ma 02719
Telephone	1-508-996-6721
Fax	
E-mail	
Supplier	Tsuchiya Co., Ltd.
Address	9-29, Kamimaezu 2-chome,
Department	Naka-ku, Nagoya 460-8330
Telephone	www.tsuchiya-group.co.jp
Fax	
E-mail	
Emergency Contact	
Emergency Telephone	
MSDS Author	
Product Code	Uniflor 8322

2. Hazards identification

GHS classification

The product is not classified according to GHS.

GHS label elements

Symbols	None.
Signal words	None.
Hazard statement	The mixture does not meet the criteria for classification.

Precautionary statement

Prevention	Observe good industrial hygiene practices.
Response	Wash hands after handling.
Storage	Store away from incompatible materials.
Disposal	Dispose of waste and residues in accordance with local authority requirements.

Other hazards which do not result in classification	Not classified.

None known.

Supplemental information

Not applicable.

Main symptoms and emergency overview

Emergency overview	Thermal decomposition will generate hydrogen fluoride, which is corrosive and can cause burns on contact with skin and other tissue. Inhalation of fumes generated during thermal decomposition may cause polymer fume fever.

3. Composition/information on ingredients

Substance or mixture	Mixture

		Gazette notification		
Components	**CAS Number**	**ENCS no.**	**ISHL no.**	**Concentration (%)**
POLYTETRAFLUOROETHYLENE	9002-84-0	6-939	(6)-939	35 - 40
Other components below reportable levels				65 - 70

Chemical formula	(C2-F4)X- (9002-84-0)

4. First aid measures

If inhaled	If symptoms develop, remove affected person from source of exposure into fresh air. Get immediate medical attention.
If on skin	Wash off with soap and water. Get medical attention if symptoms occur. Wash clothing separately before reuse.
If in eyes	Immediately flush eyes with plenty of water for at least 15 minutes. Get immediate medical attention.
If swallowed	If ingestion of a large amount does occur, seek medical attention. Do not induce vomiting without medical advice. If vomiting occurs naturally, have victim lean forward to reduce risk of aspiration. Never give anything by mouth to a victim who is unconscious or is having convulsions.
Most important symptoms/effects, acute and delayed	Direct contact with eyes may cause temporary irritation.
Protection of first-aid responders	Ensure that medical personnel are aware of the material(s) involved, and take precautions to protect themselves.
Notes to physician	Treat symptomatically.

5. Fire-fighting measures

Extinguishing media	Water fog. Foam. Dry chemical powder. Carbon dioxide (CO2). Use methods for the surrounding fire. Product does not burn.
Extinguishing media to avoid	Do not use water jet as an extinguisher, as this will spread the fire.
Specific hazards	During fire, gases hazardous to health may be formed.
Special fire fighting procedures	Move containers from fire area if you can do it without risk. Wear full protective clothing, including helmet, self-contained positive pressure or pressure demand breathing apparatus, protective clothing and face mask.
Protection of fire-fighters	Self-contained breathing apparatus and full protective clothing must be worn in case of fire.

6. Accidental release measures

Personal precautions, protective equipment and emergency measures	Keep unnecessary personnel away. Keep people away from and upwind of spill/leak. Do not touch damaged containers or spilled material unless wearing appropriate protective clothing. For personal protection, see section 8 of the MSDS. Observe precautions from other sections.
Environmental precautions	Prevent entry into waterways, sewers, basements or confined areas.
Methods or materials for containment and cleaning up	Soak up with inert absorbent material. Large Spills: Stop the flow of material, if this is without risk. Dike the spilled material, where this is possible. Cover with plastic sheet to prevent spreading. Clean contaminated surface thoroughly. Absorb in vermiculite, dry sand or earth and place into containers. Following product recovery, flush area with water. Small Spills: Wipe up with absorbent material (e.g. cloth, fleece). Clean surface thoroughly to remove residual contamination. Never return spills in original containers for re-use. For waste disposal, see section 13 of the MSDS. Clean up spills immediately, observing precautions in Protective Equipment section. Sweep up and shovel into suitable containers for disposal.

7. Handling and storage

Handling

Technical measures (e.g. Local and general ventilation)	No specific recommendations.
Safe handling advice	Observe good industrial hygiene practices.
Contact avoidance measures	Strong oxidizing agents.

Hygiene measures	When using, do not eat, drink or smoke. Launder contaminated clothing before reuse. Wash hands thoroughly after handling.

Storage

Safe storage conditions	Store in original tightly closed container. Store away from incompatible materials (see Section 10 of the MSDS).
Safe packaging materials	Keep in original container.

8. Exposure controls/personal protection

Occupational exposure limits	No exposure limits noted for ingredient(s).
Engineering measures	Use process enclosures, local exhaust ventilation, or other engineering controls to control airborne levels below recommended exposure limits.

Personal protective equipment

Respiratory protection	An air purifying respirator with an organic vapor cartridge may be used under certain circumstances where airborne concentrations are expected to exceed exposure limits, or if irritation or symptoms are experienced. No personal respiratory protective equipment normally required.
Hand protection	For prolonged or repeated skin contact use suitable protective gloves.
Eye protection	Wear safety glasses; chemical goggles (if splashing is possible).
Skin and body protection	Wear suitable protective clothing. Wear nitrile, neoprene, PVC or viton gloves.

9. Physical and chemical properties

Appearance

Physical state	Liquid.
Form	Liquid. Semi-solid
Color	White
Odor	Slight
pH	Not available.
Melting point/Freezing point	Not available.
Boiling point, initial boiling point, and boiling range	Not available.
Flash point	Not available.

Upper/lower flammability or explosive limits

Flammability limit - lower (%)	Not available.
Flammability limit - upper (%)	Not available.
Explosive limit - lower (%)	Not available.
Explosive limit - upper (%)	Not available.
Vapor pressure	Not available.
Vapor density	Not available.
Specific gravity	Not available.
Solubility(ies)	Not available.
Partition coefficient (n-octanol/water)	Not available.
Auto-ignition temperature	Not available.
Decomposition temperature	Not available.
Viscosity (Coefficient of viscosity)	Not available.

Other information

Density	1.97 g/cm³
Kinematic viscosity	800 cSt
Shelf life	4 years

10. Stability and reactivity

Reactivity	The product is stable and non-reactive under normal conditions of use, storage and transport.
Chemical stability	Stable.
Possibility of hazardous reactions	No dangerous reaction known under conditions of normal use.
Conditions to avoid	Heat, flames and sparks. Contact with incompatible materials.
Incompatible materials	Strong acids, alkalies and oxidizing agents. Alkaline metals. Alkaline earth metals. Powdered metals. Halogenated compounds.
Hazardous decomposition products	Hydrogen fluoride. Carbonyl fluoride.

11. Toxicological information

Skin corrosion/irritation	Prolonged skin contact may cause temporary irritation.
Serious eye damage/eye irritation	Knowledge about health hazard is incomplete.

Respiratory or skin sensitization

Respiratory sensitization	Knowledge about sensitization hazard is incomplete.
Skin sensitization	Knowledge about sensitization hazard is incomplete.
Germ cell mutagenicity	Knowledge about mutagenicity is incomplete.
Carcinogenicity	This product does not contain any carcinogens or potential carcinogens as listed by IARC.

IARC Monographs. Overall Evaluation of Carcinogenicity

POLYTETRAFLUOROETHYLENE (CAS 9002-84-0) 3 Not classifiable as to carcinogenicity to humans.

Reproductive toxicity	Knowledge about health hazard is incomplete.
Specific target organ toxicity - single exposure	Knowledge about health hazard is incomplete.
Specific target organ toxicity - repeated exposure	Not classified.
Aspiration hazard	Knowledge about health hazard is incomplete.
Other information	This product has no known adverse effect on human health.

12. Ecological information

Ecotoxicity	This material is not expected to be harmful to aquatic life.
Persistence and degradability	No data is available on the degradability of this product.
Bioaccumulation	No data available.
Mobility in soil	No data available.
Hazardous to the ozone layer	No data available.
Other hazardous effects	No other adverse environmental effects (e.g. ozone depletion, photochemical ozone creation potential, endocrine disruption, global warming potential) are expected from this component.

13. Disposal considerations

Dispose in accordance with all applicable regulations.

Residual waste	Dispose of in accordance with local regulations. Empty containers or liners may retain some product residues. This material and its container must be disposed of in a safe manner (see: Disposal instructions).

Contaminated packaging Empty containers should be taken to an approved waste handling site for recycling or disposal. Since emptied containers may retain product residue, follow label warnings even after container is emptied.

Local disposal regulations Contract with a disposal operator licensed by the Law on Disposal and Cleaning. Dispose in accordance with all applicable regulations. When your own wastewater treatment plant is not available, collect entire waste and then charge to a licensed industrial waste management professional with manifests for industrial waste.

14. Transport information

International regulations

IATA

Not regulated as dangerous goods.

IMDG

Not regulated as dangerous goods.

National regulations Follow regulation in section 15 for domestic transportation.

15. Regulatory information

Industrial Safety and Health Act

Notifiable substances
Not regulated.

Labeling substances
Not regulated.

Poisonous and Deleterious Substances Control Act

Specified poisonous substances
Not regulated.

Poisonous substances
Not regulated.

Deleterious substances
Not regulated.

Act on the Evaluation of Chemical Substances and Regulation of Their Manufacture, etc.

Class I specified chemical substances
Not regulated.

Class II specified chemical substances
Not regulated.

Monitoring chemical substances
Not regulated.

Priority Assessment Chemical Substances (PACs)
Not regulated.

Reporting Exempted Substances
Not regulated.

Law concerning Pollutant Release and Transfer Register

Specified class 1 substances (substance name, ordinance number and content)
Not regulated.

Class 1 substances (substance name, ordinance number and content)
Not regulated.

Class 2 substances (substance name, ordinance number and content)
Not regulated.

Ship Safety Law, Dangerous Goods Marine Transport and Storage Rule Not regulated.

Air Law, Enforcement Rule Not regulated.

Explosives Control Act
Not regulated.

16. Other information

Bibliography

HSDB® - Hazardous Substances Data Bank
IARC Monographs. Overall Evaluation of Carcinogenicity
National Toxicology Program (NTP) Report on Carcinogens
ACGIH Documentation of the Threshold Limit Values and Biological Exposure Indices
Japan Society for Occupational Health, Recommendation of Occupational Exposure Limits
JIS Z 7252:2009 Classification of chemicals based on ”Globally Harmonized System of Classification and Labelling of Chemicals (GHS)”
JIS Z 7253:2012 Hazard communication of chemicals based on GHS – Labelling and Safety Data Sheet (SDS)
Japan Chemical Industry Association (JCIA) GHS Guideline, June 2012

The information provided in this Safety Data Sheet is correct to the best of our knowledge, information and belief at the date of its publication . The information given is designed only as a guidance for safe handling, use, processing, storage, transportation, disposal and release. Nye Lubricants, Inc. makes no warranty with respect thereto and disclaims all liability with respect thereon. This safety data sheet was prepared in accordance with JIS Z 7253:2012. The information in the sheet was written based on the best knowledge and experience currently available.

This data sheet contains changes from the previous version in section(s):

This document has undergone significant changes and should be reviewed in its entirety.

Safety Data Sheet
According to 1907/2006/EC

Fett 310

Revision date: 26.08.2009 Version 04 Print date: 02.02.2012

1. Identification of the substance / preparation and of the company / undertaking

Name	**Fett 310**
Intended use of the preparation	Lubricant for professional use.
Product Name	Losoid 1191
Producer	LOSIMOL GmbH Arndtstr. 14 D – 30167 Hannover, Germany
Trading Company	Leica Microsystems CMS GmbH Ernst-Leitz-Straße 17 - 37 D - 35587 Wetzlar, Germany Tel.: +49 (0) 6441-29-0
Information on Safety Data Sheet	Environmental and Chemical Engineering Department Tel.: +49 (0) 6441-29-0 e-mail: MSDS-Info@leica-microsystems.com
Emergency telephone number	Giftinformation Mainz: Tel.: +49 (0) 6131-19240

2. Hazards identification

Classification: No particular hazards known under normal use.

3. Composition / information on ingredients

Chemical characterization: Mineral oil.

CAS-No.	Chemical Name	R-phrases	Symbol	%
-	-	-	-	-

4. First aid measures

General information	In case of accident or if you feel unwell seek medical advice (show label or SDS where possible).
After inhalation	Provide fresh air.
After contact with eyes	Wipe off excess material with cloth or paper. Rinse with plenty of water for at least 10 minutes. Seek medical advice.
After contact with skin	Wash with plenty of water and soap. Seek medical advice in case of continuous irritation.
After ingestion	Give several small portions of water to drink. Do not induce vomiting. If symptoms persist, consult a doctor.

5. Fire-fighting measures

Suitable extinguishing media	Water spray, foam, dry powder and carbon dioxide.
Extinguishing media which shall not be used for safety reasons	High volume water jet.

Special exposure hazards arising from the substance or preparation itself, combustion products, resulting gases	Not applicable.
Special protective equipment for fire fighters	Use respiratory protection independent of recirculated air.
Additional advice	Cool closed containers exposed to the fire with water spray.

6. Accidental release measures

Personal precautions	If material is released indicate risk of slipping. Do not walk through spilled material.
Environmental precautions	Do not flush into surface water or sanitary sewer systems.
Methods for cleaning up/taking up	Contain and collect spillage with absorbent materials and place in container for disposal according to local regulations.

7. Handling and storage

Save handling advice	Spilled substance increases risk of slipping. Do not eat or drink when handling.
Precautions against fire and explosion	Observe the general rules for fire prevention.
Storage	Store at room temperature in the original container. Keep container tightly closed.

8. Exposure controls / personal protection

National occupational exposure limits

EINECS-No.	Chemical Name	Type	Value	Unit
-	-	-	-	-

General protection and hygiene measures	Avoid prolonged and/or repeated contact with skin, eyes and clothing. Wash skin thoroughly with soap and water after work. Do not eat, smoke or drink when handling.
Personal protective equipment	No special protective equipment required.
Respiratory protection	Not required.
Eye protection	Not required.
Hand protection	Not required.

9. Physical and chemical properties

Form	Paste.	
Colour	White.	
Odour	Product specific.	
Boiling point / boiling range	Not applicable.	
Flash point	190°C	DIN 51478
Density	0,894 g/cm^3	at 20°C
Water solubility	Insoluble.	
Viscosity	3500 mPas	DIN 53018 Teil 1

10. Stability and reactivity

Conditions to avoid	None.
Materials to avoid	None.
Hazardous decomposition products	If stored and handled in accordance with standard industrial practices and local regulations where applicable: None known.

11. Toxicological information

The product is classified and labelled in accordance with EC directives (1999/45/EG) and the calculation procedure of the "General Classification guideline for preparations of the EU" in the latest valid version.

12. Ecological information

Ecotoxicity	Product is insoluble in water.
Effects in sewage treatment plants (bacteria toxicity, respiration/ reproduction inhibition:	According to current knowledge adverse effects on water purification plants are not expected.
Mobility	The product can be mechanically separated.
Bio-accumulative potential	Bioaccumulation is not expected to occur.
Other adverse effects	None.

13. Disposal considerations

Product	Material that cannot be used or chemically reprocesses should be disposed of at an approved facility in accordance with any applicable governmental regulations.
Uncleaned packaging	Completely discharged containers (no tear drops, no powder rest, scraped carefully) may be recycled or re-used. Observe local/state/federal regulations.

14. Transport information

ADR/RID (Land transport)	Not classified as dangerous in the meaning of transport regulations.
IMDG (Sea transport)	Not classified as dangerous in the meaning of transport regulations.
ICAO / IATA (Air transport)	Not classified as dangerous in the meaning of transport regulations.

15. Regulatory information

The preparation is evaluated in accordance with the conventional method of the preparation directive 1999/45/EC.

Symbol and indication of hazard	Not classified as dangerous.
R-phrases	None.
S-phrases	None.
National legislation	The safety datasheet has been prepared according to German legislation.

16. Other information

Full text of R-phrases appearing in section 3: -

Further information:
Applicable regulations
Preparation directive 1999/45/EC, last amended by directive 1907/2006/EC
Directive 67/548/EC, last amended by directive 2006/121/EC
Directive 1907/2006/EC (REACH)

The information provided in this Safety Data Sheet is based on the present state of our knowledge and meets the requirements of EU and national laws. The user's working conditions however, are beyond our knowledge and control. The information relates only to the specific material designated and may not be valid if the material is used in combination with any other materials or if it is processed unless specified in the text. The information given in this SDS is to describe the product only in terms of health and safety requirements and should not, therefore, be constructed as guaranteeing specific properties.

Information on SDS: Environmental and Chemical Engineering Department
Bettina Stanschus Dipl.-Ing.(FH) Tel.: +49 (0) 6441 – 29 22 88

Safety Data Sheet
According to 1907/2006/EC

Fett 410

Revision date: 26.08.2009 Version 05 Print date: 14.12.2009

1. Identification of the substance / preparation and of the company / undertaking

Name	**Fett 410**
Intended use of the preparation	Lubricant for professional use.
Handelsname	Nontrop KR 291
Hersteller	Klüber Lubrication München KG Geisenhausenerstrasse 7 D-81379 München, Germany
Trading Company	Leica Microsystems CMS GmbH Ernst-Leitz-Straße 17 - 37 D - 35587 Wetzlar, Germany Tel.: +49 (0) 6441-29-0
Information on Safety Data Sheet	Environmental and Chemical Engineering Department Tel.: +49 (0) 6441-29-0 e-mail: MSDS-Info@leica-microsystems.com
Emergency telephone number	Giftinformation Mainz: Tel.: +49 (0) 6131-19240

2. Hazards identification

Classification: No particular hazards known under normal use.

3. Composition / information on ingredients

Chemical characterization: Mineral oil and silicates.

CAS-No.	Chemical Name	R-phrases	Symbol	%
-	-	-	-	-

4. First aid measures

General information	In case of accident or if you feel unwell seek medical advice (show label or SDS where possible).
After inhalation	Provide fresh air.
After contact with eyes	Rinse with plenty of water for at least 10 minutes. Seek medical advice in case of continuous irritation.
After contact with skin	Wipe off excess material with cloth or paper. Wash with plenty of water and soap.
After ingestion	Give several small portions of water to drink. Do not induce vomiting. If symptoms persist, consult a doctor.

5. Fire-fighting measures

Suitable extinguishing media	Water spray, foam, dry powder and carbon dioxide.
Extinguishing media which shall not be used for safety reasons	High volume water jet.

Special exposure hazards arising from the substance or preparation itself, combustion products, resulting gases	Not applicable.
Special protective equipment for fire fighters	Use respiratory protection independent of recirculated air.
Additional advice	Cool closed containers exposed to the fire with water spray.

6. Accidental release measures

Personal precautions	If material is released indicate risk of slipping. Do not walk through spilled material.
Environmental precautions	Do not flush into surface water or sanitary sewer systems.
Methods for cleaning up/taking up	Contain and collect spillage with absorbent materials and place in container for disposal according to local regulations.

7. Handling and storage

Save handling advice	Spilled substance increases risk of slipping. Do not eat or drink when handling.
Precautions against fire and explosion	Observe the general rules for fire prevention.
Storage	Store at room temperature in the original container. Keep container tightly closed.

8. Exposure controls / personal protection

National occupational exposure limits

EINECS-No.	Chemical Name	Type	Value	Unit
-	-	-	-	-

General protection and hygiene measures	Avoid prolonged and/or repeated contact with skin, eyes and clothing. Wash skin thoroughly with soap and water after work. Do not eat, smoke or drink when handling.
Personal protective equipment	No special protective equipment required.
Respiratory protection	Not required.
Eye protection	Not required.
Hand protection	Not required.

9. Physical and chemical properties

Form	Paste.
Colour	Brown.
Odour	Product specific.
Boiling point / boiling range	Not applicable.
Flash point	Not applicable.
Density	0,92 g/cm^3 at 20°C
Water solubility	Insoluble.
Viscosity	Not applicable.

10. Stability and reactivity

Conditions to avoid	None.
Materials to avoid	None.
Hazardous decomposition products	If stored and handled in accordance with standard industrial practices and local regulations where applicable: None known.

11. Toxicological information

The product is classified and labelled in accordance with EC directives (1999/45/EG) and the calculation procedure of the "General Classification guideline for preparations of the EU" in the latest valid version.

12. Ecological information

Ecotoxicity	Product is unsoluble in water.
Effects in sewage treatment plants (bacteria toxicity, respiration/ reproduction inhibition:	According to current knowledge adverse effects on water purification plants are not expected.
Mobility	The product can be mechanically separated.
Bio-accumulative potential	Bioaccumulation is not expected to occur.
Other adverse effects	None.

13. Disposal considerations

Product	Material that cannot be used or chemically reprocesses should be disposed of at an approved facility in accordance with any applicable governmental regulations.
Uncleaned packaging	Completely discharged containers (no tear drops, no powder rest, scraped carefully) may be recycled or re-used. Observe local/state/federal regulations.

14. Transport information

ADR/RID (Land transport)	Not classified as dangerous in the meaning of transport regulations.
IMDG (Sea transport)	Not classified as dangerous in the meaning of transport regulations.
ICAO / IATA (Air transport)	Not classified as dangerous in the meaning of transport regulations.

15. Regulatory information

The preparation is evaluated in accordance with the conventional method of the preparation directive 1999/45/EC.

Symbol and indication of hazard	Not classified as dangerous.
R-phrases	None.
S-phrases	None.
National legislation	The safety datasheet has been prepared according to German legislation.

16. Other information

Full text of R-phrases appearing in section 3: -

Further information:
Applicable regulations
Preparation directive 1999/45/EC, last amended by directive 1907/2006/EC
Directive 67/548/EC, last amended by directive 2006/121/EC
Directive 1907/2006/EC (REACH)

The information provided in this Safety Data Sheet is based on the present state of our knowledge and meets the requirements of EU and national laws. The user's working conditions however, are beyond our knowledge and control. The information relates only to the specific material designated and may not be valid if the material is used in combination with any other materials or if it is processed unless specified in the text. The information given in this SDS is to describe the product only in terms of health and safety requirements and should not, therefore, be constructed as guaranteeing specific properties.

Information on SDS: Environmental and Chemical Engineering Department
Bettina Stanschus Dipl.-Ing.(FH) Tel.: +49 (0) 6441 – 29 22 88

ISOFLEX NBU 15

Version 1.1 Revision Date 17.06.2015 Print Date 18.06.2015

1. Identification of the substance/mixture and of the company/undertaking

1.1 Product identifier

Product name : ISOFLEX NBU 15

Article-No. : 004026

1.2 Relevant identified uses of the substance or mixture and uses advised against

Use of the Substance/Mixture : Grease

Recommended restrictions on use : Restricted to professional users.

1.3 Details of the supplier of the safety data sheet

KLÜBER LUBRICATION MÜNCHEN
Geisenhausenerstrasse 7
D-81379 München
Deutschland
Tel: +49 (0) 897876-0
Fax: +49 (0) 897876-333

E-mail address : mcm@klueber.com
Responsible/issuing person Material Compliance Management

National contact : Klüber Lubrication Deutschland
Geisenhausenerstraße 7
81379 München
Deutschland
+49-89-7876-0
Fax: +49-89-7876-565
www.klueber.com

1.4 Emergency telephone number

0049 (0) 897876-700 (24hrs)

2. Hazards identification

2.1 Classification of the substance or mixture

Classification (REGULATION (EC) No 1272/2008)

Not a hazardous substance or mixture.

Classification (67/548/EEC, 1999/45/EC)

Not a hazardous substance or mixture.

2.2 Label elements

Labelling (REGULATION (EC) No 1272/2008)

Not a hazardous substance or mixture.

Additional Labelling:

EUH210 Safety data sheet available on request.
EUH208 Contains: N-alkylated benzotriazoleMay produce an allergic reaction.

2.3 Other hazards

3. Composition/information on ingredients

3.2 Mixtures

Chemical nature : Mineral oil.
Synthetic hydrocarbon oil
ester oil
barium complex soap

Hazardous components

Chemical Name	CAS-No. EC-No. Index-No. Registration number	Classification (67/548/EEC)	Classification (REGULATION (EC) No 1272/2008)	Concentration [%]
Dec-1-ene, homopolymer, hydrogenated + 7-methylpentadecane; tetra-1-decen, dimer, trimer, hydrogenated	68037-01-4 1000172-11-1		Asp. Tox. 1; H304	>= 10 - < 20
Benzenamine, N-phenyl-, reaction products with 2,4,4-trimethylpentene	68411-46-1 270-128-1	R52/53	Aquatic Chronic 3; H412	>= 1 - < 2,5

For the full text of the R-phrases mentioned in this Section, see Section 16.
For the full text of the H-Statements mentioned in this Section, see Section 16.

4. First aid measures

4.1 Description of first aid measures

If inhaled : Remove person to fresh air. If signs/symptoms continue, get medical attention.
Keep patient warm and at rest.
If breathing is irregular or stopped, administer artificial respiration.

In case of skin contact : Remove contaminated clothing. If irritation develops, get medical attention.
In case of contact, immediately flush skin with plenty of water.

In case of eye contact : Rinse immediately with plenty of water, also under the eyelids, for at least 10 minutes.
If eye irritation persists, consult a specialist.

If swallowed : Move the victim to fresh air.

Do not induce vomiting without medical advice.

4.2 Most important symptoms and effects, both acute and delayed

Symptoms	:	No information available.
Risks	:	None known.

4.3 Indication of any immediate medical attention and special treatment needed

Treatment	:	No information available.

5. Firefighting measures

5.1 Extinguishing media

Suitable extinguishing media	:	Use extinguishing measures that are appropriate to local circumstances and the surrounding environment.
Unsuitable extinguishing media	:	High volume water jet

5.2 Special hazards arising from the substance or mixture

Specific hazards during firefighting	:	Fire may cause evolution of: Carbon oxides Metal oxides Nitrogen oxides (NOx)

5.3 Advice for firefighters

Special protective equipment for firefighters	:	In the event of fire, wear self-contained breathing apparatus. Use personal protective equipment. In the case of respirable dust and/or fumes, use self-contained breathing apparatus. Exposure to decomposition products may be a hazard to health.
Further information	:	Standard procedure for chemical fires.

6. Accidental release measures

6.1 Personal precautions, protective equipment and emergency procedures

Personal precautions	:	Evacuate personnel to safe areas. Use the indicated respiratory protection if the occupational exposure limit is exceeded and/or in case of product release (dust). Avoid breathing dust. Refer to protective measures listed in sections 7 and 8.

6.2 Environmental precautions

Environmental precautions	:	Try to prevent the material from entering drains or water courses. Local authorities should be advised if significant spillages cannot be contained.

6.3 Methods and materials for containment and cleaning up

Methods for cleaning up	:	Clean up promptly by sweeping or vacuum. Keep in suitable, closed containers for disposal.

6.4 Reference to other sections

For personal protection see section 8.

7. Handling and storage

7.1 Precautions for safe handling

Advice on safe handling	:	For personal protection see section 8. Smoking, eating and drinking should be prohibited in the application area. Wash hands and face before breaks and immediately after handling the product.

7.2 Conditions for safe storage, including any incompatibilities

Requirements for storage areas and containers	:	Store in original container. Keep container closed when not in use. Keep in a dry, cool and well-ventilated place. Containers which are opened must be carefully resealed and kept upright to prevent leakage. Store in accordance with the particular national regulations. Keep in properly labelled containers.
German storage class	:	11 Combustible Solids

7.3 Specific end use(s)

: Consult the technical guidelines for the use of this substance/mixture.

8. Exposure controls/personal protection

8.1 Control parameters

Contains no substances with occupational exposure limit values.

8.2 Exposure controls

Engineering measures

Maintain air concentrations below occupational exposure standards.

Personal protective equipment

Respiratory protection	:	Not required; except in case of aerosol formation. Filter type P
Hand protection	:	Wear protective gloves.

The selected protective gloves have to satisfy the specifications of EU Directive 89/686/EEC and the standard EN 374 derived from it.
The break through time depends amongst other things on the material, the thickness and the type of glove and therefore has to be measured for each case.
In case of contact through splashing:

: Nitrile rubber
Protective index Class 1

Eye protection : Tightly fitting safety goggles
Safety glasses with side-shields conforming to EN166

Hygiene measures : Wash face, hands and any exposed skin thoroughly after handling.

Protective measures : The type of protective equipment must be selected according to the concentration and amount of the dangerous substance at the specific workplace.
Choose body protection in relation to its type, to the concentration and amount of dangerous substances, and to the specific work-place.

Environmental exposure controls

General advice : Try to prevent the material from entering drains or water courses.
Local authorities should be advised if significant spillages cannot be contained.

9. Physical and chemical properties

9.1 Information on basic physical and chemical properties

Form	:	paste
Colour	:	beige
Odour	:	characteristic
Odour Threshold	:	No data available
pH	:	not applicable
Melting point/range	:	No data available
Boiling point/boiling range	:	No data available
Flash point	:	not applicable
Evaporation rate	:	No data available
Flammability (solid, gas)	:	No data available Combustible Solids
Lower explosion limit	:	No data available
Upper explosion limit	:	No data available

Vapour pressure	:	< 0,001 hPa, 20 °C
Relative vapour density	:	No data available
Density	:	0,99 g/cm3, 20 °C
Water solubility	:	insoluble
Solubility in other solvents	:	No data available
Partition coefficient: n-octanol/water	:	No data available
Auto-ignition temperature	:	No data available
Ignition temperature	:	No data available
Viscosity, dynamic	:	No data available
Viscosity, kinematic	:	No data available
Oxidizing properties	:	No data available

9.2 Other information

Sublimation point	:	not applicable
Bulk density	:	not applicable

10. Stability and reactivity

10.1 Reactivity

No hazards to be specially mentioned.

10.2 Chemical stability

No decomposition if stored and applied as directed.

10.3 Possibility of hazardous reactions

Hazardous reactions	:	No dangerous reaction known under conditions of normal use.

10.4 Conditions to avoid

Conditions to avoid	:	No conditions to be specially mentioned.

10.5 Incompatible materials

Materials to avoid	:	No materials to be especially mentioned.

10.6 Hazardous decomposition products

Hazardous decomposition products	:	No decomposition if stored and applied as directed.

11. Toxicological information

11.1 Information on toxicological effects

Product

Acute inhalation toxicity	:	This information is not available.
Skin corrosion/irritation	:	This information is not available.

Serious eye damage/eye irritation	:	This information is not available.
Respiratory or skin sensitisation	:	This information is not available.
Germ cell mutagenicity		
Genotoxicity in vitro	:	No data available
Genotoxicity in vivo	:	No data available
Carcinogenicity	:	No data available
Reproductive toxicity	:	No data available
Teratogenicity	:	No data available
Repeated dose toxicity	:	This information is not available.
Aspiration toxicity	:	This information is not available.
Further information	:	Information given is based on data on the components and the toxicology of similar products.

Components:

Dec-1-ene, homopolymer, hydrogenated + 7-methylpentadecane; tetra-1-decen, dimer, trimer, hydrogenated :

Acute oral toxicity	:	LD50: > 5.000 mg/kg, rat
Acute dermal toxicity	:	LD50: > 2.000 mg/kg, rat, OECD Test Guideline 402, The substance or mixture has no acute dermal toxicity
Skin corrosion/irritation	:	rabbit, Result: No skin irritation, Classification: No skin irritation, OECD Test Guideline 404, GLP: yes
Serious eye damage/eye irritation	:	rabbit, Result: No eye irritation, Classification: No eye irritation, OECD Test Guideline 405, GLP: yes
Respiratory or skin sensitisation	:	Maximisation Test (GPMT), guinea pig, Result: Does not cause skin sensitisation., Classification: Does not cause skin sensitisation., OECD Test Guideline 406, GLP: yes
Germ cell mutagenicity		
Genotoxicity in vitro	:	Ames test, Result: negative, Mutagenicity (Escherichia coli - reverse mutation assay), GLP: yes
Assessment	:	Animal testing did not show any mutagenic effects.
Aspiration toxicity	:	May be fatal if swallowed and enters airways.

Benzenamine, N-phenyl-, reaction products with 2,4,4-trimethylpentene :

Acute oral toxicity	:	LD50: > 5.000 mg/kg, rat, OECD Test Guideline 401
Acute dermal toxicity	:	LD50: > 2.000 mg/kg, rat, OECD Test Guideline 402
Skin corrosion/irritation	:	rabbit, Result: No skin irritation, Classification: No skin irritation
Serious eye damage/eye irritation	:	rabbit, Result: No eye irritation, Classification: No eye irritation

Respiratory or skin sensitisation	:	guinea pig, Result: Does not cause skin sensitisation., Classification: Does not cause skin sensitisation., OECD Test Guideline 406

12. Ecological information

12.1 Toxicity

Product:

Toxicity to fish	:	No data available
Toxicity to daphnia and other aquatic invertebrates	:	No data available
Toxicity to algae	:	No data available
Toxicity to bacteria	:	No data available

Components:

Dec-1-ene, homopolymer, hydrogenated + 7-methylpentadecane; tetra-1-decen, dimer, trimer, hydrogenated :

Toxicity to fish	:	LC50: > 1.000 mg/l, 96 h, Oncorhynchus mykiss (rainbow trout), static test, OECD Test Guideline 203, GLP: yes
Toxicity to daphnia and other aquatic invertebrates	:	EC50: > 1.000 mg/l, 48 h, Daphnia magna (Water flea), Immobilization, OECD Test Guideline 202, GLP: yes
Toxicity to algae	:	ErC50: > 1.000 mg/l, 72 h, Scenedesmus capricornutum (fresh water algae), Growth inhibition, OECD Test Guideline 201, GLP: yes
Toxicity to bacteria	:	EC50: > 1.000 mg/l, 3 h, Bacteria, Respiration inhibition, OECD 209, GLP: yes
Toxicity to daphnia and other aquatic invertebrates (Chronic toxicity)	:	NOEC: 125 mg/l, 21 d, Daphnia magna (Water flea)

Benzenamine, N-phenyl-, reaction products with 2,4,4-trimethylpentene :

Toxicity to fish	:	LC50: > 100 mg/l, 96 h, Danio rerio (zebra fish), OECD Test Guideline 203
Toxicity to daphnia and other aquatic invertebrates	:	EC50: 51 mg/l, 48 h, Daphnia magna (Water flea), Immobilization, OECD 202 T1

Ecotoxicology Assessment

Acute aquatic toxicity	:	Harmful to aquatic life.
Chronic aquatic toxicity	:	Harmful to aquatic life with long lasting effects.

12.2 Persistence and degradability

Product:

Biodegradability	:	No data available
Physico-chemical removability	:	No data available

Components:

Dec-1-ene, homopolymer, hydrogenated + 7-methylpentadecane; tetra-1-decen, dimer, trimer, hydrogenated :

Biodegradability	:	Primary biodegradation, Result: Not readily biodegradable., activated sludge, OECD Test Guideline 301B

12.3 Bioaccumulative potential

Product:

Bioaccumulation	:	This mixture contains no substance considered to be persistent, bioaccumulating nor toxic (PBT)., This mixture contains no substance considered to be very persistent nor very bioaccumulating (vPvB).

Components:

Dec-1-ene, homopolymer, hydrogenated + 7-methylpentadecane; tetra-1-decen, dimer, trimer, hydrogenated :

Bioaccumulation	:	Bioconcentration factor (BCF): > 10

Benzenamine, N-phenyl-, reaction products with 2,4,4-trimethylpentene :

Bioaccumulation	:	Due to the distribution coefficient n-octanol/water, accumulation in organisms is possible.

12.4 Mobility in soil

Product:

Mobility	:	No data available
Distribution among environmental compartments	:	No data available

12.5 Results of PBT and vPvB assessment

Product:

Assessment	:	This substance/mixture contains no components considered to be either persistent, bioaccumulative and toxic (PBT), or very persistent and very bioaccumulative (vPvB) at levels of 0.1% or higher.

Components:

Dec-1-ene, homopolymer, hydrogenated + 7-methylpentadecane; tetra-1-decen, dimer, trimer, hydrogenated :

Assessment	:	Non-classified PBT substance, Non-classified vPvB substance

12.6 Other adverse effects

Product:

Additional ecological information	:	No information on ecology is available.

13. Disposal considerations

13.1 Waste treatment methods

Product	:	The product should not be allowed to enter drains, water courses or the soil.
	:	Waste codes should be assigned by the user based on the application for which the product was used.
Contaminated packaging	:	Empty containers can be landfilled, when in accordance with the local regulations.

14. Transport information

14.1 UN number

ADR
Not dangerous goods
IMDG
Not dangerous goods
IATA
Not dangerous goods

14.2 Proper shipping name

ADR
Not dangerous goods
IMDG
Not dangerous goods
IATA
Not dangerous goods

14.3 Transport hazard class

ADR
Not dangerous goods
IMDG
Not dangerous goods
IATA
Not dangerous goods

14.4 Packing group

ADR
Not dangerous goods
IMDG
Not dangerous goods
IATA
Not dangerous goods

14.5 Environmental hazards

ADR
Not dangerous goods
IMDG
Not dangerous goods
IATA

Not dangerous goods

14.6 Special precautions for user
No data available

14.7 Transport in bulk according to Annex II of MARPOL 73/78 and the IBC Code
Not available

15. Regulatory information

15.1 Safety, health and environmental regulations/legislation specific for the substance or mixture

REACH - Candidate List of Substances of Very High Concern for Authorisation (Article 59).	:	This product does not contain substances of very high concern (Regulation (EC) No 1907/2006 (REACH), Article 57).
Major Accident Hazard Legislation	:	96/82/EC Update: not applicable
Water contaminating class (Germany)	:	WGK 1: slightly water endangering
TA Luft List (Germany)	:	Total dust: Portion other substances: 30,25 % Inorganic substances in powdered form: not applicable Inorganic substances in vapour or gaseous form: not applicable Organic Substances: portion Class 1: 0,1 % ; Portion other substances: 69,65 % Carcinogenic substances: not applicable Mutagenic: not applicable Toxic to reproduction: not applicable

15.2 Chemical Safety Assessment
This information is not available.

16. Other information

Full text of R-phrases referred to under sections 2 and 3

R52/53	Harmful to aquatic organisms, may cause long-term adverse effects in the aquatic environment.

Full text of H-Statements referred to under sections 2 and 3.

H304	May be fatal if swallowed and enters airways.
H412	Harmful to aquatic life with long lasting effects.

Further information

This safety datasheet applies only to products originally packaged and labelled by KLÜBER LUBRICATION. The information contained therein is protected by copyright and must not be reproduced or amended without the express written approval of KLÜBER LUBRICATION. This

document may be passed on only to the extent required by law. Any dissemination of our safety datasheets (e.g. as a document for download from the Internet) beyond this legally required extent is not permitted without express written consent. KLÜBER LUBRICATION provides its customers with amended safety datasheets as prescribed by law. The customer is responsible for passing on safety datasheets and any amendments contained therein to its own customers, employees and other users of the product. KLÜBER LUBRICATION provides no guarantee that safety datasheets received by users from third parties are up-to-date. All information and instructions in this safety datasheets were compiled to the best of our knowledge and are based on the information available to us. The data provided are intended to describe the product in relation to the required safety measures; they are neither an assurance of characteristics nor a guarantee of the product's suitability for particular applications and do not justify any contractual legal relationships.

SAFETY DATA SHEET

Issue Date 10-Mar-2015 **Revision Date** 10-Mar-2015 **Version** 1

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND OF THE COMPANY/UNDERTAKING

Product identifier
Product Name ISOFLEX NCA 15

Other means of identification
Product code: 004180
Synonyms None

Recommended use of the chemical and restrictions on use
Recommended Use Lubricant.
Uses advised against Consumer use

Details of the supplier of the safety data sheet
Supplier Address
Klüber Lubrication NA, LP
32 Industrial Drive
Londonderry, NH 03053
Phone: (603) 647-4104
Fax: (603) 647-4106

Emergency telephone number
Emergency Telephone CHEMTREC: 1-800-424-9300; INTERNATIONAL: (703) 527-3887

2. HAZARDS IDENTIFICATION

Classification

OSHA Regulatory Status
This chemical is not considered hazardous by the 2012 OSHA Hazard Communication Standard (29 CFR 1910.122)

Not a dangerous substance or mixture according to the Globally Harmonized System (GHS)

Label elements

EMERGENCY OVERVIEW

The product contains no substances which at their given concentration, are considered to be hazardous to health

Appearance Paste **Physical state** Solid **Odor** Mild

Hazards not otherwise classified (HNOC)
Other information
Unknown Acute Toxicity
21.0839% of the mixture consists of ingredient(s) of unknown toxicity

3. COMPOSITION/INFORMATION ON INGREDIENTS

The product contains no substances which at their given concentration, are considered to be hazardous to health.

Components	CAS-No	Weight %	Trade Secret
Mineral oil	Proprietary	30 - 40%	*

4. FIRST AID MEASURES

First aid measures

Eye contact: Flush eye with water for 15 minutes. If symptoms persist, call a physician.

Skin contact: Rinse with plenty of water. If skin irritation persists, call a physician.

Inhalation: Move to fresh air in case of accidental inhalation of fumes from overheating or combustion. If symptoms persist, call a physician.

Ingestion: Do not induce vomiting. Consult a physician.

Most important symptoms and effects, both acute and delayed

Symptoms No information available.

Indication of any immediate medical attention and special treatment needed

Notes to physician: Treat symptomatically.

5. FIRE-FIGHTING MEASURES

Suitable extinguishing media:
Carbon dioxide (CO2). Dry chemical. Dry sand. Water spray mist or foam.

Unsuitable extinguishing media Do not use a solid water stream as it may scatter and spread fire

Specific hazards arising from the chemical
Thermal decomposition can lead to release of irritating gases and vapors. Water may be used to cool closed containers.

Hazardous combustion products Carbon oxides. Nitrogen oxides (NOx). Oxides of sulfur.

Explosion data
Sensitivity to Mechanical Impact None.
Sensitivity to Static Discharge None.

Special protective equipment for firefighters:
In the event of fire and/or explosion do not breathe fumes. In the event of fire, wear self-contained breathing apparatus. Standard procedure for chemical fires.

6. ACCIDENTAL RELEASE MEASURES

Personal precautions, protective equipment and emergency procedures

Personal precautions: Contaminated surfaces will be extremely slippery. Avoid contact with skin, eyes and clothing. Wear personal protective equipment.

Environmental precautions

Environmental precautions: Do not allow material to contaminate ground water system. Prevent product from entering drains.

Methods and material for containment and cleaning up

Methods for containment Prevent further leakage or spillage if safe to do so.

Methods for cleaning up: Scrape-up. Pick up and transfer to properly labelled containers. Clean contaminated surface thoroughly.

7. HANDLING AND STORAGE

Precautions for safe handling

Handling Avoid contact with skin, eyes and clothing. Spilling onto the container`s outside will make container slippery. Do not eat, drink or smoke when using this product. Wash hands thoroughly after handling.

Conditions for safe storage, including any incompatibilities

Storage Conditions Keep container tightly closed in a dry and well-ventilated place. Keep cool. Keep in properly labelled containers. Keep away from direct sunlight

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Control parameters

Exposure Guidelines .

Components	ACGIH TLV	OSHA (TWA mg/m^3):	IDLH:
Mineral oil -	5 mg/m^3 (oil mist)	5 mg/m^3 (oil mist)	

Appropriate engineering controls

Engineering measures to reduce exposure: Ensure adequate ventilation, especially in confined areas.

Individual protection measures, such as personal protective equipment

Respiratory protection: No personal respiratory protective equipment normally required.
Hand protection: Gloves made of plastic or rubber
Eye protection: Avoid contact with eyes.
Skin and body protection: Usual safety precautions while handling the product will provide adequate protection against this potential effect
General Hygiene Considerations Avoid contact with skin, eyes and clothing

9. PHYSICAL AND CHEMICAL PROPERTIES

Information on basic physical and chemical properties

Physical state Solid
Appearance Paste **Odor** Mild **Color** Beige **Odor threshold** No information available

Property	Values	Remarks • Method	Property	Values
Melting point/freezing point	No information available		**pH**	Not applicable
			Boiling point / boiling range	No information available
Flash point	Not Applicable	ISO 2592	**Evaporation rate**	No information available
Flammability (solid, gas)	No information available		**Flammability Limit in Air**	
Upper flammability limit:	No information available		**Lower flammability limit:**	No information available
Vapor pressure	< 0.001 hPa, 20 °C		**Vapor density**	No information available
Specific Gravity	0.94		**Water solubility**	Insoluble in water
Solubility in other solvents	No information available		**Partition coefficient**	No information available
Autoignition temperature	No information available		**Decomposition temperature**	No information available
Kinematic viscosity	No information available		**Dynamic viscosity**	No information available
Explosive properties	No information available			

Oxidizing properties No information available

Other information

Softening point No information available
Molecular weight No information available
VOC Content (%) No information available
Density No information available
Bulk density No information available

10. STABILITY AND REACTIVITY

Reactivity
Not applicable

Chemical stability

Stability Stable under normal conditions

Possibility of Hazardous Reactions

Possibility of Hazardous Reactions None under normal processing.

Hazardous polymerization Hazardous polymerization does not occur.

Conditions to avoid

Conditions to avoid Heat, flames and sparks

Hazardous Decomposition Products

Hazardous Decomposition Products None under normal processing

Incompatible materials

Incompatible materials Strong oxidising agents

11. TOXICOLOGICAL INFORMATION

Information on likely routes of exposure

Product Information Product does not present an acute toxicity hazard based on known or supplied information

Eye contact Contact with eyes may cause irritation.

Skin contact Prolonged contact may cause redness and irritation.

Inhalation Vapors and/or aerosols which may be formed at elevated temperatures may be irritating to eyes and respiratory tract.

Ingestion Ingestion may cause gastrointestinal irritation, nausea, vomiting and diarrhoea.

Components	Oral LD50	Dermal LD50	Inhalation LC50
Mineral oil -	> 5000 mg/kg (Rat)	> 2000 mg/kg (Rabbit)	= 2.18 mg/L (Rat) 4 h

Information on toxicological effects

Delayed and immediate effects as well as chronic effects from short and long-term exposure

Sensitization No sensitization responses were observed.
Mutagenic effects: Did not show mutagenic or teratogenic effects in animal experiments.
Carcinogenicity This product does not contain any carcinogens or potential carcinogens as listed by OSHA, IARC or NTP.
Reproductive toxicity This product does not contain any known or suspected reproductive hazards.
STOT - Single Exposure None under normal use conditions.
STOT - Repeated Exposure None under normal use conditions.

Aspiration hazard Not applicable.

Numerical measures of toxicity - Product Information

Unknown Acute Toxicity 21.0839% of the mixture consists of ingredient(s) of unknown toxicity
The following values are calculated based on chapter 3.1 of the GHS document .
ATEmix (oral) 6807 mg/kg
ATEmix (dermal) 3577 mg/kg
ATEmix (inhalation-dust/mist) 19.6 mg/l

12. ECOLOGICAL INFORMATION

Ecotoxicity

No known hazards to the aquatic environment.

21.0709% of the mixture consists of components(s) of unknown hazards to the aquatic environment

Mineral oil -	
Algae/aquatic plants	-
Fish	5000: 96 h Oncorhynchus mykiss mg/L LC50
Crustacea	1000: 48 h Daphnia magna mg/L EC50

Persistence and degradability
No information available.

Bioaccumulation
No information available.

Mobility
The product is insoluble and floats on water.

13. DISPOSAL CONSIDERATIONS

Waste treatment methods

Disposal of wastes Disposal should be in accordance with applicable regional, national and local laws and regulations.

Contaminated packaging Empty containers should be taken for local recycling, recovery or waste disposal.

14. TRANSPORT INFORMATION

DOT Not Regulated by any means of transportation

15. REGULATORY INFORMATION

International Inventories
TSCA: Listed in TSCA
DSL: Not listed in DSL
EINECS/ELINCS This product complies with EINECS/ELINCS

CHINA:	This product complies with China IECSC.
KECL:	This product does not comply with Korea KECL.
PICCS:	This product does not comply with Philippines PICCS.
AICS:	All the constituents of this material are listed on the Australian AICS

Legend:
TSCA - United States Toxic Substances Control Act Section 8(b) Inventory
DSL/NDSL - Canadian Domestic Substances List/Non-Domestic Substances List
EINECS/ELINCS - European Inventory of Existing Chemical Substances/European List of Notified Chemical Substances
ENCS - Japan Existing and New Chemical Substances
IECSC - China Inventory of Existing Chemical Substances
KECL - Korean Existing and Evaluated Chemical Substances
PICCS - Philippines Inventory of Chemicals and Chemical Substances
AICS - Australian Inventory of Chemical Substances

Federal Regulations

SARA 313
Section 313 of Title III of the Superfund Amendments and Reauthorization Act of 1986 (SARA). This product does not contain any chemicals which are subject to the reporting requirements of the Act and Title 40 of the Code of Federal Regulations, Part 372

SARA 311/312 Hazard Categories

Acute Health Hazard	No
Chronic Health Hazard	No
Fire Hazard	No
Sudden release of pressure hazard	No
Reactive Hazard	No

CWA (Clean Water Act)
This product does not contain any substances regulated as pollutants pursuant to the Clean Water Act (40 CFR 122.21 and 40 CFR 122.42)

CERCLA
This material, as supplied, does not contain any substances regulated as hazardous substances under the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) (40 CFR 302) or the Superfund Amendments and Reauthorization Act (SARA) (40 CFR 355). There may be specific reporting requirements at the local, regional, or state level pertaining to releases of this material

State Regulations (RTK)

California Proposition 65
This product does not contain any Proposition 65 chemicals

U.S. State Right-to-Know Regulations

Components	NJRTK:	MARTK:	PARTK:
Mineral oil -	Substance no. 1437 Listed. Substance no. 4004 Listed.	Not Listed	Not Listed

U.S. EPA Label Information
EPA Pesticide Registration Number Not applicable

16. OTHER INFORMATION

Nfpa:
Health: 1
Flammability: 1
Instability 0
NFPA/HMIS * for Carc, Muta, Tera, Specific Organ *
HMIS health rating:
Health: 1
Flammability: 1
Physical hazards 0
Personal protection B

Issue Date 10-Mar-2015
Revision Date 10-Mar-2015
Revision Note
Not applicable

Disclaimer

The information provided in this Safety Data Sheet is correct to the best of our knowledge, information and belief at the date of its publication. The information given is designed only as a guidance for safe handling, use, processing, storage, transportation, disposal and release and is not to be considered a warranty or quality specification. The information relates only to the specific material designated and may not be valid for such material used in combination with any other materials or in any process, unless specified in the text.

End of Safety Data Sheet

SAFETY DATA SHEET

1. Identification

Product identifier **RHEOLUBE 365**

Other means of identification

Product Code RHEOLUBE 365

Recommended use Lubricating Grease

Recommended restrictions None known.

Manufacturer/Importer/Supplier/Distributor information

Manufacturer

Company name Nye Lubricants, Inc.

Address 12 Howland Road
Fairhaven, MA 02719
United States

Telephone General Assistance 508-996-6721

Website www.nyelubricants.com

E-mail sds@nyelubricants.com

Contact person Nye Lubricants EH&S

Emergency phone number 3E Online 800-451-8346

2. Hazard(s) identification

Physical hazards Not classified.

Health hazards Not classified.

Environmental hazards Not classified.

OSHA defined hazards Not classified.

Label elements

Hazard symbol None.

Signal word None.

Hazard statement The mixture does not meet the criteria for classification.

Precautionary statement

Prevention Observe good industrial hygiene practices.

Response Wash hands after handling.

Storage Store away from incompatible materials.

Disposal Dispose of waste and residues in accordance with local authority requirements.

Hazard(s) not otherwise classified (HNOC) None known.

Supplemental information None.

3. Composition/information on ingredients

Mixtures

The manufacturer lists no ingredients as hazardous according to OSHA 29 CFR 1910.1200.

*Designates that a specific chemical identity and/or percentage of composition has been withheld as a trade secret.

4. First-aid measures

Inhalation Move to fresh air.

Skin contact Wash off with soap and water. Get medical attention if irritation develops and persists.

Eye contact Get medical attention if irritation develops or persists.

Ingestion Rinse mouth. Get medical attention if symptoms occur.

Most important symptoms/effects, acute and delayed	Direct contact with eyes may cause temporary irritation.
Indication of immediate medical attention and special treatment needed	Treat symptomatically.
General information	Ensure that medical personnel are aware of the material(s) involved, and take precautions to protect themselves.

5. Fire-fighting measures

Suitable extinguishing media	Water fog. Foam. Dry chemical powder. Carbon dioxide (CO2).
Unsuitable extinguishing media	Do not use water jet as an extinguisher, as this will spread the fire.
Specific hazards arising from the chemical	During fire, gases hazardous to health may be formed.
Special protective equipment and precautions for firefighters	Self-contained breathing apparatus and full protective clothing must be worn in case of fire.
Fire fighting equipment/instructions	Move containers from fire area if you can do so without risk.
Specific methods	Use standard firefighting procedures and consider the hazards of other involved materials.
General fire hazards	No unusual fire or explosion hazards noted.

6. Accidental release measures

Personal precautions, protective equipment and emergency procedures	Keep unnecessary personnel away. For personal protection, see section 8 of the SDS.
Methods and materials for containment and cleaning up	Soak up with inert absorbent material. Clean contaminated surface thoroughly. Large Spills: Stop the flow of material, if this is without risk. Dike the spilled material, where this is possible. Cover with plastic sheet to prevent spreading. Absorb in vermiculite, dry sand or earth and place into containers. Following product recovery, flush area with water. Small Spills: Wipe up with absorbent material (e.g. cloth, fleece). Clean surface thoroughly to remove residual contamination. Never return spills to original containers for re-use. For waste disposal, see section 13 of the SDS. Clean up spills immediately, observing precautions in Protective Equipment section. Sweep up and shovel into suitable containers for disposal.
Environmental precautions	Avoid discharge into drains, water courses or onto the ground.

7. Handling and storage

Precautions for safe handling	Observe good industrial hygiene practices.
Conditions for safe storage, including any incompatibilities	Store in original tightly closed container. Store away from incompatible materials (see Section 10 of the SDS).

8. Exposure controls/personal protection

Occupational exposure limits	No exposure limits noted for ingredient(s).
Biological limit values	No biological exposure limits noted for the ingredient(s).
Appropriate engineering controls	Good general ventilation (typically 10 air changes per hour) should be used. Ventilation rates should be matched to conditions. If applicable, use process enclosures, local exhaust ventilation, or other engineering controls to maintain airborne levels below recommended exposure limits. If exposure limits have not been established, maintain airborne levels to an acceptable level.

Individual protection measures, such as personal protective equipment

Eye/face protection	Wear safety glasses with side shields (or goggles).
Skin protection	
Hand protection	Wear appropriate chemical resistant gloves. Suitable gloves can be recommended by the glove supplier.
Other	Wear suitable protective clothing.
Respiratory protection	In case of insufficient ventilation, wear suitable respiratory equipment.

Thermal hazards	Wear appropriate thermal protective clothing, when necessary.



General hygiene considerations	Always observe good personal hygiene measures, such as washing after handling the material and before eating, drinking, and/or smoking. Routinely wash work clothing and protective equipment to remove contaminants.

9. Physical and chemical properties

Appearance	
Physical state	Liquid.
Form	Liquid. Semi-solid
Color	Light Tan, Smooth
Odor	Slight
Odor threshold	Not available.
pH	Not available.
Melting point/freezing point	Not available.
Initial boiling point and boiling range	Not available.
Flash point	536.0 °F (280.0 °C) ASTM D-92 JG090609 04/06/15
Evaporation rate	Not available.
Flammability (solid, gas)	Not applicable.
Upper/lower flammability or explosive limits	
Flammability limit - lower (%)	Not available.
Flammability limit - upper (%)	Not available.
Explosive limit - lower (%)	Not available.
Explosive limit - upper (%)	Not available.
Vapor pressure	Not available.
Vapor density	Not available.
Relative density	Not available.
Solubility(ies)	
Solubility (water)	Not available.
Partition coefficient (n-octanol/water)	Not available.
Auto-ignition temperature	Not available.
Decomposition temperature	Not available.
Viscosity	Not available.
Other information	
Density	0.82 g/cm³
Dropping point	209
Explosive properties	Not explosive.
Flammability class	Combustible IIIB estimated
Flash point class	Combustible IIIB
Kinematic viscosity	99 cSt
Kinematic viscosity temperature	104 °F (40 °C)
Oxidizing properties	Not oxidizing.
Pour point	-61.6 °F (-52 °C)
Shelf life	4 years

10. Stability and reactivity

Reactivity	The product is stable and non-reactive under normal conditions of use, storage and transport.
Chemical stability	Material is stable under normal conditions.
Possibility of hazardous reactions	No dangerous reaction known under conditions of normal use.
Conditions to avoid	Contact with incompatible materials.
Incompatible materials	Strong acids, alkalies and oxidizing agents.
Hazardous decomposition products	Carbon monoxide, carbon dioxide and/or low molecular weight hydrocarbons.

11. Toxicological information

Information on likely routes of exposure

Inhalation	No adverse effects due to inhalation are expected.
Skin contact	No adverse effects due to skin contact are expected.
Eye contact	Direct contact with eyes may cause temporary irritation.
Ingestion	Expected to be a low ingestion hazard.
Symptoms related to the physical, chemical and toxicological characteristics	Direct contact with eyes may cause temporary irritation.

Information on toxicological effects

Acute toxicity	Not available.
Skin corrosion/irritation	Prolonged skin contact may cause temporary irritation.
Serious eye damage/eye irritation	Direct contact with eyes may cause temporary irritation.

Respiratory or skin sensitization

Respiratory sensitization	Not a respiratory sensitizer.
Skin sensitization	This product is not expected to cause skin sensitization.
Germ cell mutagenicity	No data available to indicate product or any components present at greater than 0.1% are mutagenic or genotoxic.
Carcinogenicity	This product is not considered to be a carcinogen by IARC, ACGIH, NTP, or OSHA.

IARC Monographs. Overall Evaluation of Carcinogenicity

Not available.

US. National Toxicology Program (NTP) Report on Carcinogens

Not available.

Reproductive toxicity	This product is not expected to cause reproductive or developmental effects.
Specific target organ toxicity - single exposure	Not classified.
Specific target organ toxicity - repeated exposure	Not classified.
Aspiration hazard	Not an aspiration hazard.

12. Ecological information

Ecotoxicity	The product is not classified as environmentally hazardous. However, this does not exclude the possibility that large or frequent spills can have a harmful or damaging effect on the environment.
Persistence and degradability	No data is available on the degradability of this product.
Bioaccumulative potential	No data available.
Mobility in soil	No data available.
Other adverse effects	No other adverse environmental effects (e.g. ozone depletion, photochemical ozone creation potential, endocrine disruption, global warming potential) are expected from this component.

13. Disposal considerations

Disposal instructions	Collect and reclaim or dispose in sealed containers at licensed waste disposal site.
Local disposal regulations	Dispose in accordance with all applicable regulations.

Hazardous waste code	The waste code should be assigned in discussion between the user, the producer and the waste disposal company.
Waste from residues / unused products	Dispose of in accordance with local regulations. Empty containers or liners may retain some product residues. This material and its container must be disposed of in a safe manner (see: Disposal instructions).
Contaminated packaging	Since emptied containers may retain product residue, follow label warnings even after container is emptied. Empty containers should be taken to an approved waste handling site for recycling or disposal.

14. Transport information

DOT

Not regulated as dangerous goods.

IATA

Not regulated as dangerous goods.

IMDG

Not regulated as dangerous goods.

Transport in bulk according to Annex II of MARPOL 73/78 and the IBC Code	Not established.

15. Regulatory information

US federal regulations This product is not known to be a "Hazardous Chemical" as defined by the OSHA Hazard Communication Standard, 29 CFR 1910.1200.

TSCA Section 12(b) Export Notification (40 CFR 707, Subpt. D)

Not regulated.

CERCLA Hazardous Substance List (40 CFR 302.4)

Not listed.

SARA 304 Emergency release notification

Not regulated.

Superfund Amendments and Reauthorization Act of 1986 (SARA)

Hazard categories

Immediate Hazard - No
Delayed Hazard - No
Fire Hazard - No
Pressure Hazard - No
Reactivity Hazard - No

SARA 302 Extremely hazardous substance

Not listed.

SARA 311/312 Hazardous chemical	No

SARA 313 (TRI reporting)

Not regulated.

Other federal regulations

Clean Air Act (CAA) Section 112 Hazardous Air Pollutants (HAPs) List

Not regulated.

Clean Air Act (CAA) Section 112(r) Accidental Release Prevention (40 CFR 68.130)

Not regulated.

Safe Drinking Water Act (SDWA)	Not regulated.

US state regulations

US. California Controlled Substances. CA Department of Justice (California Health and Safety Code Section 11100)

Not listed.

US. Massachusetts RTK - Substance List

Not regulated.

US. New Jersey Worker and Community Right-to-Know Act

Not regulated.

US. Pennsylvania RTK - Hazardous Substances

Not regulated.

US. Pennsylvania Worker and Community Right-to-Know Law

Not listed.

US. Rhode Island RTK

Not regulated.

US. California Proposition 65

California Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65): This material is not known to contain any chemicals currently listed as carcinogens or reproductive toxins.

International Inventories

Country(s) or region	Inventory name	On inventory (yes/no)*
Australia	Australian Inventory of Chemical Substances (AICS)	Yes
Canada	Domestic Substances List (DSL)	No
Canada	Non-Domestic Substances List (NDSL)	Yes
China	Inventory of Existing Chemical Substances in China (IECSC)	Yes
Europe	European Inventory of Existing Commercial Chemical Substances (EINECS)	No
Europe	European List of Notified Chemical Substances (ELINCS)	No
Japan	Inventory of Existing and New Chemical Substances (ENCS)	Yes
Korea	Existing Chemicals List (ECL)	Yes
New Zealand	New Zealand Inventory	Yes
Philippines	Philippine Inventory of Chemicals and Chemical Substances (PICCS)	No
United States & Puerto Rico	Toxic Substances Control Act (TSCA) Inventory	Yes

*A "Yes" indicates that all components of this product comply with the inventory requirements administered by the governing country(s)
A "No" indicates that one or more components of the product are not listed or exempt from listing on the inventory administered by the governing country(s).

16. Other information, including date of preparation or last revision

Issue date September-08-2014

Revision date January-13-2016

Version # 03

Disclaimer Nye Lubricants, Inc. cannot anticipate all conditions under which this information and its product, or the products of other manufacturers in combination with its product, may be used. It is the user's responsibility to ensure safe conditions for handling, storage and disposal of the product, and to assume liability for loss, injury, damage or expense due to improper use. The information in the sheet was written based on the best knowledge and experience currently available.

Revision information This document has undergone significant changes and should be reviewed in its entirety.

SAFETY DATA SHEET for OZONE

(Formerly MSDS)

1. PRODUCT IDENTIFICATION

Product Name: Ozone

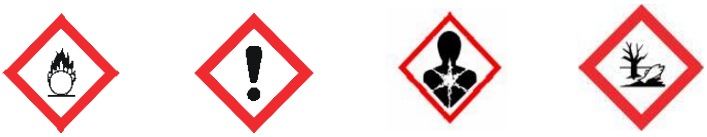
Common Names/Synonyms: Triatomic Oxygen, Trioxygen, O_3

Ozone Generator Manufacturer/Supplier

Ozone Solutions, Inc. website: www.ozonesolutions.com
451 Black Forest Rd. email: tech@ozonesolutions.com
Hull, IA 51239
712-439-6880

Product Use: This SDS is limited to ozone produced in gaseous form on site by an ozone generator, in varying concentrations in either air or aqueous solution, for the purposes of odor abatement, oxidation of organic compounds, or antimicrobial intervention, in a variety of applications, from food processing to ground water remediation.

2. HAZARD IDENTIFICATION



GHS Classifications:

Physical Hazards	Health Hazards	Environmental Hazards
Oxidizing Gas	Skin Irritation – Category 3	Acute Aquatic Toxicity – Category I
	Eye Irritation – Category 2B	
	Respiratory Systemic Toxicity – Category 1 (Acute & Repeated Exposures)	

NOTE: Severe respiratory toxicity will develop before skin or eye irritation go beyond listed categories. ***Anyone with chronic pulmonary problems, especially asthma, should avoid exposure to ozone.***

WHMIS Classifications (Workplace Hazardous Materials Information System, Canada)

D1A	Acute lethality – Very toxic, immediately	C	Oxidizing
D2A	Chronic Toxicity –Very Toxic	F	Dangerously Reactive
D2B	Mutagenicity – Toxic		

3. COMPOSITION

Chemical name	Ozone
Common names	Triatomic oxygen, trioxygen
Chemical Formula	O_3
CAS Registry Number	10028-15-6

4. FIRST AID MEASURES

Route of Entry		**Symptoms**	**First Aid**
Skin Contact	YES	Irritation	Rinse with water
Skin Absorption	NO	NA	NA
Eye Contact	YES	Irritation	Rinse with water, remove contacts
Ingestion	NO	NA	NA
Inhalation	YES	Headache, cough, dry throat, heavy chest, shortness of breath	Remove to fresh air, provide oxygen therapy as needed

For severe cases, or when symptoms don't improve, seek medical help.

5. FIRE FIGHTING MEASURES

While ozone itself is not flammable, it is a strong oxidant and may accelerate, even initiate, combustion, or cause explosions. Use whatever extinguishing agents are indicated for burning materials.

6. ACCIDENTAL RELEASE MEASURES

Turn off ozone generator, and ventilate the area. Evacuate the area until ozone levels subside.

7. HANDLING AND STORAGE

Ozone must be contained within ozone-resistant tubing and pipes from the generation point to the application point. Any leaks must be repaired before further use.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

OSHA Permissible Exposure Limit: 8 hour Time Weighted Average **0.1 ppm**
ANSI/ASTM: 8 hour TWA **0.1 ppm**, Short Term Exposure Limit **0.3 ppm**
ACGIH: 8 hour TWA **0.1 ppm**; STEL **0.3 ppm**
NIOSH: Exposure Limit Ceiling Value **0.1 ppm** light; **0.08 ppm** moderate; **0.05 ppm**, heavy;
Light, moderate, heavy work TWA <= 2 hours, **.2 ppm**
Immediately Dangerous to Life or Health **5 ppm**

Respiratory Protection: Use full face self-contained breathing apparatus for entering areas with high concentration of ozone.

Engineering controls: use ozone destruct units (thermal and/or catalytic) for off gassing ozone.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical state	Gas	pH	NA
Molecular Weight	48.0	Flash point	NA
Appearance	Clear at low concentrations, blue at higher concentrations	Evaporation rate	NA
Odor	Distinctive pungent odor	Flammability	NA
Odor threshold	0.02 to 0.05 ppm; exposure desensitizes	Explosive limits	NA

Melting point	-193°C/-315°F	Relative density	NA
Boiling point	-112°C/-169°F	Partition coefficient	NA
Vapor pressure	> 1 atm	Auto-ignition temperature	NA
Vapor density	1.6 (air = 1)	Decomposition temperature	NA
Solubility in water	570 mg/L @20°C, 100% O_3; 0.64 @0°C (vol/vol)	Viscosity	NA

10. STABILITY AND REACTIVITY

Ozone is highly unstable and highly reactive. Avoid contact with oxidizable substances, including alkenes, benzene and other aromatic compounds, rubber, dicyanogen, bromine diethyl ether, dintrogen tetroxide, nitrogen trichloride, hydrogen bromide, and tetraluorohydrazine. Ozone will readily react and spontaneously decompose under normal ambient temperatures.

11. TOXICOLOGICAL INFORMATION

Likely routes of exposure: inhalation, eyes, skin exposure.

Effects of Acute Exposure: Discomfort, including headache, coughing, dry throat, shortness of breath, heavy feeling in chest (including possible pulmonary edema/fluid in the lungs); higher levels of exposure intensify symptoms. Irritation of skin and/or eyes is also possible.

Effects of Chronic Exposure: Similar to acute exposure effects, with possible development of chronic breathing disorders, including asthma.

Inhalation LC_{50}: mice, 12.6 ppm for 3 hours; hamsters, 35.5 ppm for 3 hours

Irritancy of Ozone	YES
Sensitization to Ozone	NO
Carcinogenicity (NTP, IARC, OSHA)	NO
Reproductive Toxicity	Not Proven
Teratogenicity	Not Proven
Mutagenicity	Not Proven
Toxicologically Synergistic Products	Increase susceptibility to allergens, pathogens, irritants

12. ECOLOGICAL INFORMATION

The immediate surrounding area may be adversely affected by an ozone release, particularly plant life. Discharge of ozone in water solution would also be harmful to any aquatic life. Due to natural decomposition, bioaccumulation will not occur, and the area affected would be limited.

13. DISPOSAL CONSIDERATIONS

Off-gassing of ozone should be through an ozone destruct unit which uses heat and/or a catalyst to accomplish the breakdown of ozone to oxygen before release into the atmosphere.

14. TRANSPORT INFORMATION

NOT APPLICABLE, as ozone is unstable and either reacts with other substances in the environment or decomposes, and therefore must be generated at the location and time of use.

15. REGULATORY INFORMATION

SARA = Superfund Amendments and Renewal Act
SARA Title III Section 302 Extremely Hazardous Substance TPQ: 100 lbs.
SARA Title III Section 304, EHS RQ: 100 lbs.
SARA Title III Section 313: Ozone is reportable if more than 10,000 lbs. are used/year.

TPQ (Threshold Planning Quantity) requires emergency planning activities if this amount is on site at any time during year

RQ (Reportable Quantity) requires any release of this amount into the environment to be reported to the National Response Center

Source: EPA List of Lists

16. OTHER INFORMATION

The half-life of ozone is much shorter in water than in air. Increased temperature in either solvent decreases the half-life. Published research indicates a half-life of 20 minutes for ozone dissolved in water at 20°C, and a half-life of approximately 25 hours for ozone in dry air at 24°C (McClurkin & Maier, 2010). The practical half-life time is actually less, especially in air, due to air circulation, humidity, the presence of contaminants or walls with which to react, etc. In many situations, with air movement, warmer temperatures, and normal relative humidity, the half-life of ozone in air could be 1 hour or less. Further, ventilation of a closed space to other areas will also disperse the ozone, so that concentration levels can rapidly decrease after generation ceases.

Source websites:

Canadian Centre for Occupational Health and Safety: Chemical Profiles: Ozone
http://www.ccohs.ca/oshanswers/chemicals/chem_profiles/ozone/

Haz-Map: Occupational Exposure to Hazardous Agents: Ozone
http://hazmap.nlm.nih.gov/cgi-bin/hazmap_generic?tbl=TblAgents&id=68

International Chemical Safety Cards #0068: Ozone
http://www.cdc.gov/niosh/ipcsneng/neng0068.html

NIOSH Pocket Guide to Chemical Hazards: Ozone http://www.cdc.gov/niosh/npg/npgd0476.html

United States National Library of Medicine ChemIDplus Lite: Ozone 10028-15-6
http://chem.sis.nlm.nih.gov/chemidplus/ProxyServlet?objectHandle=DBMaint&actionHandle=default&nextPage=jsp/chemidlite/ResultScreen.jsp&TXTSUPERLISTID=0010028156

Preparer: Tim McConnel, Ozone Solutions
Date of Preparation: 5/1/2012

Disclaimer: Ozone Solutions provides this information in good faith, but makes no claim as to its comprehensiveness or accuracy. It is intended solely as a guide for the safe handling of the product by properly trained personnel, and makes no representations or warranties, express or implied, of the merchantability or fitness of the product for any purpose, and Ozone Solutions will not be responsible for any damages resulting from the use of, or reliance upon, this information.

SAFETY DATA SHEET

Creation Date 01-Sep-2009 **Revision Date** 27-Oct-2016 **Revision Number** 11

SECTION 1: IDENTIFICATION OF THE SUBSTANCE/MIXTURE AND OF THE COMPANY/UNDERTAKING

1.1. Product identification

Product Description:	**Propan-2-ol**
Cat No. :	**P/7555/15, P/7555/17, P/7555/21, P/7555/25**
Synonyms	2-Propanol; IPA; Isopropyl alcohol; Propan-2-ol; Isopropanol
CAS-No	67-63-0
EC-No.	200-661-7
Molecular Formula	C3 H8 O
Reach Registration Number	01-2119457558-25

1.2. Relevant identified uses of the substance or mixture and uses advised against

Recommended Use	Laboratory chemicals.
Sector of use	SU3 - Industrial uses: Uses of substances as such or in preparations at industrial sites
Product category	PC21 - Laboratory chemicals
Process categories	PROC15 - Use as a laboratory reagent
Environmental release category	ERC6a - Industrial use resulting in manufacture of another substance (use of intermediates)
Uses advised against	No Information available

1.3. Details of the supplier of the safety data sheet

Company	Fisher Scientific UK Bishop Meadow Road, Loughborough, Leicestershire LE11 5RG, United Kingdom
E-mail address	begel.sdsdesk@thermofisher.com

1.4. Emergency telephone number

Tel: 01509 231166
Chemtrec US: (800) 424-9300
Chemtrec EU: 001 (202) 483-7616

SECTION 2: HAZARDS IDENTIFICATION

2.1. Classification of the substance or mixture

CLP Classification - Regulation (EC) No 1272/2008

Physical hazards

Flammable liquids	Category 2 (H225)

Health hazards

Serious Eye Damage/Eye Irritation	Category 2 (H319)
Specific target organ toxicity - (single exposure)	Category 3 (H336)

Environmental hazards
Based on available data, the classification criteria are not met

2.2. Label elements



Signal Word **Danger**

Hazard Statements

H225 - Highly flammable liquid and vapor
H319 - Causes serious eye irritation
H336 - May cause drowsiness or dizziness

Precautionary Statements

P210 - Keep away from heat/sparks/open flames/hot surfaces. - No smoking
P240 - Ground/bond container and receiving equipment
P261 - Avoid breathing dust/ fume/ gas/ mist/ vapors/ spray
P280 - Wear protective gloves/ protective clothing/ eye protection/ face protection
P305 + P351 + P338 - IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing

2.3. Other hazards

Substance is not considered persistent, bioaccumulative and toxic (PBT) / very persistent and very bioaccumulative (vPvB)

SECTION 3: COMPOSITION/INFORMATION ON INGREDIENTS

3.1. Substances

Component	CAS-No	EC-No.	Weight %	CLP Classification - Regulation (EC) No 1272/2008
Isopropyl alcohol	67-63-0	200-661-7	>95	Flam. Liq. 2 (H225) Eye Irrit. 2 (H319) STOT SE 3 (H336)

Reach Registration Number	01-2119457558-25

Full text of Hazard Statements: see section 16

SECTION 4: FIRST AID MEASURES

4.1. Description of first aid measures

Eye Contact Rinse immediately with plenty of water, also under the eyelids, for at least 15 minutes. Obtain medical attention.

Skin Contact Wash off immediately with plenty of water for at least 15 minutes. Get medical attention if symptoms occur.

Ingestion Do not induce vomiting. Obtain medical attention.

Inhalation Move to fresh air. Obtain medical attention. If not breathing, give artificial respiration.

Protection of First-aiders Ensure that medical personnel are aware of the material(s) involved, take precautions to protect themselves and prevent spread of contamination.

4.2. Most important symptoms and effects, both acute and delayed

Breathing difficulties. May cause central nervous system depression: Inhalation of high vapor concentrations may cause symptoms like headache, dizziness, tiredness, nausea and vomiting

4.3. Indication of any immediate medical attention and special treatment needed

Notes to Physician Treat symptomatically. Symptoms may be delayed.

SECTION 5: FIREFIGHTING MEASURES

5.1. Extinguishing media

Suitable Extinguishing Media
CO_2, dry chemical, dry sand, alcohol-resistant foam. Cool closed containers exposed to fire with water spray.

Extinguishing media which must not be used for safety reasons
Do not use water jet. Do not use a solid water stream as it may scatter and spread fire.

5.2. Special hazards arising from the substance or mixture

Flammable. Risk of ignition. Vapors may form explosive mixtures with air. Vapors may travel to source of ignition and flash back. Containers may explode when heated.

Hazardous Combustion Products
Carbon monoxide (CO), Carbon dioxide (CO_2), peroxides.

5.3. Advice for firefighters

As in any fire, wear self-contained breathing apparatus pressure-demand, MSHA/NIOSH (approved or equivalent) and full protective gear. Thermal decomposition can lead to release of irritating gases and vapors.

SECTION 6: ACCIDENTAL RELEASE MEASURES

6.1. Personal precautions, protective equipment and emergency procedures

Use personal protective equipment. Remove all sources of ignition. Take precautionary measures against static discharges. Avoid contact with skin, eyes and clothing.

6.2. Environmental precautions

Should not be released into the environment. See Section 12 for additional ecological information.

6.3. Methods and material for containment and cleaning up

Prevent further leakage or spillage if safe to do so. Remove all sources of ignition. Soak up with inert absorbent material. Take precautionary measures against static discharges. Use spark-proof tools and explosion-proof equipment. Keep in suitable, closed containers for disposal.

6.4. Reference to other sections

Refer to protective measures listed in Sections 8 and 13.

SECTION 7: HANDLING AND STORAGE

7.1. Precautions for safe handling

Wear personal protective equipment. Keep away from open flames, hot surfaces and sources of ignition. Use explosion-proof equipment. Use only non-sparking tools. Take precautionary measures against static discharges. Do not get in eyes, on skin, or on clothing. Do not breathe vapors or spray mist. To avoid ignition of vapors by static electricity discharge, all metal parts of the

equipment must be grounded.

Hygiene Measures
Handle in accordance with good industrial hygiene and safety practice. Keep away from food, drink and animal feeding stuffs. Do not eat, drink or smoke when using this product. Remove and wash contaminated clothing before re-use. Wash hands before breaks and at the end of workday.

7.2. Conditions for safe storage, including any incompatibilities

Keep away from heat and sources of ignition. Flammables area. Keep container tightly closed in a dry and well-ventilated place.

7.3. Specific end use(s)

Use in laboratories

SECTION 8: EXPOSURE CONTROLS/PERSONAL PROTECTION

8.1. Control parameters

Exposure limits
List source(s): **UK** - EH40/2005 Containing the workplace exposure limits (WELs) for use with the Control of Substances Hazardous to Health Regulations (COSHH) 2002 (as amended). Updated by September 2006 official press release and October 2007 Supplement. **IRE -** 2010 Code of Practice for the Safety, Health and Welfare at Work (Chemical Agents) Regulations 2001. Published by the Health and Safety Authority.

Component	European Union	The United Kingdom	France	Belgium	Spain
Isopropyl alcohol		STEL: 500 ppm 15 min STEL: 1250 mg/m³ 15 min TWA: 400 ppm 8 hr TWA: 999 mg/m³ 8 hr	STEL / VLCT: 400 ppm. STEL / VLCT: 980 mg/m³.	TWA: 200 ppm 8 uren TWA: 500 mg/m³ 8 uren STEL: 400 ppm 15 minuten STEL: 1000 mg/m³ 15 minuten	STEL / VLA-EC: 400 ppm (15 minutos). STEL / VLA-EC: 1000 mg/m³ (15 minutos). TWA / VLA-ED: 200 ppm (8 horas) TWA / VLA-ED: 500 mg/m³ (8 horas)

Component	Italy	Germany	Portugal	The Netherlands	Finland
Isopropyl alcohol		TWA: 200 ppm (8 Stunden). AGW - exposure factor 2 TWA: 500 mg/m³ (8 Stunden). AGW - exposure factor 2 TWA: 200 ppm (8 Stunden). MAK TWA: 500 mg/m³ (8 Stunden). MAK Höhepunkt: 400 ppm Höhepunkt: 1000 mg/m³	STEL: 400 ppm 15 minutos TWA: 200 ppm 8 horas		TWA: 200 ppm 8 tunteina TWA: 500 mg/m³ 8 tunteina STEL: 250 ppm 15 minuutteina STEL: 620 mg/m³ 15 minuutteina

Component	Austria	Denmark	Switzerland	Poland	Norway
Isopropyl alcohol	MAK-KZW: 800 ppm 15 Minuten MAK-KZW: 2000 mg/m³ 15 Minuten MAK-TMW: 200 ppm 8 Stunden MAK-TMW: 500 mg/m³ 8 Stunden	TWA: 200 ppm 8 timer TWA: 490 mg/m³ 8 timer	STEL: 400 ppm 15 Minuten STEL: 1000 mg/m³ 15 Minuten TWA: 200 ppm 8 Stunden TWA: 500 mg/m³ 8 Stunden	STEL: 1200 mg/m³ 15 minutach TWA: 900 mg/m³ 8 godzinach	TWA: 100 ppm 8 timer TWA: 245 mg/m³ 8 timer STEL: 100 ppm 15 minutter. STEL: 245 mg/m³ 15 minutter.

Component	Bulgaria	Croatia	Ireland	Cyprus	Czech Republic
Isopropyl alcohol	TWA: 980.0 mg/m³ STEL : 1225.0 mg/m³	TWA-GVI: 400 ppm 8 satima. TWA-GVI: 999 mg/m³ 8 satima. STEL-KGVI: 500 ppm	TWA: 200 ppm 8 hr. STEL: 400 ppm 15 min Skin		TWA: 500 mg/m³ 8 hodinách. Potential for cutaneous absorption Ceiling: 1000 mg/m³

		15 minutama. STEL-KGVI: 1250 mg/m³ 15 minutama.			

Component	Estonia	Gibraltar	Greece	Hungary	Iceland
Isopropyl alcohol	TWA: 150 ppm 8 tundides. TWA: 350 mg/m³ 8 tundides. STEL: 250 ppm 15 minutites. STEL: 600 mg/m³ 15 minutites.		STEL: 500 ppm STEL: 1225 mg/m³ TWA: 400 ppm TWA: 980 mg/m³	STEL: 2000 mg/m³ 15 percekben. CK TWA: 500 mg/m³ 8 órában. AK lehetséges borön keresztüli felszívódás	TWA: 200 ppm 8 klukkustundum. TWA: 490 mg/m³ 8 klukkustundum. Skin notation Ceiling: 400 ppm Ceiling: 980 mg/m³

Component	Latvia	Lithuania	Luxembourg	Malta	Romania
Isopropyl alcohol	STEL: 600 mg/m³ TWA: 350 mg/m³	TWA: 150 ppm IPRD TWA: 350 mg/m³ IPRD STEL: 250 ppm STEL: 600 mg/m³			TWA: 81 ppm 8 ore TWA: 200 mg/m³ 8 ore STEL: 203 ppm 15 minute STEL: 500 mg/m³ 15 minute

Component	Russia	Slovak Republic	Slovenia	Sweden	Turkey
Isopropyl alcohol	TWA: 10 mg/m³ 1721 STEL: 50 mg/m³ 1721	Ceiling: 1000 mg/m³ TWA: 200 ppm TWA: 500 mg/m³	TWA: 200 ppm 8 urah TWA: 500 mg/m³ 8 urah STEL: 800 ppm 15 minutah STEL: 2000 mg/m³ 15 minutah	Indicative STLV: 250 ppm 15 minuter Indicative STLV: 600 mg/m³ 15 minuter LLV: 150 ppm 8 timmar. LLV: 350 mg/m³ 8 timmar.	

Biological limit values
List source(s):

Component	European Union	United Kingdom	France	Spain	Germany
Isopropyl alcohol				Acetone: 40 mg/L urine end of workweek	Acetone: 25 mg/L whole blood (end of shift) Acetone: 25 mg/L urine (end of shift)

Component	Italy	Finland	Denmark	Bulgaria	Romania
Isopropyl alcohol					Acetone: 50 mg/L urine end of shift

Monitoring methods
BS EN 14042:2003 Title Identifier: Workplace atmospheres. Guide for the application and use of procedures for the assessment of exposure to chemical and biological agents.
MDHS70 General methods for sampling airborne gases and vapours
MDHS 88 Volatile organic compounds in air. Laboratory method using diffusive samplers, solvent desorption and gas chromatography
MDHS 96 Volatile organic compounds in air - Laboratory method using pumped solid sorbent tubes, solvent desorption and gas chromatography

Derived No Effect Level (DNEL) See table for values

Route of exposure	Acute effects (local)	Acute effects (systemic)	Chronic effects (local)	Chronic effects (systemic)
Oral				
Dermal				888 mg/kg
Inhalation				500 mg/m³

Predicted No Effect Concentration (PNEC) According to our experience and to the information provided to us, the product does not have any harmful effects if it is used and handled as specified. See values below.
Fresh water 140.9 mg/l
Fresh water sediment 552 mg/kg

Marine water	140.9 mg/l
Water Intermittent	140.9 mg/l
Food chain	160 mg/kg
Microorganisms in sewage treatment	2251 mg/l
Soil (Agriculture)	28 mg/kg

8.2. Exposure controls

Engineering Measures

Ensure that eyewash stations and safety showers are close to the workstation location. Use explosion-proof electrical/ventilating/lighting/equipment. Ensure adequate ventilation, especially in confined areas.

Wherever possible, engineering control measures such as the isolation or enclosure of the process, the introduction of process or equipment changes to minimise release or contact, and the use of properly designed ventilation systems, should be adopted to control hazardous materials at source

Personal protective equipment

Eye Protection	Goggles (European standard - EN 166)
Hand Protection	Protective gloves

Glove material	Breakthrough time	Glove thickness	EU standard	Glove comments
Butyl rubber	> 480 minutes	0.5 mm	EN 374	Permeation rate < 0.9 µg/cm2/min
Nitrile rubber	> 360 - 480 minutes	0.35 - 0.55 mm		As tested under EN374-3 Determination of Resistance to Permeation by Chemicals
Viton (R)	> 480 minutes	0.4 mm		
Neoprene	< 40 minutes	0.7 mm		

Skin and body protection Wear appropriate protective gloves and clothing to prevent skin exposure

Inspect gloves before use.

Please observe the instructions regarding permeability and breakthrough time which are provided by the supplier of the gloves. (Refer to manufacturer/supplier for information)

Ensure gloves are suitable for the task: Chemical compatability, Dexterity, Operational conditions, User susceptibility, e.g. sensitisation effects, also take into consideration the specific local conditions under which the product is used, such as the danger of cuts, abrasion.

Remove gloves with care avoiding skin contamination.

Respiratory Protection	When workers are facing concentrations above the exposure limit they must use appropriate certified respirators. To protect the wearer, respiratory protective equipment must be the correct fit and be used and maintained properly
Large scale/emergency use	Use a NIOSH/MSHA or European Standard EN 136 approved respirator if exposure limits are exceeded or if irritation or other symptoms are experienced **Recommended Filter type:** Organic gases and vapours filter Type A Brown conforming to EN14387
Small scale/Laboratory use	Use a NIOSH/MSHA or European Standard EN 149:2001 approved respirator if exposure limits are exceeded or if irritation or other symptoms are experienced. **Recommended half mask:-** Valve filtering: EN405; Half mask: EN140; plus filter, EN 141 When RPE is used a face piece Fit Test should be conducted
Environmental exposure controls	No information available.

SECTION 9: PHYSICAL AND CHEMICAL PROPERTIES

9.1. Information on basic physical and chemical properties

Appearance	Colorless	
Physical State	Liquid	
Odor	Alcohol-like	
Odor Threshold	No data available	
pH	7	1% aq. sol
Melting Point/Range	-89.5 °C / -129.1 °F	
Softening Point	No data available	

Boiling Point/Range	81 - 83 °C / 177.8 - 181.4 °F	@ 760 mmHg
Flash Point	12 °C / 53.6 °F	**Method -** Abel Closed Cup (BS 2000 Part 170, IP 170, AS/NZS 2106)
Evaporation Rate	1.7	ASTM D 3539 (Butyl acetate = 1.0)
Flammability (solid,gas)	Not applicable	Liquid
Explosion Limits	**Lower** 2 Vol% **Upper** 12 Vol%	
Vapor Pressure	43 mmHg @ 20 °C	
Vapor Density	2.1 @ 20 °C / 68 °F	(Air = 1.0)
Specific Gravity / Density	0.785	ASTM D-4052
Bulk Density	Not applicable	Liquid
Water Solubility	Miscible	
Solubility in other solvents	No information available	
Partition Coefficient (n-octanol/water)		
Component	**log Pow**	
Isopropyl alcohol	0.05	
Autoignition Temperature	425 - °C / 797 - °F	ASTM E-659
Decomposition Temperature	No data available	
Viscosity	2.27 mPa.s at 20 °C	
Explosive Properties	Not explosive	explosive air/vapour mixtures possible Vapors may form explosive mixtures with air
Oxidizing Properties	No information available	

9.2. Other information

Molecular Formula	C3 H8 O
Molecular Weight	60.1
VOC Content(%)	59.9 % (EC/1999/13)
Refractive index	1.377 at 20 °C / 68 °F (ASTM D-1218)
Surface tension	22.7 mN/m at 20 °C / 68 °F
Coefficient of expansion	0.0009 / °C
Dielectric constant	18.6 at 20 °C / 68 °F
Heat of vapourisation	665 J/g
Specific heat capacity	3 kJ/kg °C at 20 °C / 68 °F
Thermal conductivity	0.137 W/m °C at 20 °C / 68 °F

SECTION 10: STABILITY AND REACTIVITY

10.1. Reactivity

None known, based on information available

10.2. Chemical stability

Stable under normal conditions.

10.3. Possibility of hazardous reactions

Hazardous Polymerization Hazardous polymerization does not occur.

Hazardous Reactions None under normal processing.

10.4. Conditions to avoid

Heat, flames and sparks. Keep away from open flames, hot surfaces and sources of ignition.

10.5. Incompatible materials

Strong oxidizing agents. Acids. Halogens. Acid anhydrides.

10.6. Hazardous decomposition products

Carbon monoxide (CO). Carbon dioxide (CO_2). peroxides.

SECTION 11: TOXICOLOGICAL INFORMATION

11.1. Information on toxicological effects

Product Information

(a) acute toxicity;

Oral Based on available data, the classification criteria are not met
Dermal Based on available data, the classification criteria are not met
Inhalation Based on available data, the classification criteria are not met

Component	LD50 Oral	LD50 Dermal	LC50 Inhalation
Isopropyl alcohol	5840 mg/kg (Rat)	13900 mg/kg (Rat) 12870 mg/kg (Rabbit)	72.6 mg/L (Rat) 4 h

(b) skin corrosion/irritation; Based on available data, the classification criteria are not met

(c) serious eye damage/irritation; Category 2

(d) respiratory or skin sensitization;

Respiratory Based on available data, the classification criteria are not met
Skin Based on available data, the classification criteria are not met

(e) germ cell mutagenicity; Based on available data, the classification criteria are not met

(f) carcinogenicity; Based on available data, the classification criteria are not met

There are no known carcinogenic chemicals in this product

(g) reproductive toxicity; Based on available data, the classification criteria are not met

(h) STOT-single exposure; Category 3

Results / Target organs Central nervous system (CNS).

(i) STOT-repeated exposure; Based on available data, the classification criteria are not met

Target Organs None known.

(j) aspiration hazard; Based on available data, the classification criteria are not met

Symptoms / effects,both acute and delayed May cause central nervous system depression: Inhalation of high vapor concentrations may cause symptoms like headache, dizziness, tiredness, nausea and vomiting

SECTION 12: ECOLOGICAL INFORMATION

12.1. Toxicity

Ecotoxicity effects . Do not empty into drains.

Component	Freshwater Fish	Water Flea	Freshwater Algae	Microtox
Isopropyl alcohol	LC50: > 1400000 µg/L, 96h (Lepomis macrochirus) LC50: = 11130 mg/L, 96h static (Pimephales promelas) LC50: = 9640 mg/L, 96h flow-through (Pimephales promelas)	13299 mg/L EC50 = 48 h 9714 mg/L EC50 = 24 h	EC50: > 1000 mg/L, 72h (Desmodesmus subspicatus) EC50: > 1000 mg/L, 96h (Desmodesmus subspicatus)	= 35390 mg/L EC50 Photobacterium phosphoreum 5 min

12.2. Persistence and degradability Expected to be biodegradable

Persistence Persistence is unlikely, based on information available.

12.3. Bioaccumulative potential Bioaccumulation is unlikely

Component	log Pow	Bioconcentration factor (BCF)

Isopropyl alcohol	0.05	No data available

12.4. Mobility in soil The product contains volatile organic compounds (VOC) which will evaporate easily from all surfaces Will likely be mobile in the environment due to its volatility. Disperses rapidly in air

Surface tension 22.7 mN/m at 20 °C / 68 °F

12.5. Results of PBT and vPvB assessment Substance is not considered persistent, bioaccumulative and toxic (PBT) / very persistent and very bioaccumulative (vPvB).

12.6. Other adverse effects

Endocrine Disruptor Information This product does not contain any known or suspected endocrine disruptors

Persistent Organic Pollutant This product does not contain any known or suspected substance

Ozone Depletion Potential This product does not contain any known or suspected substance

SECTION 13: DISPOSAL CONSIDERATIONS

13.1. Waste treatment methods

Waste from Residues / Unused Products Waste is classified as hazardous. Dispose of in accordance with the European Directives on waste and hazardous waste. Dispose of in accordance with local regulations.

Contaminated Packaging Dispose of this container to hazardous or special waste collection point. Empty containers retain product residue, (liquid and/or vapor), and can be dangerous. Keep product and empty container away from heat and sources of ignition.

European Waste Catalogue (EWC) According to the European Waste Catalogue, Waste Codes are not product specific, but application specific.

Other Information Waste codes should be assigned by the user based on the application for which the product was used. Do not dispose of waste into sewer. Can be incinerated, when in compliance with local regulations.

SECTION 14: TRANSPORT INFORMATION

IMDG/IMO

14.1. UN number UN1219

14.2. UN proper shipping name Isopropanol (Isopropyl alcohol)

14.3. Transport hazard class(es) 3

14.4. Packing group II

ADR

14.1. UN number UN1219

14.2. UN proper shipping name Isopropanol (Isopropyl alcohol)

14.3. Transport hazard class(es) 3

14.4. Packing group II

IATA

14.1. UN number UN1219

14.2. UN proper shipping name Isopropanol

14.3. Transport hazard class(es) 3

14.4. Packing group II

14.5. Environmental hazards No hazards identified

14.6. Special precautions for user No special precautions required

14.7. Transport in bulk according to Annex II of MARPOL73/78 and the IBC Code Not applicable, packaged goods

SECTION 15: REGULATORY INFORMATION

15.1. Safety, health and environmental regulations/legislation specific for the substance or mixture

International Inventories X = listed

Component	EINECS	ELINCS	NLP	TSCA	DSL	NDSL	PICCS	ENCS	IECSC	AICS	KECL
Isopropyl alcohol	200-661-7	-		X	X	-	X	X	X	X	X

National Regulations

Component	Germany - Water Classification (VwVwS)	Germany - TA-Luft Class
Isopropyl alcohol	WGK 1	

Component	France - INRS (Tables of occupational diseases)
Isopropyl alcohol	Tableaux des maladies professionnelles (TMP) - RG 84

Take note of Control of Substances Hazardous to Health Regulations (COSHH) 2002 and 2005 Amendment.
Take note of Dir 94/33/EC on the protection of young people at work
Take note of Directive 98/24/EC on the protection of the health and safety of workers from the risks related to chemical agents at work

15.2. Chemical safety assessment

A Chemical Safety Assessment/Report (CSA/CSR) has been conducted by the manufacturer/importer

SECTION 16: OTHER INFORMATION

Full text of H-Statements referred to under sections 2 and 3
H225 - Highly flammable liquid and vapor
H319 - Causes serious eye irritation
H336 - May cause drowsiness or dizziness

Legend

CAS - Chemical Abstracts Service

EINECS/ELINCS - European Inventory of Existing Commercial Chemical Substances/EU List of Notified Chemical Substances
PICCS - Philippines Inventory of Chemicals and Chemical Substances
IECSC - Chinese Inventory of Existing Chemical Substances
KECL - Korean Existing and Evaluated Chemical Substances

TSCA - United States Toxic Substances Control Act Section 8(b) Inventory
DSL/NDSL - Canadian Domestic Substances List/Non-Domestic Substances List
ENCS - Japanese Existing and New Chemical Substances
AICS - Australian Inventory of Chemical Substances
NZIoC - New Zealand Inventory of Chemicals

WEL - Workplace Exposure Limit
ACGIH - American Conference of Governmental Industrial Hygienists
DNEL - Derived No Effect Level
RPE - Respiratory Protective Equipment
LC50 - Lethal Concentration 50%
NOEC - No Observed Effect Concentration
PBT - Persistent, Bioaccumulative, Toxic

TWA - Time Weighted Average
IARC - International Agency for Research on Cancer
PNEC - Predicted No Effect Concentration
LD50 - Lethal Dose 50%
EC50 - Effective Concentration 50%
POW - Partition coefficient Octanol:Water
vPvB - very Persistent, very Bioaccumulative

ADR - European Agreement Concerning the International Carriage of Dangerous Goods by Road
IMO/IMDG - International Maritime Organization/International Maritime Dangerous Goods Code
OECD - Organisation for Economic Co-operation and Development
BCF - Bioconcentration factor

ICAO/IATA - International Civil Aviation Organization/International Air Transport Association
MARPOL - International Convention for the Prevention of Pollution from Ships
ATE - Acute Toxicity Estimate
VOC - Volatile Organic Compounds

Key literature references and sources for data
Suppliers safety data sheet, Chemadvisor - LOLI, Merck index, RTECS

Training Advice
Chemical hazard awareness training, incorporating labelling, Safety Data Sheets (SDS), Personal Protective Equipment (PPE) and hygiene.

Use of personal protective equipment, covering appropriate selection, compatibility, breakthrough thresholds, care, maintenance, fit and standards.
First aid for chemical exposure, including the use of eye wash and safety showers.
Fire prevention and fighting, identifying hazards and risks, static electricity, explosive atmospheres posed by vapours and dusts.

Creation Date	01-Sep-2009
Revision Date	27-Oct-2016
Revision Summary	SDS sections updated, 8.

This safety data sheet complies with the requirements of Regulation (EC) No. 1907/2006

Disclaimer

The information provided in this Safety Data Sheet is correct to the best of our knowledge, information and belief at the date of its publication. The information given is designed only as a guidance for safe handling, use, processing, storage, transportation, disposal and release and is not to be considered a warranty or quality specification. The information relates only to the specific material designated and may not be valid for such material used in combination with any other materials or in any process, unless specified in the text

End of Safety Data Sheet

SAFETY DATA SHEET

Creation Date 28-Apr-2009 **Revision Date** 27-Sep-2016 **Revision Number** 8

SECTION 1: IDENTIFICATION OF THE SUBSTANCE/MIXTURE AND OF THE COMPANY/UNDERTAKING

1.1. Product identification

Product Description:	**Acetone**
Cat No. :	**A/0520/25, A/0520/17, A/0520/PB17, A/0520/MC15, A/0520/M25, A/0520/21RSS, A/0520/24RSS, A/0520/25RSS, A/0520/34RSS, A/0520/27RSS**
Synonyms	2-Propanone
CAS-No	67-64-1
EC-No.	200-662-2
Molecular Formula	C3 H6 O
Reach Registration Number	01-2119471330-49

1.2. Relevant identified uses of the substance or mixture and uses advised against

Recommended Use	Laboratory chemicals.
Uses advised against	No Information available

1.3. Details of the supplier of the safety data sheet

Company	Fisher Scientific UK Bishop Meadow Road, Loughborough, Leicestershire LE11 5RG, United Kingdom
E-mail address	begel.sdsdesk@thermofisher.com

1.4. Emergency telephone number

Chemtrec US: (800) 424-9300
Chemtrec EU: 001 (202) 483-7616
Tel: 01509 231166

SECTION 2: HAZARDS IDENTIFICATION

2.1. Classification of the substance or mixture

CLP Classification - Regulation (EC) No 1272/2008

Physical hazards

Flammable liquids	Category 2 (H225)

Health hazards

Serious Eye Damage/Eye Irritation	Category 2 (H319)
Specific target organ toxicity - (single exposure)	Category 3 (H336)

Environmental hazards
Based on available data, the classification criteria are not met

2.2. Label elements



Signal Word **Danger**

Hazard Statements

H225 - Highly flammable liquid and vapor
H319 - Causes serious eye irritation
H336 - May cause drowsiness or dizziness
EUH066 - Repeated exposure may cause skin dryness or cracking

Precautionary Statements

P210 - Keep away from heat/sparks/open flames/hot surfaces. - No smoking
P240 - Ground/Bond container and receiving equipment
P261 - Avoid breathing dust/ fume/ gas/ mist/ vapors/ spray
P280 - Wear protective gloves/ protective clothing/ eye protection/ face protection
P305 + P351 + P338 - IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing

2.3. Other hazards

Substance is not considered persistent, bioaccumulative and toxic (PBT) / very persistent and very bioaccumulative (vPvB)

SECTION 3: COMPOSITION/INFORMATION ON INGREDIENTS

3.1. Substances

Component	CAS-No	EC-No.	Weight %	CLP Classification - Regulation (EC) No 1272/2008
Acetone	67-64-1	EEC No. 200-662-2	>95	Flam. Liq. 2 (H225) Eye Irrit. 2 (H319) STOT SE 3 (H336) EUH066

Reach Registration Number	01-2119471330-49

Full text of Hazard Statements: see section 16

SECTION 4: FIRST AID MEASURES

4.1. Description of first aid measures

Eye Contact Rinse immediately with plenty of water, also under the eyelids, for at least 15 minutes. Obtain medical attention.

Skin Contact Wash off immediately with plenty of water for at least 15 minutes. Obtain medical attention.

Ingestion Do not induce vomiting. Obtain medical attention.

Inhalation Move to fresh air. If breathing is difficult, give oxygen. Get medical attention immediately if symptoms occur.

Protection of First-aiders Remove all sources of ignition. Use personal protective equipment.

4.2. Most important symptoms and effects, both acute and delayed

Breathing difficulties. Symptoms of overexposure may be headache, dizziness, tiredness, nausea and vomiting: May cause pulmonary edema

4.3. Indication of any immediate medical attention and special treatment needed

Notes to Physician Treat symptomatically. Symptoms may be delayed.

SECTION 5: FIREFIGHTING MEASURES

5.1. Extinguishing media

Suitable Extinguishing Media
CO_2, dry chemical, dry sand, alcohol-resistant foam. Water spray. Cool closed containers exposed to fire with water spray.

Extinguishing media which must not be used for safety reasons
Do not use water jet.

5.2. Special hazards arising from the substance or mixture

Flammable. Risk of ignition. Containers may explode when heated. Vapors may form explosive mixtures with air. Vapors may travel to source of ignition and flash back.

Hazardous Combustion Products
Carbon monoxide (CO), Carbon dioxide (CO_2), Formaldehyde, Methanol.

5.3. Advice for firefighters

As in any fire, wear self-contained breathing apparatus pressure-demand, MSHA/NIOSH (approved or equivalent) and full protective gear. Thermal decomposition can lead to release of irritating gases and vapors.

SECTION 6: ACCIDENTAL RELEASE MEASURES

6.1. Personal precautions, protective equipment and emergency procedures

Use personal protective equipment. Ensure adequate ventilation. Remove all sources of ignition. Take precautionary measures against static discharges. Keep people away from and upwind of spill/leak. Avoid contact with skin, eyes and inhalation of vapors.

6.2. Environmental precautions

Should not be released into the environment.

6.3. Methods and material for containment and cleaning up

Remove all sources of ignition. Take precautionary measures against static discharges. Soak up with inert absorbent material. Keep in suitable, closed containers for disposal. Use spark-proof tools and explosion-proof equipment.

6.4. Reference to other sections

Refer to protective measures listed in Sections 8 and 13.

SECTION 7: HANDLING AND STORAGE

7.1. Precautions for safe handling

Do not breathe vapors or spray mist. Do not get in eyes, on skin, or on clothing. Wear personal protective equipment. Ensure adequate ventilation. Keep away from open flames, hot surfaces and sources of ignition. Take precautionary measures against static discharges. Use only non-sparking tools. Use explosion-proof equipment. To avoid ignition of vapors by static electricity discharge, all metal parts of the equipment must be grounded.

Hygiene Measures

Handle in accordance with good industrial hygiene and safety practice. Keep away from food, drink and animal feeding stuffs. Do not eat, drink or smoke when using this product. Remove and wash contaminated clothing before re-use. Wash hands before breaks and at the end of workday.

7.2. Conditions for safe storage, including any incompatibilities

Flammables area. Keep containers tightly closed in a dry, cool and well-ventilated place. Keep away from heat and sources of ignition.

7.3. Specific end use(s)

Use in laboratories

SECTION 8: EXPOSURE CONTROLS/PERSONAL PROTECTION

8.1. Control parameters

Exposure limits
List source(s): **EU** - Commission Directive 2006/15/EC of 7 February 2006 establishing a second list of indicative occupational exposure limit values in implementation of Council Directive 98/24/EC and amending Directives 91/322/EEC and 2000/39/EC on the protection of the health and safety of workers from the risks related to chemical agents at work. **UK** - EH40/2005 Containing the workplace exposure limits (WELs) for use with the Control of Substances Hazardous to Health Regulations (COSHH) 2002 (as amended). Updated by September 2006 official press release and October 2007 Supplement. **IRE -** 2010 Code of Practice for the Safety, Health and Welfare at Work (Chemical Agents) Regulations 2001. Published by the Health and Safety Authority.

Component	European Union	The United Kingdom	France	Belgium	Spain
Acetone	TWA: 500 ppm 8 hr TWA: 1210 mg/m³ 8 hr	TWA: 500 ppm TWA: 1210 mg/m³ STEL: 1500 ppm STEL: 3620 mg/m³	TWA / VME: 500 ppm (8 heures). restrictive limit TWA / VME: 1210 mg/m³ (8 heures). restrictive limit STEL / VLCT: 1000 ppm. restrictive limit STEL / VLCT: 2420 mg/m³. restrictive limit	TWA: 500 ppm 8 uren TWA: 1210 mg/m³ 8 uren STEL: 1000 ppm 15 minuten STEL: 2420 mg/m³ 15 minuten	TWA / VLA-ED: 500 ppm (8 horas) TWA / VLA-ED: 1210 mg/m³ (8 horas)

Component	Italy	Germany	Portugal	The Netherlands	Finland
Acetone	TWA: 500 ppm 8 ore. Media Ponderata nel Tempo TWA: 1210 mg/m³ 8 ore. Media Ponderata nel Tempo	TWA: 500 ppm TWA: 1200 mg/m³	STEL: 750 ppm 15 minutos TWA: 500 ppm 8 horas TWA: 1210 mg/m³ 8 horas	STEL: 2420 mg/m³ 15 minuten TWA: 1210 mg/m³ 8 uren	TWA: 500 ppm 8 tunteina TWA: 1200 mg/m³ 8 tunteina STEL: 630 ppm 15 minuutteina STEL: 1500 mg/m³ 15 minuutteina

Component	Austria	Denmark	Switzerland	Poland	Norway
Acetone	MAK-KZW: 2000 ppm 15 Minuten MAK-KZW: 4800 mg/m³ 15 Minuten MAK-TMW: 500 ppm 8 Stunden MAK-TMW: 1200 mg/m³ 8 Stunden	TWA: 250 ppm 8 timer TWA: 600 mg/m³ 8 timer	STEL: 1000 ppm 15 Minuten STEL: 2400 mg/m³ 15 Minuten TWA: 500 ppm 8 Stunden TWA: 1200 mg/m³ 8 Stunden	STEL: 1800 mg/m³ 15 minutach TWA: 600 mg/m³ 8 godzinach	TWA: 125 ppm 8 timer TWA: 295 mg/m³ 8 timer STEL: 125 ppm 15 minutter. STEL: 295 mg/m³ 15 minutter.

Component	Bulgaria	Croatia	Ireland	Cyprus	Czech Republic
Acetone	TWA: 600 mg/m³ STEL : 1400 mg/m³	TWA-GVI: 500 ppm 8 satima. TWA-GVI: 1210 mg/m³ 8 satima. STEL-KGVI: 1500 ppm 15 minutama. STEL-KGVI: 3620 mg/m³ 15 minutama.	TWA: 500 ppm 8 hr. TWA: 1210 mg/m³ 8 hr. STEL: 1500 ppm 15 min STEL: 3630 mg/m³ 15 min	Skin-potential for cutaneous absorption TWA: 500 ppm TWA: 1210 mg/m³	TWA: 800 mg/m³ 8 hodinách. Ceiling: 1500 mg/m³

Component	Estonia	Gibraltar	Greece	Hungary	Iceland
Acetone	TWA: 500 ppm 8 tundides. TWA: 1210 mg/m³ 8 tundides.	TWA: 500 ppm 8 hr TWA: 1210 mg/m³ 8 hr	STEL: 3560 mg/m³ TWA: 1780 mg/m³	STEL: 2420 mg/m³ 15 percekben. CK Substances with European indicative limits (96/94/EC, 2000/39/EC, 2006/15/EC, 2009/161/EU), which currently has no peak limit concentration. In these cases, Annex 3.1. should be used exercised TWA: 1210 mg/m³ 8 órában. AK	TWA: 250 ppm 8 klukkustundum. TWA: 600 mg/m³ 8 klukkustundum. Ceiling: 500 ppm Ceiling: 1200 mg/m³

Component	Latvia	Lithuania	Luxembourg	Malta	Romania
Acetone	TWA: 500 ppm TWA: 1210 mg/m³	TWA: 500 ppm IPRD TWA: 1210 mg/m³ IPRD STEL: 1000 ppm STEL: 2420 mg/m³	TWA: 500 ppm 8 Stunden TWA: 1210 mg/m³ 8 Stunden	TWA: 500 ppm TWA: 1210 mg/m³	TWA: 500 ppm 8 ore TWA: 1210 mg/m³ 8 ore

Component	Russia	Slovak Republic	Slovenia	Sweden	Turkey
Acetone	TWA: 200 mg/m³ STEL: 800 mg/m³ vapor	Ceiling: 2420 mg/m³ TWA: 500 ppm TWA: 1210 mg/m³	TWA: 500 ppm 8 urah TWA: 1210 mg/m³ 8 urah	STV: 500 ppm 15 minuter STV: 1200 mg/m³ 15 minuter LLV: 250 ppm 8 timmar. LLV: 600 mg/m³ 8 timmar.	TWA: 500 ppm 8 saat TWA: 1210 mg/m³ 8 saat

Biological limit values
List source(s):

Component	European Union	United Kingdom	France	Spain	Germany
Acetone			Acetone: 100 mg/L urine end of shift	Acetone: 50 mg/L urine end of shift	Acetone: 80 mg/L urine (end of shift)

Component	Italy	Finland	Denmark	Bulgaria	Romania
Acetone				Acetone: 80 mg/L urine at the end of exposure or end of shift	Acetone: 50 mg/L urine end of shift

Component	Gibraltar	Latvia	Slovak Republic	Luxembourg	Turkey
Acetone			Acetone: 80 mg/L urine end of exposure or work shift		

Monitoring methods
BS EN 14042:2003 Title Identifier: Workplace atmospheres. Guide for the application and use of procedures for the assessment of exposure to chemical and biological agents.
MDHS70 General methods for sampling airborne gases and vapours
MDHS 88 Volatile organic compounds in air. Laboratory method using diffusive samplers, solvent desorption and gas chromatography
MDHS 96 Volatile organic compounds in air - Laboratory method using pumped solid sorbent tubes, solvent desorption and gas chromatography

Derived No Effect Level (DNEL) See table for values

Route of exposure	Acute effects (local)	Acute effects (systemic)	Chronic effects (local)	Chronic effects (systemic)
Oral				
Dermal				186 mg/kg
Inhalation	2420 mg/m³			1210 mg/m³

Predicted No Effect Concentration (PNEC)	See values below.
Fresh water	10.6 mg/l
Fresh water sediment	30.4 mg/kg
Marine water	1.06 mg/l
Marine water sediment	3.04 mg/kg
Water Intermittent	21 mg/l
Microorganisms in sewage treatment	100 mg/l
Soil (Agriculture)	29.5 mg/kg

8.2. Exposure controls

Engineering Measures
Ensure adequate ventilation, especially in confined areas. Ensure that eyewash stations and safety showers are close to the workstation location. Use explosion-proof electrical/ventilating/lighting/equipment.
Wherever possible, engineering control measures such as the isolation or enclosure of the process, the introduction of process or equipment changes to minimise release or contact, and the use of properly designed ventilation systems, should be adopted to control hazardous materials at source

Personal protective equipment

Eye Protection	Goggles (European standard - EN 166)
Hand Protection	Protective gloves

Glove material	Breakthrough time	Glove thickness	EU standard	Glove comments
Butyl rubber	> 480 minutes	0.5 mm	EN 374 Level 6	As tested under EN374-3 Determination of Resistance to Permeation by Chemicals
Neoprene gloves	< 30 minutes	0.45 mm		

Skin and body protection Wear appropriate protective gloves and clothing to prevent skin exposure

Inspect gloves before use.
Please observe the instructions regarding permeability and breakthrough time which are provided by the supplier of the gloves. (Refer to manufacturer/supplier for information)
Ensure gloves are suitable for the task: Chemical compatability, Dexterity, Operational conditions, User susceptibility, e.g. sensitisation effects, also take into consideration the specific local conditions under which the product is used, such as the danger of cuts, abrasion.
Remove gloves with care avoiding skin contamination.

Respiratory Protection	When workers are facing concentrations above the exposure limit they must use appropriate certified respirators. To protect the wearer, respiratory protective equipment must be the correct fit and be used and maintained properly
Large scale/emergency use	Use a NIOSH/MSHA or European Standard EN 136 approved respirator if exposure limits are exceeded or if irritation or other symptoms are experienced **Recommended Filter type:** low boiling organic solvent Type AX Brown conforming to EN371
Small scale/Laboratory use	Use a NIOSH/MSHA or European Standard EN 149:2001 approved respirator if exposure limits are exceeded or if irritation or other symptoms are experienced. **Recommended half mask:-** Valve filtering: EN405; or; Half mask: EN140; plus filter, EN 141 When RPE is used a face piece Fit Test should be conducted
Environmental exposure controls	Do not allow material to contaminate ground water system.

SECTION 9: PHYSICAL AND CHEMICAL PROPERTIES

9.1. Information on basic physical and chemical properties

Appearance	Colorless
Physical State	Liquid
Odor	sweet

Odor Threshold	19.8 ppm	
pH	7	
Melting Point/Range	-95 °C / -139 °F	
Softening Point	No data available	
Boiling Point/Range	56 °C / 132.8 °F	
Flash Point	-20 °C / -4 °F	**Method -** Closed cup
Evaporation Rate	5.6 (Butyl Acetate = 1.0)	
Flammability (solid,gas)	Not applicable	Liquid
Explosion Limits	**Lower** 2.1 vol% **Upper** 13 vol%	
Vapor Pressure	247 mbar @ 20 °C	
Vapor Density	2.0	(Air = 1.0)
Specific Gravity / Density	0.790	
Bulk Density	Not applicable	Liquid
Water Solubility	soluble	
Solubility in other solvents	No information available	

Partition Coefficient (n-octanol/water)

Component	**log Pow**
Acetone	-0.24

Autoignition Temperature	465 °C / 869 °F	
Decomposition Temperature	> 4°C	
Viscosity	0.32 mPa.s @ 20 °C	
Explosive Properties	Not explosive	Vapors may form explosive mixtures with air
Oxidizing Properties	Not oxidising	

9.2. Other information

Molecular Formula	C3 H6 O
Molecular Weight	58.08
Refractive index	1.358 - 1.359

SECTION 10: STABILITY AND REACTIVITY

10.1. Reactivity

None known, based on information available

10.2. Chemical stability

Stable under normal conditions.

10.3. Possibility of hazardous reactions

Hazardous Polymerization	Hazardous polymerization does not occur.
Hazardous Reactions	None under normal processing.

10.4. Conditions to avoid

Heat, flames and sparks. Incompatible products. Keep away from open flames, hot surfaces and sources of ignition.

10.5. Incompatible materials

Strong oxidizing agents. Strong reducing agents. Strong bases. Peroxides. Halogenated compounds. Alkali metals. Amines.

10.6. Hazardous decomposition products

Carbon monoxide (CO). Carbon dioxide (CO_2). Formaldehyde. Methanol.

SECTION 11: TOXICOLOGICAL INFORMATION

11.1. Information on toxicological effects

Product Information

(a) acute toxicity;

Oral Based on available data, the classification criteria are not met
Dermal Based on available data, the classification criteria are not met
Inhalation Based on available data, the classification criteria are not met

Component	LD50 Oral	LD50 Dermal	LC50 Inhalation
Acetone	5800 mg/kg (Rat)	> 15800 mg/kg (rabbit) > 7400 mg/kg (rat)	76 mg/l, 4 h, (rat)

(b) skin corrosion/irritation; Based on available data, the classification criteria are not met

(c) serious eye damage/irritation; Category 2
Test method OECD Test Guideline 405
Test species rabbit
Observation end point Irritating to eyes

(d) respiratory or skin sensitization;
Respiratory Based on available data, the classification criteria are not met
Skin Based on available data, the classification criteria are not met

(e) germ cell mutagenicity; Based on available data, the classification criteria are not met

Component	Test method	Test species	Study result
Acetone 67-64-1 (>95)	OECD Test Guideline 471 AMES test	in vivo	negative
	OECD Test Guideline 476 Mammalian Gene cell mutation	in vitro	negative

(f) carcinogenicity; Based on available data, the classification criteria are not met

There are no known carcinogenic chemicals in this product

(g) reproductive toxicity; Based on available data, the classification criteria are not met

(h) STOT-single exposure; Category 3

Results / Target organs Central nervous system (CNS).

(i) STOT-repeated exposure; Based on available data, the classification criteria are not met

Target Organs No information available.

(j) aspiration hazard; Based on available data, the classification criteria are not met

Symptoms / effects,both acute and delayed Symptoms of overexposure may be headache, dizziness, tiredness, nausea and vomiting: May cause pulmonary edema

SECTION 12: ECOLOGICAL INFORMATION

12.1. Toxicity
Ecotoxicity effects .

Component	Freshwater Fish	Water Flea	Freshwater Algae	Microtox
Acetone	Oncorhynchus mykiss: LC50 = 5540 mg/l 96h Alburnus alburnus: LC50 = 11000 mg/l 96h Leuciscus idus: LC50 = 11300 mg/L/48h Salmo gairdneri: LC50 = 6100 mg/L/24h	EC50 = 8800 mg/L/48h EC50 = 12700 mg/L/48h EC50 = 12600 mg/L/48h	NOEC = 430 mg/l (algae; 96 h)	EC50 = 14500 mg/L/15 min

12.2. Persistence and degradability Readily biodegradable

Persistence Persistence is unlikely, based on information available.

Component	Degradability
Acetone 67-64-1 (>95)	91 % (28 d) (OECD 301 B)

12.3. Bioaccumulative potential Does not bioaccumulate

Component	log Pow	Bioconcentration factor (BCF)
Acetone	-0.24	0.69

12.4. Mobility in soil The product contains volatile organic compounds (VOC) which will evaporate easily from all surfaces Will likely be mobile in the environment due to its volatility. Disperses rapidly in air

12.5. Results of PBT and vPvB assessment Substance is not considered persistent, bioaccumulative and toxic (PBT) / very persistent and very bioaccumulative (vPvB).

12.6. Other adverse effects

Endocrine Disruptor Information This product does not contain any known or suspected endocrine disruptors

Persistent Organic Pollutant This product does not contain any known or suspected substance

Ozone Depletion Potential This product does not contain any known or suspected substance

SECTION 13: DISPOSAL CONSIDERATIONS

13.1. Waste treatment methods

Waste from Residues / Unused Products Waste is classified as hazardous. Dispose of in accordance with the European Directives on waste and hazardous waste. Dispose of in accordance with local regulations.

Contaminated Packaging Dispose of this container to hazardous or special waste collection point. Empty containers retain product residue, (liquid and/or vapor), and can be dangerous. Keep product and empty container away from heat and sources of ignition.

European Waste Catalogue (EWC) According to the European Waste Catalogue, Waste Codes are not product specific, but application specific.

Other Information Waste codes should be assigned by the user based on the application for which the product was used. Do not dispose of waste into sewer. Can be incinerated, when in compliance with local regulations.

SECTION 14: TRANSPORT INFORMATION

IMDG/IMO

14.1. UN number UN1090
14.2. UN proper shipping name ACETONE
14.3. Transport hazard class(es) 3
14.4. Packing group II

ADR

14.1. UN number UN1090
14.2. UN proper shipping name ACETONE
14.3. Transport hazard class(es) 3
14.4. Packing group II

IATA

14.1. UN number UN1090
14.2. UN proper shipping name ACETONE
14.3. Transport hazard class(es) 3
14.4. Packing group II

14.5. Environmental hazards No hazards identified

14.6. Special precautions for user No special precautions required

14.7. Transport in bulk according to Annex II of MARPOL73/78 and the IBC Code Not applicable, packaged goods

SECTION 15: REGULATORY INFORMATION

15.1. Safety, health and environmental regulations/legislation specific for the substance or mixture

International Inventories X = listed

Component	EINECS	ELINCS	NLP	TSCA	DSL	NDSL	PICCS	ENCS	IECSC	AICS	KECL
Acetone	200-662-2	-		X	X	-	X	X	X	X	X

National Regulations

Component	Germany - Water Classification (VwVwS)	Germany - TA-Luft Class
Acetone	WGK 1	

Component	France - INRS (Tables of occupational diseases)
Acetone	Tableaux des maladies professionnelles (TMP) - RG 84

Take note of Control of Substances Hazardous to Health Regulations (COSHH) 2002 and 2005 Amendment.
Take note of Dir 94/33/EC on the protection of young people at work
Take note of Directive 98/24/EC on the protection of the health and safety of workers from the risks related to chemical agents at work

15.2. Chemical safety assessment

A Chemical Safety Assessment/Report (CSA/CSR) has been conducted by the manufacturer/importer

SECTION 16: OTHER INFORMATION

Full text of H-Statements referred to under sections 2 and 3
H225 - Highly flammable liquid and vapor
H319 - Causes serious eye irritation
H336 - May cause drowsiness or dizziness
EUH066 - Repeated exposure may cause skin dryness or cracking

Legend

CAS - Chemical Abstracts Service

EINECS/ELINCS - European Inventory of Existing Commercial Chemical Substances/EU List of Notified Chemical Substances
PICCS - Philippines Inventory of Chemicals and Chemical Substances
IECSC - Chinese Inventory of Existing Chemical Substances
KECL - Korean Existing and Evaluated Chemical Substances

TSCA - United States Toxic Substances Control Act Section 8(b) Inventory
DSL/NDSL - Canadian Domestic Substances List/Non-Domestic Substances List
ENCS - Japanese Existing and New Chemical Substances
AICS - Australian Inventory of Chemical Substances
NZIoC - New Zealand Inventory of Chemicals

WEL - Workplace Exposure Limit
ACGIH - American Conference of Governmental Industrial Hygienists
DNEL - Derived No Effect Level
RPE - Respiratory Protective Equipment
LC50 - Lethal Concentration 50%
NOEC - No Observed Effect Concentration
PBT - Persistent, Bioaccumulative, Toxic

TWA - Time Weighted Average
IARC - International Agency for Research on Cancer
PNEC - Predicted No Effect Concentration
LD50 - Lethal Dose 50%
EC50 - Effective Concentration 50%
POW - Partition coefficient Octanol:Water
vPvB - very Persistent, very Bioaccumulative

ADR - European Agreement Concerning the International Carriage of Dangerous Goods by Road
IMO/IMDG - International Maritime Organization/International Maritime

ICAO/IATA - International Civil Aviation Organization/International Air Transport Association

Dangerous Goods Code

MARPOL - International Convention for the Prevention of Pollution from Ships

OECD - Organisation for Economic Co-operation and Development

ATE - Acute Toxicity Estimate

BCF - Bioconcentration factor

VOC - Volatile Organic Compounds

Key literature references and sources for data

Suppliers safety data sheet, Chemadvisor - LOLI, Merck index, RTECS

Training Advice

Chemical hazard awareness training, incorporating labelling, Safety Data Sheets (SDS), Personal Protective Equipment (PPE) and hygiene.

Use of personal protective equipment, covering appropriate selection, compatibility, breakthrough thresholds, care, maintenance, fit and standards.

First aid for chemical exposure, including the use of eye wash and safety showers.

Fire prevention and fighting, identifying hazards and risks, static electricity, explosive atmospheres posed by vapours and dusts.

Creation Date	28-Apr-2009
Revision Date	27-Sep-2016
Revision Summary	Update to Format, SDS sections updated, 2, 7, 11.

This safety data sheet complies with the requirements of Regulation (EC) No. 1907/2006

Disclaimer

The information provided in this Safety Data Sheet is correct to the best of our knowledge, information and belief at the date of its publication. The information given is designed only as a guidance for safe handling, use, processing, storage, transportation, disposal and release and is not to be considered a warranty or quality specification. The information relates only to the specific material designated and may not be valid for such material used in combination with any other materials or in any process, unless specified in the text

End of Safety Data Sheet

Fisher Scientific

Part of Thermo Fisher Scientific

SAFETY DATA SHEET

Creation Date 02-Feb-2010 **Revision Date** 07-Nov-2016 **Revision Number** 2

1. Identification

Product Name **Ethylene glycol**

Cat No. : **E177-4; E177-20**

Synonyms Monoethylene glycol; 1,2-Ethanediol

Recommended Use Laboratory chemicals.

Uses advised against No Information available

Details of the supplier of the safety data sheet

Company
Fisher Scientific
One Reagent Lane
Fair Lawn, NJ 07410
Tel: (201) 796-7100

Emergency Telephone Number
CHEMTREC®, Inside the USA: 800-424-9300
CHEMTREC®, Outside the USA: 001-703-527-3887

2. Hazard(s) identification

Classification

This chemical is considered hazardous by the 2012 OSHA Hazard Communication Standard (29 CFR 1910.1200)

Acute oral toxicity	Category 4
Specific target organ toxicity (single exposure)	Category 3
Target Organs - Central nervous system (CNS).	
Specific target organ toxicity - (repeated exposure)	Category 2
Target Organs - Kidney, Liver.	

Label Elements

Signal Word
Warning

Hazard Statements
Harmful if swallowed
May cause drowsiness or dizziness
May cause damage to organs through prolonged or repeated exposure



Precautionary Statements
Prevention
Wash face, hands and any exposed skin thoroughly after handling
Do not eat, drink or smoke when using this product
Do not breathe dust/fume/gas/mist/vapors/spray
Use only outdoors or in a well-ventilated area
Response
Get medical attention/advice if you feel unwell
Inhalation
IF INHALED: Remove victim to fresh air and keep at rest in a position comfortable for breathing
Call a POISON CENTER or doctor/physician if you feel unwell
Ingestion
IF SWALLOWED: Call a POISON CENTER or doctor/physician if you feel unwell
Rinse mouth
Storage
Store in a well-ventilated place. Keep container tightly closed
Store locked up
Disposal
Dispose of contents/container to an approved waste disposal plant
Hazards not otherwise classified (HNOC)
None identified
WARNING! This product contains a chemical known in the State of California to cause birth defects or other reproductive harm.

3. Composition / information on ingredients

Component	CAS-No	Weight %
Ethylene glycol	107-21-1	>95

4. First-aid measures

Eye Contact Rinse immediately with plenty of water, also under the eyelids, for at least 15 minutes. Obtain medical attention.

Skin Contact Wash off immediately with plenty of water for at least 15 minutes. Get medical attention immediately if symptoms occur.

Inhalation Move to fresh air. Do not use mouth-to-mouth method if victim ingested or inhaled the substance; give artificial respiration with the aid of a pocket mask equipped with a one-way valve or other proper respiratory medical device. Get medical attention immediately if symptoms occur. If not breathing, give artificial respiration.

Ingestion Do not induce vomiting. Call a physician or Poison Control Center immediately.

Most important symptoms/effects Breathing difficulties.
Notes to Physician Treat symptomatically

5. Fire-fighting measures

Suitable Extinguishing Media Use water spray, alcohol-resistant foam, dry chemical or carbon dioxide.

Unsuitable Extinguishing Media No information available

Flash Point 111 °C / 231.8 °F
Method - DIN 51758

Autoignition Temperature 413 °C / 775.4 °F
Explosion Limits

Upper	15.30 vol %
Lower	3.20 vol %
Sensitivity to Mechanical Impact	No information available
Sensitivity to Static Discharge	No information available

Specific Hazards Arising from the Chemical
Thermal decomposition can lead to release of irritating gases and vapors. Keep product and empty container away from heat and sources of ignition.

Hazardous Combustion Products
Carbon monoxide (CO) Carbon dioxide (CO_2)
Protective Equipment and Precautions for Firefighters
As in any fire, wear self-contained breathing apparatus pressure-demand, MSHA/NIOSH (approved or equivalent) and full protective gear.

NFPA

Health	Flammability	Instability	Physical hazards
2	1	1	N/A

6. Accidental release measures

Personal Precautions	Ensure adequate ventilation. Use personal protective equipment.
Environmental Precautions	Should not be released into the environment. See Section 12 for additional ecological information.
Methods for Containment and Clean Up	Soak up with inert absorbent material. Keep in suitable, closed containers for disposal.

7. Handling and storage

Handling	Wear personal protective equipment. Ensure adequate ventilation. Do not breathe vapors or spray mist. Avoid contact with skin, eyes and clothing.
Storage	Keep containers tightly closed in a dry, cool and well-ventilated place. Keep away from heat and sources of ignition.

8. Exposure controls / personal protection

Exposure Guidelines

Component	ACGIH TLV	OSHA PEL	NIOSH IDLH
Ethylene glycol	Ceiling: 100 mg/m³	(Vacated) Ceiling: 50 ppm (Vacated) Ceiling: 125 mg/m³	

Component	Quebec	Mexico OEL (TWA)	Ontario TWAEV
Ethylene glycol	Ceiling: 50 ppm Ceiling: 127 mg/m³	Ceiling: 100 mg/m³	CEV: 100 mg/m³

Legend

ACGIH - American Conference of Governmental Industrial Hygienists
OSHA - Occupational Safety and Health Administration

Engineering Measures Ensure adequate ventilation, especially in confined areas. Ensure that eyewash stations and safety showers are close to the workstation location.

Personal Protective Equipment

Eye/face Protection Wear appropriate protective eyeglasses or chemical safety goggles as described by OSHA's eye and face protection regulations in 29 CFR 1910.133 or European Standard EN166.

Skin and body protection Wear appropriate protective gloves and clothing to prevent skin exposure.

Respiratory Protection Follow the OSHA respirator regulations found in 29 CFR 1910.134 or European Standard EN 149. Use a NIOSH/MSHA or European Standard EN 149 approved respirator if exposure limits are exceeded or if irritation or other symptoms are experienced.

Hygiene Measures Handle in accordance with good industrial hygiene and safety practice.

9. Physical and chemical properties

Physical State	Viscous liquid Liquid
Appearance	Colorless
Odor	Odorless
Odor Threshold	No information available
pH	5.5-7.5 50% aq. sol
Melting Point/Range	-13 °C / 8.6 °F
Boiling Point/Range	196 - 198 °C / 384.8 - 388.4 °F @ 760 mmHg
Flash Point	111 °C / 231.8 °F
Method -	DIN 51758
Evaporation Rate	No information available
Flammability (solid,gas)	Not applicable
Flammability or explosive limits	
Upper	15.30 vol %
Lower	3.20 vol %
Vapor Pressure	0.12 mmHg @ 20 °C
Vapor Density	2.14 (Air = 1.0)
Specific Gravity	1.113
Solubility	miscible
Partition coefficient; n-octanol/water	No data available
Autoignition Temperature	413 °C / 775.4 °F
Decomposition Temperature	> 500°C
Viscosity	21 cP (20°C)
Molecular Formula	C2 H6 O2
Molecular Weight	62.06

10. Stability and reactivity

Reactive Hazard None known, based on information available

Stability Hygroscopic.

Conditions to Avoid Incompatible products. Excess heat. Exposure to moist air or water.

Incompatible Materials Strong oxidizing agents, Strong acids, Strong bases, Aldehydes

Hazardous Decomposition Products Carbon monoxide (CO), Carbon dioxide (CO_2)

Hazardous Polymerization Hazardous polymerization does not occur.

Hazardous Reactions None under normal processing.

11. Toxicological information

Acute Toxicity

Product Information

Component Information

Component	LD50 Oral	LD50 Dermal	LC50 Inhalation
Ethylene glycol	7712 mg/kg (Rat)	9530 µL/kg (Rabbit) 10600 mg/kg (Rat)	Not listed

Toxicologically Synergistic Products No information available

Delayed and immediate effects as well as chronic effects from short and long-term exposure

Irritation May cause eye, skin, and respiratory tract irritation

Sensitization No information available

Carcinogenicity The table below indicates whether each agency has listed any ingredient as a carcinogen.

Component	CAS-No	IARC	NTP	ACGIH	OSHA	Mexico
Ethylene glycol	107-21-1	Not listed	Not listed	Not listed	Not listed	Not listed

Mutagenic Effects No information available

Reproductive Effects No information available.

Developmental Effects No information available.

Teratogenicity No information available.

STOT - single exposure Central nervous system (CNS)
STOT - repeated exposure Kidney Liver

Aspiration hazard No information available

Symptoms / effects,both acute and delayed No information available
Endocrine Disruptor Information No information available

Other Adverse Effects The toxicological properties have not been fully investigated.

12. Ecological information

Ecotoxicity
Do not empty into drains. .

Component	Freshwater Algae	Freshwater Fish	Microtox	Water Flea
Ethylene glycol	EC50: 6500 - 13000 mg/L, 96h (Pseudokirchneriella subcapitata)	LC50: = 16000 mg/L, 96h static (Poecilia reticulata) LC50: 40000 - 60000 mg/L, 96h static (Pimephales promelas) LC50: = 40761 mg/L, 96h static (Oncorhynchus mykiss) LC50: = 27540 mg/L, 96h static (Lepomis macrochirus) LC50: 14 - 18 mL/L, 96h static (Oncorhynchus mykiss) LC50: = 41000 mg/L, 96h (Oncorhynchus mykiss)	Not listed	EC50: = 46300 mg/L, 48h (Daphnia magna)

Persistence and Degradability Miscible with water Persistence is unlikely based on information available.
Bioaccumulation/ Accumulation No information available.

Mobility Will likely be mobile in the environment due to its water solubility.

Component	log Pow
Ethylene glycol	-1.93

13. Disposal considerations

Waste Disposal Methods Chemical waste generators must determine whether a discarded chemical is classified as a hazardous waste. Chemical waste generators must also consult local, regional, and

national hazardous waste regulations to ensure complete and accurate classification.

14. Transport information

DOT Not regulated
TDG Not regulated
IATA Not regulated
IMDG/IMO Not regulated

15. Regulatory information

All of the components in the product are on the following Inventory lists: X = listed

International Inventories

Component	TSCA	DSL	NDSL	EINECS	ELINCS	NLP	PICCS	ENCS	AICS	IECSC	KECL
Ethylene glycol	X	X	-	203-473-3	-		X	X	X	X	X

Legend:
X - Listed
E - Indicates a substance that is the subject of a Section 5(e) Consent order under TSCA.
F - Indicates a substance that is the subject of a Section 5(f) Rule under TSCA.
N - Indicates a polymeric substance containing no free-radical initiator in its inventory name but is considered to cover the designated polymer made with any free-radical initiator regardless of the amount used.
P - Indicates a commenced PMN substance
R - Indicates a substance that is the subject of a Section 6 risk management rule under TSCA.
S - Indicates a substance that is identified in a proposed or final Significant New Use Rule
T - Indicates a substance that is the subject of a Section 4 test rule under TSCA.
XU - Indicates a substance exempt from reporting under the Inventory Update Rule, i.e. Partial Updating of the TSCA Inventory Data Base Production and Site Reports (40 CFR 710(B).
Y1 - Indicates an exempt polymer that has a number-average molecular weight of 1,000 or greater.
Y2 - Indicates an exempt polymer that is a polyester and is made only from reactants included in a specified list of low concern reactants that comprises one of the eligibility criteria for the exemption rule.

U.S. Federal Regulations

TSCA 12(b) Not applicable

SARA 313

Component	CAS-No	Weight %	SARA 313 - Threshold Values %
Ethylene glycol	107-21-1	>95	1.0

SARA 311/312 Hazard Categories

Acute Health Hazard	Yes
Chronic Health Hazard	Yes
Fire Hazard	No
Sudden Release of Pressure Hazard	No
Reactive Hazard	No

CWA (Clean Water Act) Not applicable

Clean Air Act

Component	HAPS Data	Class 1 Ozone Depletors	Class 2 Ozone Depletors
Ethylene glycol	X		-

OSHA Occupational Safety and Health Administration
Not applicable

CERCLA
This material, as supplied, contains one or more substances regulated as a hazardous substance under the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) (40 CFR 302)

Component	Hazardous Substances RQs	CERCLA EHS RQs
Ethylene glycol	5000 lb	-

California Proposition 65 This product does not contain any Proposition 65 chemicals

Component	CAS-No	California Prop. 65	Prop 65 NSRL	Category
Ethylene glycol	107-21-1	Developmental	-	Developmental

U.S. State Right-to-Know Regulations

Component	Massachusetts	New Jersey	Pennsylvania	Illinois	Rhode Island
Ethylene glycol	X	X	X	X	-

U.S. Department of Transportation

Reportable Quantity (RQ): Y
DOT Marine Pollutant N
DOT Severe Marine Pollutant N

U.S. Department of Homeland Security
This product does not contain any DHS chemicals.

Other International Regulations

Mexico - Grade Slight risk, Grade 1

Canada
This product has been classified in accordance with the hazard criteria of the Controlled Products Regulations (CPR) and the MSDS contains all the information required by the CPR

WHMIS Hazard Class D1B Toxic materials
D2A Very toxic materials



16. Other information

Prepared By Regulatory Affairs
Thermo Fisher Scientific
Email: EMSDS.RA@thermofisher.com

Creation Date 02-Feb-2010
Revision Date 07-Nov-2016
Print Date 07-Nov-2016
Revision Summary This document has been updated to comply with the US OSHA HazCom 2012 Standard replacing the current legislation under 29 CFR 1910.1200 to align with the Globally Harmonized System of Classification and Labeling of Chemicals (GHS)

Disclaimer
The information provided in this Safety Data Sheet is correct to the best of our knowledge, information and belief at the date of its publication. The information given is designed only as a guidance for safe handling, use, processing, storage, transportation, disposal and release and is not to be considered a warranty or quality specification. The information relates only to the specific material designated and may not be valid for such material used in combination with any other materials or in any process, unless specified in the text

End of SDS

SAFETY DATA SHEET

GALLIUM ARSENIDE OPTICAL CRYSTAL

According to Regulation (EC) No.1907/2006 (REACH)

Revision 2015 : Issued 1st September 2015

1. IDENTIFICATION OF THE SUBSTANCE AND THE COMPANY

1.1. PRODUCT IDENTIFIERS:

Product Name: Gallium Arsenide Optical Crystal

Synonyms, Trade Names: GaAs

1.2. RELEVANT IDENTIFIED USES OF THE SUBSTANCE OR MIXTURE AND USES ADVISED AGAINST

Identified Uses: Optical Material for manufacture of Optical Components.

1.3. DETAILS OF THE SUPPLIER OF THE SAFETY DATA SHEET

Company: CRYSTRAN LTD, 1 Broom Road Business Park, Poole, Dorset UK BH12 4PA

☎ +44 1202 307650

1.4. EMERGENCY TELEPHONE NUMBER

Emergency Phone: ☎ +44 1202 307650 (Monday to Friday 08:30 to 17:00 GMT)

Emergency Action: In the event of a medical enquiry involving this product, please contact your doctor or local hospital accident and emergency department. The attending health professional will be able to contact the National Poisons Information Service.

2. HAZARDS IDENTIFICATION

2.1. CLASSIFICATION OF THE SUBSTANCE OR MIXTURE

Class 6.1 Poison. Toxic by ingestion and inhalation with a danger of cumulative effects. Liberates highly toxic hydrogen selenide in contact with gastric juices. Dermatitis may result from prolonged contact. Particular care must be exercised when machining and creating dust or particles. Symptoms include garlic odour on breath. Dangerous for the environment.

2.2. LABEL ELEMENTS

Signal Word: Danger

H301	Toxic if swallowed
H331	Toxic if inhaled
H410	Very toxic to aquatic life with long lasting effects

Precautionary Statements:

P262	Do not breathe dust/fume/gas/mist/vapours/spray.
P264	Wash thoroughly after handling.
P270	Do not eat, drink or smoke when handling this product
P273	Avoid release to the environment.
P301+P310	IF SWALLOWED: Immediately call a poison centre or doctor. Rinse mouth.
P304+P312	IF INHALED: Call a poison centre or doctor/physician if you feel unwell.





2.3. OTHER HAZARDS

None

3. COMPOSITION/INFORMATION ON INGREDIENTS

3.1. SUBSTANCES

Component Name	CAS number	%	EC number (EINECS)	EU index	UN number
Gallium Arsenide	1303-00-0	100%	215-114-8	033-002-00-5	1557

4. FIRST AID MEASURES

4.1. DESCRIPTION OF FIRST AID MEASURES

GENERAL: Consult a doctor for specific advice.

EYES: Irrigate thoroughly with water for at least 15 minutes. Obtain medical attention.

SKIN: Wash thoroughly with soap and water. Dry area with clean towel. Remove contaminated clothing and wash clothing before re-use.

INHALATION: Remove to fresh air. Perform artificial respiration if breathing has stopped. When breathing is difficult, properly trained personnel may administer oxygen. Keep affected person warm and at rest. Obtain medical attention.

INGESTION: Do not induce vomiting. Wash out mouth thoroughly with water and give 2 cups of water to drink. Do not give carbonated drinks. Never give anything by mouth to an unconscious person. Obtain medical attention immediately.

4.2. MOST IMPORTANT SYMPTOMS AND EFFECTS, BOTH ACUTE AND DELAYED

Refer to Section 2.2 and to section 11.

4.3. INDICATION OF ANY IMMEDIATE MEDICAL ATTENTION AND SPECIAL TREATMENT NEEDED

No Data.

5. FIRE FIGHTING MEASURES

5.1. EXTINGUISHING MEDIA

This product does not burn.

5.2. SPECIAL HAZARDS ARISING FROM THE SUBSTANCE OR MIXTURE

None known.

5.3. ADVICE FOR FIREFIGHTERS

None.

6. ACCIDENTAL RELEASE MEASURES

6.1. PERSONAL PRECAUTIONS, PROTECTIVE EQUIPMENT AND EMERGENCY PROCEDURES

Wear suitable protective clothing & equipment as listed under Section 8. Avoid making dust.

6.2. ENVIRONMENTAL PRECAUTIONS

Prevent further leakage or spillage. Do not let product enter drains. Do not discharge to the environment.

6.3. METHODS AND MATERIALS FOR CONTAINMENT AND CLEANING UP

Take up and containerize for proper disposal. Containerize any cleaning materials used for proper disposal.

6.4. REFERENCE TO OTHER SECTIONS

Dispose as in Section 13.

7. HANDLING AND STORAGE

7.1. PRECAUTIONS FOR SAFE HANDLING:

Keep away from heat. Avoid contact with skin and eyes. Protect against physical damage. Avoid generating dust.

7.2. CONDITIONS FOR SAFE STORAGE, INCLUDING ANY INCOMPATIBILITIES

Keep away from foodstuffs. Keep away from acids and strong bases.

7.3. SPECIFIC END USES

Optical Material for Manufacture of Optical Components.

8. EXPOSURE CONTROL AND PERSONAL PROTECTION

8.1. CONTROL PARAMETERS

OCCUPATIONAL EXPOSURE LIMITS (OEL) = 0.1 mg/m^3 in 8 hour Time Weighted Average (TWA)

8.2. EXPOSURE CONTROLS

Protective gloves made of PVA are required. Use of a laboratory coat is suggested. Safety goggles or safety glasses with side shields are required if there is any possibility of chipping or dust creation. Respirators must be worn when the threshold limit is exceeded. Provide adequate general mechanical ventilation, and local exhaust ventilation. Wash hands immediately after handling the product.

9. PHYSICAL AND CHEMICAL PROPERTIES

9.1. INFORMATION ON BASIC PHYSICAL AND CHEMICAL PROPERTIES

APPEARANCE :	Grey-black metallic geometric shapes.	FLASH POINT:	Not Applicable
BOILING POINT (760mm Hg)	Not determined	FLAMMABILITY:	Not Applicable
MELTING POINT:	1238°C	EXPLOSIVE PROPERTIES:	Not Applicable
SPECIFIC GRAVITY:	5.31 g/mL	VAPOUR PRESSURE:	Not determined
SOLUBILITY IN WATER:	Insoluble	pH IN AQUEOUS SOLUTION:	Not determined

9.2. OTHER SAFETY INFORMATION

None

10. STABILITY AND REACTIVITY

10.1. REACTIVITY
Reacts with strong mineral acids and strong oxidising materials

10.2. CHEMICAL STABILITY
Stable under normal conditions of storage and use

10.3. POSSIBILITY OF HAZARDOUS REACTIONS
None known

10.4. CONDITIONS TO AVOID
Can react with oxidising agents. Avoid strong acids

10.5. INCOMPATIBLE MATERIALS
Strong Mineral Acids. Strong oxidising materials

10.6. HAZARDOUS DECOMPOSITION PRODUCTS
Contact with acids releases toxic gases. Arsine and oxides of arsenic can be formed

11. TOXICOLOGICAL INFORMATION

11.1. INFORMATION ON TOXICOLOGICAL EFFECTS

Toxic by ingestion and inhalation of dust, with a cumulative effect. Affects nervous system. Particular care must be exercised when machining and creating dust or particles. Inhalation of dust may irritate respiratory system.

TOXIC DOSE - LD50 > 4700 g/kg **CARCINOGENICITY:** No evidence of carcinogenic properties.

MUTAGENICITY/TERATOGENICITY: Refer to attached report. Particular care should be exercised when machining and creating dust or particles.

12. ECOLOGICAL INFORMATION

12.1. TOXICITY
Danger to drinking water. Poisonous to Fish

12.2. PERSISTENCE AND DEGRADABILITY
No Data

12.3. BIOACCUMULATIVE POTENTIAL
No Data

13. DISPOSAL CONSIDERATIONS

13.1. WASTE TREATMENT METHODS

Chemical residues are generally classified as special waste, and are covered by regulations which vary according to location. Contact your local waste disposal authority for advice, or pass to a chemical disposal company.

14. TRANSPORT INFORMATION

14.1. UN NUMBER: 1557

14.2. UN PROPER SHIPPING NAME:
Arsenic Compound, Solid, N.O.S. (Gallium Arsenide).

14.3. TRANSPORT HAZARD CLASS: 6.1

14.4. PACKING GROUP: II

14.5. ENVIRONMENTAL HAZARDS: Marine Pollutant

14.6. SPECIAL PRECAUTIONS FOR USER: None

14.7. TRANSPORT IN BULK MARPOL / IBC: No Data

15. REGULATORY INFORMATION

15.1. SAFETY, HEALTH AND ENVIRONMENTAL REGULATIONS / LEGISLATION SPECIFIC FOR THE SUBSTANCE OR MIXTURE

TSCA: Not Listed in the TSCA inventory

REACH: Refer to restrictions on the manufacture, placing on the market and use Annex XVII/19 EC/552/200 - 19. Arsenic Compounds.

16. OTHER INFORMATION

REVISION DATE: 1st September 2015 ©2015 Crystran Ltd.

The above information is believed to be correct but does not purport to be all inclusive and must be used only as a guide.

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Email: sales@crystran.co.uk www.crystran.co.uk Registered in England No.2863378

NTP Toxicology and Carcinogenesis Studies of Gallium Arsenide (CAS No. 1303-00-0) in F344/N Rats and B6C3F1 Mice (Inhalation Studies).

US National Toxicology Program Tech Rep Ser. 2000 Sep;492:1-306

Gallium arsenide is used primarily to make light- emitting diodes, lasers, laser windows, and photodetectors and in the photoelectronic transmission of data through optical fibers. Gallium arsenide was nominated for study because of its widespread use in the microelectronics industry, the potential for worker exposure, and the absence of chronic toxicity data. Male and female F344/N rats and B6C3F1 mice were exposed to gallium arsenide particles (greater than 98% pure; mass median aerodynamic diameter = 0.8 to 1.0 mg/m^3) by inhalation for 16 days, 14 weeks, or 2 years. Genetic toxicology studies were conducted in Salmonella typhimurium, and the frequency of micronuclei was determined in the peripheral blood of mice exposed to gallium arsenide for 14 weeks.

16-DAY STUDY IN RATS: Groups of five male and five female rats were exposed to particulate aerosols of gallium arsenide with a mass median aerodynamic diameter of approximately at concentrations of 0, 1, 10, 37, 75, or 150 mg/m^3 by inhalation, 6 hours per day, 5 days per week, for 16 days. All rats survived to the end of the study. The final mean body weights of all exposed groups of males and females were similar to those of the chamber controls. Compared to chamber controls, the liver and lung weights of males exposed to 1 mg/m^3 or greater and females exposed to 10 mg/m^3 or greater were increased; the thymus weights of all exposed groups of males were decreased. Gallium arsenide particles were visible in the alveolar spaces and, to a lesser extent, within alveolar macrophages of exposed rats. Moderate proteinosis (surfactant mixed with small amounts of fibrin) and minimal histiocytic cellular infiltrate were observed in the alveoli of exposed males and females. Epithelial hyperplasia and squamous metaplasia of the larynx were observed primarily in males exposed to 150 mg/m^3.

16-DAY STUDY IN MICE: Groups of five male and four or five female mice were exposed to particulate aerosols of gallium arsenide with a mass median aerodynamic diameter of approximately 1 &mgr;m at concentrations of 0, 1, 10, 37, 75, or 150 mg/m^3 by inhalation, 6 hours per day, 5 days per week, for 16 days. The final mean body weights were similar among exposed and chamber control groups. Compared to chamber controls, the lung weights of males and females exposed to 10 mg/m^3 or greater were increased. Gallium ar senide particles were visible in alveolar spaces and macrophages in some mice exposed to 150 mg/m^3. Moderate proteinosis, mild epithelial hyperplasia, and histiocytic infiltration of the lung were observed in males and females exposed to 10 mg/m^3 or greater. In the larynx, mild squamous metaplasia was seen in mice exposed to 10 mg/m^3 or greater, and mild chronic inflammation occurred in mice exposed to 75 or 150 mg/m^3.

14-WEEK STUDY IN RATS: Groups of 10 male and 10 female rats were exposed by inhalation to gallium arsenide particulate at concentrations of 0, 0.1, 1, 10, 37, or 75 mg/m^3, 6 hours per day, 5 days per week, for 14 weeks. All rats survived until the end of the study. The final mean body weight and body weight gain of males exposed to 75 mg/m^3 were significantly less than those of the chamber controls. Hematology and clinical chemistry results indicated that exposure to gallium arsenide induced a microcytic responsive anemia with an erythrocytosis and increased zinc protoporphyrin/heme ratios in exposed groups of rats. There were also increases in platelet and neutrophil counts, a transient decrease in leukocyte counts, and increases in the serum activities of alanine aminotransferase and sorbitol dehydrogenase. These changes were of greater magnitude in male rats. The lung weights of all exposed groups of rats were increased, while testis, cauda epididymis, and epididymis weights of males exposed to 37 or 75 mg/m^3 were generally less than those of chamber controls. Total spermatid heads and spermatid counts were significantly decreased in males exposed to 75 mg/m^3, while epididymal spermatozoa motility was significantly reduced in males ees exposed to 10 mg/m^3 or greater. Gallium arsenide particles were visible in alveolar spaces and macrophages in the lungs of exposed rats. Minimal to marked proteinosis and minimal histiocytic cellular infiltration of the alveoli were observed in all exposed groups; minimal squamous metaplasia in the larynx and lymphoid cell hyperplasia of the mediastinal lymph node were observed in some males and females exposed to 37 or 75 mg/m^3. Exposure-related increases in the incidences of plasma cell hyperplasia of the mandibular lymph node, testicular atrophy, epididymal hypospermia, bone marrow hyperplasia (males), and hemosiderosis in the liver were observed in the 37 and 75 mg/m^3 groups.

14-WEEK STUDY IN MICE: Groups of 10 male and 10 female mice were exposed by inhalation to gallium arsenide particulate at concentrations of 0, 0.1, 1, 10, 37, or 75 mg/m^3, 6 hours per day, 5 days per week, for 14 weeks. One female mouse exposed to 75 mg/m^3 died before the end of the study. Final mean body weights and body weight gains of males in the 75 mg/m^3 group were significantly less than the chamber controls. Hematology and clinical chemistry results indicated that exposure to gallium arsenide

affected the circulating erythroid mass and induced a microcytic responsive anemia with an erythrocytosis and increased zinc protoporphyrin/heme ratios in male and female mice. There were also increases in platelet and neutrophil counts. Compared to the chamber controls, the lung weights of males exposed to 1 mg/m^3 or greater and females exposed to 10 mg/m^3 or greater were increased. Testis, cauda epididymis, and epididymis weights, total spermatid heads, spermatid counts, and concentration and motility of epididymal spermatozoa were generally decreased. Gallium arsenide particles were visible in alveolar spaces and macrophages in the lungs of mice exposed to 1 mg/m^3 or greater. Mild to marked proteinosis, histiocytic infiltration, and epithelial hyperplasia were observed in the alveoli of males and females exposed to 1 mg/m^3 or greater. Minimal to mild suppurative inflammation and granuloma in the lung and squamous metaplasia in the larynx were present in males and females exposed to 10 mg/m^3 or greater. Min imal hyperplasia was observed in the tracheobronchial lymph node of males exposed to 10 mg/m^3 or greater and females exposed to 37 or 75 mg/m^3. Exposure- related increases in the incidences of testicular atrophy, epididymal hypospermia, hematopoietic cell proliferation of the spleen, and hemosiderosis of the liver and spleen were observed in groups of male and female mice exposed to 10 mg/m^3 or greater.

2-YEAR STUDY IN RATS: Groups of 50 male and 50 female rats were exposed by inhalation to gallium arsenide particulate at concentrations of 0, 0.01, 0.1, or 1.0 mg/m^3, 6 hours per day, 5 days per week, for 105 weeks. Survival and Body Weights: Survival of exposed male and female rats was similar to the chamber controls. Mean body weights of males exposed to 1.0 mg/m^3 were generally less than those of the chamber controls throughout the study; females exposed to 1.0 mg/m^3 had slightly lower mean body weights during the second year. Pathology Findings: Compared to the chamber controls, the incidences of alveolar/bronchiolar neoplasms were significantly increased in females exposed to 1.0 mg/m^3 and exceeded the historical control ranges. Exposure-related nonneoplastic lesions in the lungs of male and female rats included atypical hyperplasia, alveolar epithelial hyperplasia, chronic active inflammation, proteinosis, and alveolar epithelial metaplasia. In the larynx of males exposed to 1.0 mg/m^3, the incidences of hyperplasia, chronic active inflammation, squamous metaplasia, and hyperplasia of the epiglottis were significantly increased. The incidences of benign pheochromocytoma of the adrenal medulla occurred with a positive trend in female rats, and the incidence was significantly increased in the 1.0 mg/m^3 group and exceeded the historical control range. The incidence of mononuclear cell leukemia was significantly increased in females exposed to 1.0 mg/m^3 and exceeded the historical control range.

2-YEAR STUDY IN MICE: Groups of 50 male and 50 female mice were exposed by inhalation to gallium arsenide particulate at concentrations of 0, 0.1, 0.5, or 1.0 mg/m^3, 6 hours per day, 5 days per week, for 105 (males) or 106 (females) weeks. Survival and Body Weights: Survival of male and female mice was similar to the chamber controls. Mean body weights of exposed groups of males were similar to those of the chamber controls throughout the study; mean body weights of exposed groups of females were greater than those of the chamber controls from week 13 until the end of the study. Pathology Findings: Exposure-related nonneoplastic lesions in the lung of all groups of exposed mice included suppurative focal inflammation, chronic focal inflammation, histiocyte cellular infiltration, alveolar epithelial hyperplasia, and proteinosis. Increased incidences of minimal lymphoid hyperplasia of the tracheobronchial lymph node occurred in mice exposed to 1.0 mg/m^3 and in 0.5 mg/m^{3}mg/m^3 males.

GENETIC TOXICOLOGY: Gallium arsenide was not mutagenic in several strains of Salmonella typhimurium, with or without S9 metabolic activation enzymes, and no increase in the frequency of micronucleated erythrocytes was observed in peripheral blood of male or female mice exposed to gallium arsenide by inhalation for 14 weeks.

CONCLUSIONS: Under the conditions of these 2-year inhalation studies, there was no evidence of carcinogenic activity of gallium arsenide in male F344/N rats exposed to 0.01, 0.1, or 1.0 mg/m^3. There was clear evidence of carcinogenic activity in female F344/N rats based on increased incidences of benign and malignant neoplasms in the lung. Increased incidences of benign neoplasms of the adrenal medulla and increased incidences of mononuclear cell leukemia were also considered to be exposure related. There was no evidence of carcinogenic activity in male or female B6C3F1 mice exposed to 0.1, 0.5, or 1.0 mg/m^3. Exposure to gallium arsenide caused a spectrum of nonneoplastic lesions in the lung of rats and mice, the larynx of male rats and hyperplasia of the tracheobronchial lymph node in mice.

Safety Data Sheet

Material: 3879817 **Hyper pure Silicon Wafers (polished, epitaxial and non polished)**

Version: 1.1 (INTL-GHS) Date of print: 06.02.2017 Date of last alteration: 11.10.2016

SECTION 1: Identification of the substance/mixture and of the company/undertaking

1.1 Product identifier

Commercial product name: **Hyper pure Silicon Wafers (polished, epitaxial and non polished)**

CAS No.: 7440-21-3

1.2 Relevant identified uses of the substance or mixture and uses advised against

Use of substance / preparation:
Industrial.
electronic

1.3 Details of the supplier of the safety data sheet

Manufacturer/distributor:	Siltronic AG	
Street/POB-No.:	Johannes-Hess-Straße 24	
State/postal code/city:	D 84489 Burghausen	
Telephone:	+49 8677 83-3930	
Telefax:	+49 8677 83-62171	
Information about the Safety Data Sheet:	Telephone	+49 8677 83-4888
	Telefax	+49 8677 886-9722
	eMail	WLCP-MSDS@wacker.com

1.4 Emergency telephone number

Emergency Information (German):	**Plant fire brigade**	**+49 8677 83-2222**
Emergency Information (internat.):	**National Response Center**	**+49 621 60-43333**

SECTION 2: Hazards identification

2.1 Classification of the substance or mixture

Not a hazardous substance or mixture.

2.2 Label elements

No labeling according to GHS required.

2.3 Other hazards

No data available.

SECTION 3: Composition/information on ingredients

3.1 Substances

3.1.1 Chemical characteristics

CAS No.: 7440-21-3

Silicon

3.1.2 Hazardous ingredients

This material does not contain any reportable hazardous ingredients.

3.2 Mixtures

not applicable

SECTION 4: First aid measures

4.1 Description of first aid measures

General information:
No special measures required.

After contact with the eyes:
Rinse immediately with plenty of water for 10-15 minutes and seek medical advice.

After contact with the skin:
No special measures required.

After inhalation:
In case of dust formation: Provide fresh air.

After swallowing:
No special measures required. In cases of sickness seek medical advice (show label if possible).

4.2 Most important symptoms and effects, both acute and delayed

Any relevant information can be found in other parts of this section.

4.3 Indication of any immediate medical attention and special treatment needed

Further toxicology information in section 11 must be observed.

SECTION 5: Firefighting measures

5.1 Extinguishing media

Suitable extinguishing media:
Use extinguishing measures appropriate to the source of fire.

Extinguishing media which must not be used for safety reasons:
not applicable

5.2 Special hazards arising from the substance or mixture

Hazardous combustion products: silicon dioxide .

5.3 Advice for firefighters

Special protective equipment for fire fighting:
Use respiratory protection independent of recirculated air.

SECTION 6: Accidental release measures

6.1 Personal precautions, protective equipment and emergency procedures

Wear personal protection equipment (see section 8).

6.2 Environmental precautions

No special measures required.

6.3 Methods and material for containment and cleaning up

Take up mechanically and dispose of according to local/state/federal regulations.

6.4 Reference to other sections

Relevant information in other sections has to be considered. This applies in particular for information given on personal protective equipment (section 8) and on disposal (section 13).

SECTION 7: Handling and storage

7.1 Precautions for safe handling

Precautions for safe handling:
Keep container closed when not in use. Keep away from incompatible substances in accordance with section 10.

Precautions against fire and explosion:
Observe the general rules for fire prevention. Product can separate hydrogen in contact with lyes.

7.2 Conditions for safe storage, including any incompatibilities

Conditions for storage rooms and vessels:
none known

Advice for storage of incompatible materials:
Keep away from alkalis. Avoid contact with acids.

Further information for storage:
Keep container tightly closed.

7.3 Specific end use(s)

No data available.

SECTION 8: Exposure controls/personal protection

8.1 Control parameters

Maximum airborne concentrations at the workplace:
not applicable

8.2 Exposure controls

8.2.1 Exposure in the work place limited and controlled

General protection and hygiene measures:
Observe standard industrial hygiene practices for the handling of chemical substances. Avoid contact with eyes and skin. Do not eat, drink or smoke when handling. Wash hands at the end of work and before eating.

Personal protection equipment:

Respiratory protection

In accordance with instructions: not required . In case of dust formation: fine dust mask without protection rating .

Eye protection

In case of mechanical handling: protective goggles .

Hand protection

Recommendation: Protective gloves, non-cuttable .

8.2.2 Exposure to the environment limited and controlled

-

SECTION 9: Physical and chemical properties

9.1 Information on basic physical and chemical properties

Property:	Value:	Method:
Appearance		
Physical state / form	solid - compact	
Colour	silver	

Odour
Odour .....: odourless
pH-Value
pH-Value .....: not applicable
Melting point/freezing point
Melting point / melting range .....: 1410 °C
Initial boiling point and boiling range
Boiling point / boiling range .....: 2355 °C
Flash point
Flash point.....: not applicable
Upper/lower flammability or explosive limits
Lower explosion limit (LEL) .....: not applicable
Upper explosion limit (UEL).....: not applicable
Vapour pressure
Vapour pressure.....: not applicable
Solubility(ies)
Water solubility / miscibility.....: virtually insoluble
Vapour density
Relative gas/vapour density .....: No data known.
Relative Density
Relative Density .....: approx. 2,32 (Water / 4 °C = 1,00)
Density .....: approx. 2,32 g/cm³
Partition coefficient: n-octanol/water
Partition coefficient: n-octanol/water.....: No data known.
Auto-ignition temperature
Ignition temperature .....: not applicable
Viscosity
Viscosity (dynamic) .....: not applicable
Viscosity (kinematic).....: not applicable

9.2 Other information

No data available.

SECTION 10: Stability and reactivity

10.1 – 10.3 Reactivity; Chemical stability; Possibility of hazardous reactions

If stored and handled in accordance with standard industrial practices no hazardous reactions are known.

Relevant information can possibly be found in other parts of this section.

10.4 Conditions to avoid

none known

10.5 Incompatible materials

Reacts with: lyes . Reaction causes the formation of: hydrogen . Reacts with: strong oxidizing agents , acids .

10.6 Hazardous decomposition products

If stored and handled properly: none known .

SECTION 11: Toxicological information

11.1 Information on toxicological effects

11.1.1 Acute toxicity

Assessment:

For this endpoint no toxicological test data is available for the whole product.

11.1.2 Skin corrosion/irritation

Assessment:

For this endpoint no toxicological test data is available for the whole product.

11.1.3 Serious eye damage / eye irritation

Assessment:

For this endpoint no toxicological test data is available for the whole product.

11.1.4 Respiratory or skin sensitization

Assessment:

For this endpoint no toxicological test data is available for the whole product.

11.1.5 Germ cell mutagenicity

Assessment:

For this endpoint no toxicological test data is available for the whole product.

11.1.6 Carcinogenicity

Assessment:

For this endpoint no toxicological test data is available for the whole product.

11.1.7 Reproductive toxicity

Assessment:

For this endpoint no toxicological test data is available for the whole product.

11.1.8 Specific target organ toxicity (single exposure)

Assessment:

For this endpoint no toxicological test data is available for the whole product.

11.1.9 Specific target organ toxicity (repeated exposure)

Assessment:

For this endpoint no toxicological test data is available for the whole product.

11.1.10 Aspiration hazard

Assessment:

Based on the physical-chemical properties of the product no aspiration hazard must be expected.

11.1.11 Further toxicological information

By handling the product for many years no damage to health was observed.

SECTION 12: Ecological information

12.1 Toxicity

Assessment:

No expected damaging effects to aquatic organisms. According to current knowledge adverse effects on water purification plants are not expected.

12.2 Persistence and degradability

Assessment:

Insoluble in water. Separation by sedimentation.

12.3 Bioaccumulative potential

Assessment:

No adverse effects expected.

12.4 Mobility in soil

Assessment:

Insoluble in water.

12.5 Other adverse effects

none known

SECTION 13: Disposal considerations

13.1 Waste treatment methods

13.1.1 Material

Recommendation:
Observe local/state/federal regulations.

13.1.2 Uncleaned packaging

Recommendation:
Completely discharge containers (no tear drops, no powder rest, scraped carefully). Containers may be recycled or re-used.
Observe local/state/federal regulations.

SECTION 14: Transport information

14.1 – 14.4 UN number; UN proper shipping name; Transport hazard class(es); Packing group

Road ADR:
Valuation .....: Not regulated for transport

Railway RID:
Valuation .....: Not regulated for transport

Transport by sea IMDG-Code:
Valuation .....: Not regulated for transport

Air transport ICAO-TI/IATA-DGR:
Valuation .....: Not regulated for transport

14.5 Environmental hazards

Hazardous to the environment: no

14.6 Special precautions for user

Relevant information in other sections has to be considered.

14.7 Transport in bulk according to Annex II of MARPOL and the IBC Code

Bulk transport in tankers is not intended.

SECTION 15: Regulatory information

15.1 Safety, health and environmental regulations/legislation specific for the substance or mixture

National and local regulations must be observed.

For information on labelling please refer to section 2 of this document.

15.2 Details of international registration status

Relevant information about individual substance inventories, where available, is given below.

South Korea (Republic of Korea) :	**ECL** (Existing Chemicals List): This product is listed in, or complies with, the substance inventory.
Japan :	**ENCS** (Handbook of Existing and New Chemical Substances): This product is listed in, or complies with, the substance inventory.
Australia :	**AICS** (Australian Inventory of Chemical Substances): This product is listed in, or complies with, the substance inventory.
People's Republic of China :	**IECSC** (Inventory of Existing Chemical Substances in China): This product is listed in, or complies with, the substance inventory.
Canada :	**DSL** (Domestic Substance List): This product is listed in, or complies with, the substance inventory.
Philippines :	**PICCS** (Philippine Inventory of Chemicals and Chemical Substances): This product is listed in, or complies with, the substance inventory.
United States of America (USA) :	**TSCA** (Toxic Substance Control Act Chemical Substance Inventory): This product is listed in, or complies with, the substance inventory.
European Economic Area (EEA) :	**REACH** (Regulation (EC) No 1907/2006): General note: the registration obligations for substances imported into the EEA or manufactured within the EEA by the supplier mentioned in section 1 are fulfilled by the said supplier. The registration obligations for substances imported into the EEA by customers or other downstream users must be fulfilled by the latter.

SECTION 16: Other information

16.1 Material

The details in this document are based on the state of our knowledge at the time of revision. They do not constitute an assurance of the described product properties in terms of statutory warranty requirements.

The providing of this document to a recipient does not relieve the recipient of his or her responsibility toward compliance with all laws and stipulations applicable to the product. This applies in particular to the further sale or distribution of the product or substances or items containing the product, in other jurisdictions and with regard to the protection of third-party intellectual property rights. If the described product is processed or mixed with other substances or materials, the details stated in this document cannot be conferred to the resultant new product unless this has been expressly mentioned. If the product is repackaged, the recipient is obligated to additionally provide the required safety-related information.

16.2 Further information:

Commas appearing in numerical data denote a decimal point. Vertical lines in the left-hand margin indicate changes compared with the previous version. This version supersedes all previous versions.

- End of Safety Data Sheet -

Lamp Material Information Sheet

UAI-LMIS- 002 Rev. B USH-SUV-UXM

June, 2013

Material Safety Data Sheets (MSDS)

Information and Applicability

The Material Safety Data Sheet (MSDS) requirements of the Occupational Safety and Health Administration (OSHA) for regulated chemicals, under , 29 CFR 1910.1200 (C) are ***not applicable*** to manufactured articles. Ushio Mercury lamps are classified as articles, therefore exempt from this regulation.

No material contained in a lamp is released during normal use and operation.

The following information is provided as a service to our customers. The following Lamp Material information Sheet contains applicable Material Data Sheet Information.

Section 1. Manufacturer and Product Identification

Product: **Ushio High Pressure Mercury Lamps**

Applicable Lamp Types: **USH, SUV, UXM**

USHIO America, Inc.

5440 Cerritos Ave.

Cypress, CA 90630

714-236-8600

24 Hr Emergency Phone number: 800-262-8200 CHEMTREC and 703-741-5500

Section 2. Lamp Materials and Hazardous Ingredients

Glass

The lamp's main body consists of quartz glass. The quartz lamp contains a small amount of Mercury. The lamp also contains a small amount of inert gas. Argon or Xenon is used as a fill gas. The lamp also contains a small amount of other materials, used as an emission mix on the electrodes, but there would be no significant exposure from lamp breakage.

Metals

Electrodes are made of Tungsten and Leads fused in the quartz glass are of Nickel, Molybdenum, or Stainless Steel. Many of the lamps use nickel – plated brass terminations.

Section 3. Health Concerns/Hazard Identification

Ultraviolet (UV) Radiation

These lamps can emit ultraviolet radiation that may be harmful to eyes and skin. These discharge lamps are not open fixture rated and should only be used in enclosed fixtures with ultraviolet absorbing filter glass. Do not operate these lamps if the ultraviolet absorbing filter glass is broken or not installed. For additional information on protection from UV radiation, visit the FDA website for more information: http://www.fda.gov/cdrh/radhealth/products/uburns.html

Mercury Exposure

A MSDS declaration for Mercury can be downloaded from http://www.virginmercury.com/pdf/MSDS.pdf.

Emergency Overview: Warning for Lamps during operation

These lamps operate under very high pressure conditions and at high temperature and may unexpectedly shatter

- These lamps generate ultraviolet (UV) radiation which may cause skin irritation and serious eye damage with prolonged exposure. Do not expose bare skin directly or indirectly to the lamp emission (otherwise it could cause skin irritation).
- Do not look directly or indirectly at the light from the lamp without adequate eye protection (otherwise it could cause eye pain or damage to vision).
- Do not bump, apply excessive stress or scratch the lamp as the lamp is a glass product filled with high pressure gas (otherwise it could cause an injury from lamp breakage).
- Do not open the lamp housing during lamp operation or until the lamp properly cooled down after the lamp is turned off. The internal pressure of the lamp is especially high when in operation and immediately after is it turned off (otherwise it could cause an injury from lamp breakage).
- Do not touch the lamp during lamp operation or until the lamp properly cooled down after the lamp is turned off (otherwise it could cause a burn).
- Do not operate the lamp in close proximity to paper, cloth or any other combustible material near the lamp, nor cover the lamp with such materials during lamp operation or until the lamp properly cooled down after the lamp is turned off (otherwise it could cause a fire).
- Turn off the power supply to the lamp when installing or removing the lamp to or from equipment (otherwise it could cause an electric shock).
- In the event of a bulb rupture, a limited amount of mercury vapor could be emitted into the room. To avoid inhaling this mercury vapor (which is toxic and can be harmful to the lungs and nervous system) the room of use should be thoroughly ventilated for some period (30 minutes - Time is depending on room size, room conditions and ventilation).

Emergency Overview: Lamp Materials

There are no known health hazards from exposure to lamps that are intact and which are used within an enclosed fixture. No adverse effects are expected from occasional exposure to broken lamps. As a matter of good practice, avoid prolonged or frequent exposure to broken lamps unless there is adequate ventilation. The major hazard from broken lamps is the possibility of sustaining glass cuts.

NIOSH/OSHA Occupational Health Guidelines for Chemical Hazards **and/or** ***NIOSH Pocket Guide to Chemical Hazards*** lists the following effects of overexposure to the chemicals/materials tabulated below when they are inhaled, ingested or contacted with skin or eyes.

Mercury - Exposure to high concentrations of vapors for brief periods can cause acute symptoms such as pneumonitis, chest pains, and shortness of breath, coughing, gingivitis, salivation and possibly stomatitis. May cause redness and irritation as a result of contact with skin and/or eyes.

Quartz, Fused - Fibrosis of the lungs causing shortness of breath and coughing has been associated with silica exposure.

Tungsten - Inhalation of dust may cause mild irritation of nose and throat. Contact may cause mechanical irritation of skin and eyes.

Molybdenum - *Oxides* have caused irritation to the eyes, nose, and throat; weight loss and digestive disturbances in experimental animals.

Section 4. First-Aid Measures

Measures listed below refer to the situation where a person came in contact with one of those substances mentioned in the former paragraph (being Mercury, Tungsten, (Fused) Quartz, Nickel and Molybdenum) and developed symptoms of discomfort, irritation or pain.

Glass Cuts*:* Perform normal first aid procedures. Seek medical attention as required.

Inhalation: If discomfort, irritation or symptoms of pulmonary involvement develop, remove from exposure and seek medical attention.

Ingestion**:** Seek medical attention.

Contact, Skin*:* Thoroughly wash affected area with mild soap or detergent and water and prevent further contact. Seek medical attention if irritation occurs.

Contact, Eye*:* Wash eyes immediately with water for 15 minutes. Seek medical attention.

Section 5. Fire and explosion data

Warning: Unexpected lamp rupture may cause injury, fire, or property damage. Do not use lamp beyond rated life and adhere to all applicable caution and warranty notices. To further reduce the possibility of rupture, turn lamps off at least 15 minutes per week.

An arc tube rupture can burst and shatter the glass resulting in the discharge of glass fragments and extremely hot quartz particles (± 1000°C). There is risk of personal injury, property damage, burns, and fire.
Further guidance on the application and use of Quartz Metal Halide lamps, see attached NEMA document LSD 25, ***Best Practices for Metal Halide Lighting System, plus Questions and Answers about lamp Ruptures in Metal halide Lighting System.***

Section 6. Accidental release measures

Ventilation in view of concentrations of mercury vapor:
Use adequate general and local exhaust ventilation to maintain exposure levels below the PEL or
TLV limits. If such ventilation is unavailable, use respirators.
If lamps are broken, ventilate area (if necessary) where breakage occurred, Clean-up with Mercury vacuum cleaner or other suitable means that avoids dust and mercury vapor generation. Take usual precautions for collection of broken glass. Place materials in closed containers to avoid generating dust and mercury vapor.
See also additional Handling Information – Section 9: Broken Lamps

Section 7. Handling – Precautions for safety and use

Lamp installation / replacement
Handling

- Only use the lamp in the equipment for which it is approved and only after reading and understanding the operating manual for such equipment. Do not make any other use of the lamp (otherwise it could cause lamp breakage or damage to the equipment).
- Do not touch quartz envelope with bare hands. If quartz envelope is dirty, wipe with alcohol-soaked clean cloth (otherwise it could cause lamp breakage or shorten lamp life).
- Do not subject the lamp to vibration or shock (otherwise it could cause lamp breakage or shorten lamp life).
- Do not throw away the original packaging and the protective cover if attached, as they will be needed in transporting or disposing of the lamp.
- Store the lamp in its original protective packaging and the protective cover.

Installation and Removal

- Before installing the lamp in equipment, make sure that there is no rust, burning or discoloration where electrical connections are made between the lamp and the equipment.
- Install the lamp in the correct polarity (otherwise it could cause lamp breakage or shorten lamp life).

- Install the lamp properly in the equipment, without twisting, bending or otherwise applying excessive stress to the lamp (otherwise it could cause lamp breakage, failure of the lamp to remain in place or shorten lamp life).
- Properly attach the lamp lead wire to the terminal, and without applying excessive stress to the lamp (otherwise it could cause overheating or smoke).
- Remove the protective cover immediately prior to installation.
- Use proper care in installing or removing the lamp (otherwise it could cause lamp breakage or damage to the equipment).

Use

- Do not use where volatiles are present (otherwise it could cause fire or explosion).
- When a lamp has been used for longer than its rated life it must be replaced. The risk of lamp breakage increases the longer the lamp is used beyond its rated life in the application.

Section 8. Disposal Considerations

TCLP (Toxicology Characteristic Leaching Procedure)
Disposal of these lamps is regulated in many states. Many businesses in the United States manage these lamps as Universal Waste.

Some states require all mercury containing lamps to be recycled, contact your state environmental department for any regulation that may apply. To check state regulations or to locate a recycler, go to:
http://www.lamprecycle.org/

Waste Disposal Method.
At the end of rated life, when lamp is removed from service, please dispose of in accordance with local Universal Waste law (Lamps are stamped with Hg mark).
Ushio America Inc. encourages recycling of its products by qualified recyclers.

Section 9. Special handling information- Broken Lamps

Lamp Breakage

- In the event the lamp ruptures during operation, leave the area and ventilate the area for 30 minutes. There is a possibility of inhaling mercury fumes (inhaling mercury fumes could be harmful to health).
- After the lamp and lamp housing have cooled down, remove any remaining mercury with packing tape, a thin paper or a syringe.
- Place any collected mercury and the materials used for collecting mercury in an airtight non metallic container.

Ventilation: Use adequate general and local exhaust ventilation to maintain exposure levels below the PEL or TLV limits. If such ventilation is unavailable, use respirators.

Eye Protection: OSHA specified safety glasses, goggles or face shield are recommended if lamps are being broken.

Protective Clothing: Protective gloves are recommended for dealing with broken lamps.

Hygienic Practices: After handling broken lamps, wash thoroughly before eating, smoking or handling tobacco products, applying cosmetics or using toilet facilities.

Section 10. Regulatory information

Air transportation mode, applicable International regulation: ICAO (IATA) - 2.7 DOT No. UN3506. CFR 173.4 Also DOT 49CFR Ch.1, §173.164

These mercury containing lamps being shipped in the manufacturer's original packaging are not regulated by law using truck or during ocean shipment. As a waste, spent lamps would be regulated in several states within the US as well as in other regions within the world. This Lamp Material Information Sheet does not constitute "knowledge of the waste", in certain jurisdictions.

Section 11. Other Information and Legal Disclaimer

--Information in this document is subject to change without notice—

Although Ushio America Inc. believes the information contained in this Lamp Material Information Sheet (LMIS) to be reliable, no guarantee is made as to its accuracy or completeness, and assumes no liability for any loss, damage or injury of any kind which may result from, or arise out of, the use of/or reliance on the information by any person.

The conditions of use, handling, storage, and disposal, and the suitability of the product are assumed by the user. We expressly disclaim all warranties of any kind and nature, expressed or implied, including the warranties of merchantability and fitness for a particular purpose.

Date of Issue: June, 2013

Version: B.

Prepared by: Ushio America Inc.

WARNING:
In accordance with ANSI/IESNA Standard RP-27, this HBO bulb is a Risk Group 3 product.
Read and understand this warning before using this bulb!

RUPTURE & RADIATION (UV- VISIBLE) HAZARD:

1. The discharge vessel of HBO lamps is constructed of quartz glass that is filled with a quantity of mercury and either Argon or Xenon gas. Most HBO lamps are not at positive pressure when cold (not operating, at room temperature). However, there are several HBO lamps that DO have a positive internal pressure of up to approximately 8 bar (or approximately 120 psi) in the cold (room temperature) state. The printing of the following bold warning statement on individual packages identifies them as positive-pressure lamps.

   WARNING
   RISK OF LAMP RUPTURING. TO AVOID PERSONAL INJURY OR PROPERTY DAMAGE, ALWAYS WEAR PROTECTIVE CLOTHING WHEN HANDLING THESE LAMPS. Never handle these lamps unless government-approved (OSHA-approved in the U.S.A.) safety glasses, facemask (with neck protector), chest protector, and gauntlets are worn.

   These positive-pressure lamps may unexpectedly rupture resulting in the discharge of quartz and/or metal fragments as well as exposing the surrounding area to mercury. In the event of such a rupture, there is a risk of personal injury or property damage. Therefore these positive-pressure lamps should be handled in accordance with these safety instructions.
2. All HBO lamps have high internal pressures (400 – 1100 psi or 30 to 75 bar) during operation and may unexpectedly rupture resulting in the discharge of hot fragments (approximately 800°C / 1472°F) of quartz and/or metal particles, as well as the release of mercury/mercury vapor. In the event of such a rupture, there is a risk of personal injury, burns, and fire.
3. All HBO lamps generate intense ultraviolet (UV) and visible radiation during operation. This radiation can cause permanent damage to the eyes (including blindness) and serious injury to the skin (including burns and blistering). To avoid eye damage, other personal injury, and/or property damage, the lamp MUST be operated in a suitable fixture.
4. A suitable fixture is one that will prevent the arc from being viewed directly while operating, and in the event of a lamp rupture, will prevent hot (up to 800°C / 1472°F), flying fragments of quartz and/or metal from escaping into the area.
5. Fixtures for lamps that produce ozone during operation should be ventilated and filtered to the outside for ozone removal.
6. To minimize the risk of a lamp rupture, replace the lamp at or before the end of rated life (see OSRAM SYLVANIA product catalog for rated life) or when the lamp shows signs of blackening.

BROKEN LAMPS (MERCURY VAPOR RELEASE AND DISPOSAL):

1. In the event of a lamp rupturing during operation, all personnel should leave the area immediately to avoid the inhalation of mercury vapor. The area should then be thoroughly ventilated for a minimum of 30 minutes or until the mercury vapor in the area is below the ACGIH TLV (American Conference of Governmental Industrial Hygienists Threshold Limit Value). Inhaling vapor or small particles of mercury or its compounds can be harmful to lungs, kidneys, and nervous system. Penetration of the skin or ingestion can also be harmful.
2. To avoid mercury vapor getting into air conditioning systems, instruments/equipment using lamps of 350 watts or greater should be connected to separate air exhaust systems through mercury vapor-absorbing filters. When the lamp housing has cooled, ***mercury residue may be picked up with special mercury adsorptive agents or a mercury vacuum cleaner (available from laboratory safety equipment suppliers) and disposed of in accordance with local, state, and federal regulations***. There should be no direct skin contact with and/or inhalation of mercury residues that may be residing in lamp housing, optics or lamp parts.

   If a cold (room temperature) lamp is broken, proceed with clean-up and disposal as indicated above (in the ***bold, italicized statement***).

GENERAL SAFETY & INSTALLATION TIPS

INSTALLATION:

1. Do not use if lamp is scratched, cracked, or damaged in any way.
2. To prevent electric shock, shut off main power to the fixture before attempting to service or replace lamp.
3. To avoid damaging the quartz and causing premature lamp failure, do not handle lamp with bare hands.
4. Only handle lamp with suitable, clean safety gloves. See special, bolded warning for using government-approved safety equipment when handling positive-pressure lamps.
5. If the quartz parts are inadvertently touched, clean fingerprints off with denatured alcohol and wipe dry with a soft, clean, lint-free cloth. Do not use cleaning rags or material that can leave a residue.
6. To prevent skin burns, allow lamp to cool before handling.
7. To avoid breakage, mounting of the lamp must be free of mechanical stress during installation and during operation by allowing for thermal expansion along its axis. For this reason, HBO lamps should be fixed at one end only and the electrical connection on the other end must be flexible enough to avoid stressing the lamp.
8. HBO lamps should not be subjected to force/stress during installation.
9. Replace all fixture covers and shields after replacing lamp to prevent eye damage, other personal injury, or property damage.
10. Use only in instruments/equipment specifying this light source.
11. Make sure lamp is properly installed into socket/connector to obtain good electrical and thermal contact and avoid damaging lamp and/or socket/connector. Electrical connections should be free from dirt and corrosion.
12. Socket/connector condition may affect lamp life. Replace socket/connector or lamp if deterioration (pitting, scorching, corrosion, etc.) of either is observed.

OPERATION:

1. Some HBO lamps are designed for operation on only AC or only DC while some are designed for operation on either AC or DC.
2. Note: all HBO lamps with power consumption of 350 W and higher are only suited for DC operation. Make sure that the polarity is correct before turning power on. Incorrect polarity can destroy the lamp in a matter of seconds.
3. Operate with compatible power supply and fixture only.
4. To ensure that AC-suited lamps operate at correct power during AC operation, connections on the ballast/choke in the power supply should be made to the voltage taps that are marked the same as the marking on the lamp base (L1 or L2). Some power supplies are equipped with a switch (or taps) for selecting L1 or L2. For correct and safe lamp operation, use only those ballasts/power supplies that have been approved or meet minimum requirements as specified by OSRAM. See your OSRAM dealer for list of approved equipment.
5. HBO lamps need 5 to 20 minutes (depending on lamp type and cooling conditions) before they reach their operating temperatures. To ensure proper ignition on subsequent start-up, lamps should not be switched off during the warm-up period.
6. The average service life of high wattage HBO lamps ($\geq$350 watts) is determined by their ON/OFF duty cycle. These lamps have been designed for a limited amount of ignitions only (less than 10). Lamp performance is reduced with increased duty cycle.

OPERATING POSITION:

HBO lamps may only be operated in the operating positions described in the OSRAM SYLVANIA product catalog.

Some HBO lamps are designed to operate horizontally (mainly low wattage types in the power range of 50 to 200 W) and others, vertically (all lamp types with power consumption of 350 W and higher). Greater arc stability is obtained in vertically operating lamps when they are operated as close to vertical as possible. See catalog for permissible operating positions and electrode positions.

OZONE GENERATION:

During operation, HBO lamps produce a spectrum that ranges from about 150 nm in the ultraviolet region to the infrared region.

If the quartz glass bulb is transparent in the ultraviolet region between 180 and 220 nm, this short-wave radiation will convert a small quantity of atmospheric oxygen (O_2) surrounding the lamp into ozone (O_3). Moreover, the oxygen molecules will link together with the nitrogen (N_2) in the air, creating nitrogen oxides (NO_x). (Some believe that the smell attributed to ozone is in actuality from the nitrogen oxides.)

Ozone gas is toxic when inhaled in high concentrations over long periods of time. Ozone levels can be measured and monitored with commercial measuring equipment. Always keep ozone levels below the applicable TLV (threshold limit value).

The production of ozone and nitrogen oxide can be suppressed by using doped quartz glass, which absorbs the ozone-producing ultraviolet radiation. The quartz glass used in high wattage i-line (365nm) enhanced HBO lamps only transmits wavelengths above 250 nm, which provides effective, ozone-free lamps. Please be advised that the OSRAM HBO 4000 W/PL lamp is designed to generate UV wavelengths below 250nm.

Consequently, this lamp will generate ozone in operation and should be externally ventilated.

An "ozone smell" (or smell of nitrogen oxide) may be detected shortly after ignition. There are two probable causes for this condition. O_3 and NO_x production is caused by the (short-duration) radiation of the spark gap used for lamp ignition. Or, the cold condition of the quartz glass bulb has slightly shifted its UV-absorption characteristics thus permitting a small amount of radiation in the very short-wave ultraviolet range to be emitted by the bulb. Typically, after the lamp has run up to its operating temperature range, virtually no ozone is produced by the lamp, as a rule, due to the quartz glass absorption and the self-absorption of the plasma.

LAMP COOLING:

1. To prevent premature failure, lamp base temperatures must be kept below 230ºC (446ºF) for 50 to 350 watt lamps and below 200ºC (392ºF) for all lamps with power consumption of more than 350 watts.
2. Discoloration, surface pitting, and/or corrosion of the lamp connections indicates a thermal overload. Components exhibiting these conditions must be cleaned or replaced.
3. If convection cooling is insufficient and additional cooling is required, cooling fins may be applied to the bases and/or forced air may be used.
4. If forced air is used, care must be taken to direct airflow at the bases only. Striking elsewhere on the lamp with the airflow will result in poor lamp performance or premature failure.

LAMP REMOVAL:

Turn off power to the lamp and allow lamp to cool (forced or convection) for a minimum of 30 minutes prior to shutting main fixture power and opening fixture. Do not remove lamp until it has cooled. See special, bolded warning for using government-approved safety equipment when handling positive-pressure lamps.

Lamps should be placed in their original OSRAM SYLVANIA packaging for temporary storage until disposal and/or transportation to a disposal location. See “Lamp Transportation” and “Lamp Disposal” sections below for relevant information.

LAMP TRANSPORTATION

1. All HBO lamps should be transported ONLY in their original packaging.
2. Transportation in non-original packaging can damage the lamp and void warranty.
3. U.S. Federal regulations require mercury-containing lamps to be shipped ONLY in DOT-compliant packaging. Original OSRAM packaging is DOT-compliant.
4. When transporting positive-pressure lamps, the bolded warning found in the “Rupture & Radiation Hazard” section MUST be placed on outside surface of the shipping carton and the warning instructions must also be placed inside the shipping packaging:

MERCURY FILL OF HBO LAMPS:

Mercury is referred to by its chemical symbol, Hg, which is derived from the Greek and Latin “hydrargyrum,” a silvery shiny liquid metal at room temperature. In humid air it is covered with a gray oxide skin. Of all metals it has the highest vapor pressure which increases exponentially with rising temperatures. For this reason, mercury is volatile at room temperature. The colorless and odorless vapors produced are poisonous and heavier than air.

The inhalation (respiration) of mercury or mercury compounds as vapor or dust will lead to the damage of lungs, kidneys, and the nervous system. Apart from inhalation, mercury can be transmitted through the skin (penetration) or through the gastro-intestinal tract (ingestion), which is also harmful.

The ACGIH threshold limit values (TLVs) are merely guidelines to assist in the control of health hazards. The ACGIH says that the TLVs refer to airborne concentrations of substances and represent conditions under which it is believed that nearly all workers may be repeatedly exposed day after day without adverse health effects. Therefore, the TLV for mercury should never be exceeded.

Analytical detection of mercury vapor is possible by means of gas/vapor detector tubes (rough measurement) or air-monitors that absorb mercury vapor.

OSRAM HBO® lamps have the following mercury contents:

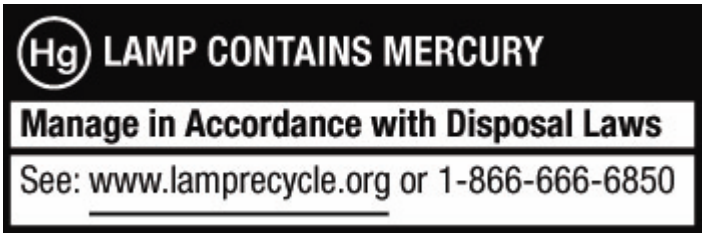
Power level	**Maximum Mercury content (mg)**
50 – 200 W	110
350 W	300
500 W	500
1,000 W	1000
1,500 W	800
2,000 – 2,500 W	5,000
3,500 W and higher	12,000

PROPERTIES OF MERCURY:

- Chemical symbol: Hg
- Atomic number: 80
- Molecular Weight: 200.59
- Density: 13.6 g/cm^3 @ 20°C / 68°F
- Melting Point: -39°C / -38.2°F
- Boiling Point: 357°C / 674°F
- Vapor pressure: 160 Pa @ 20ºC / 68ºF
  370 Pa @ 30ºC / 86ºF
  823 Pa @ 40ºC / 104ºF
- Concentration in air: 13.6 mg/m^3 @ 20ºC / 68ºF
  29.6 mg/m^3 @ 30ºC / 86ºF
  62.7 mg/m^3 @ 40ºC / 104ºF
- CAS Registry Number: 7439-97-6
- RCRA waste number: U151
- Other Names: Hydrargyrum, Colloidal mercury, Kwik, Mercure, Mercurio, Metallic mercury, Quecksilber, Quick silver, Liquid Silver

LAMP DISPOSAL:

1. Disposal of spent lamps must be in accordance with applicable federal, state/provincial, and local regulations. State laws differ in their disposal requirements for lamps containing mercury.
2. Lamp users in North America may obtain specific state or province information concerning disposal regulations, toll-free, by calling 1-866-666-6850.



3. OSRAM SYLVANIA Products Inc. cannot advise lamp users as to general or specific disposal regulations for federal, state/provincial, and/or local municipalities.

Special disposal note for cold, positive-pressure lamps (see "RUPTURE & RADIATION HAZARD" section for applicable lamps)

There is a risk that these lamps could rupture because of their high internal pressure when hot (during operation) and when cold (at room temperature when not operating). A lamp rupture could result in personal injury or property damage from flying fragments of quartz and/or metal. Therefore, spent (end-of-life) lamps should ALWAYS be stored in the packaging in which they originally came.

Fisher Scientific

Part of Thermo Fisher Scientific

SAFETY DATA SHEET

Creation Date 20-Aug-2014 **Revision Date** 20-Aug-2014 **Revision Number** 1

1. Identification

Product Name **Mercury (Laboratory)**

Cat No. : **M140-1LB; M140-5LB; M140-14LB**

Synonyms Colloidal mercury; Hydrargyrum; Metallic mercury

Recommended Use Laboratory chemicals.

Uses advised against No Information available

Details of the supplier of the safety data sheet

Company
Fisher Scientific
One Reagent Lane
Fair Lawn, NJ 07410
Tel: (201) 796-7100

Emergency Telephone Number
CHEMTREC®, Inside the USA: 800-424-9300
CHEMTREC®, Outside the USA: 001-703-527-3887

2. Hazard(s) identification

Classification

This chemical is considered hazardous by the 2012 OSHA Hazard Communication Standard (29 CFR 1910.1200)

Corrosive to metals	Category 1
Acute Inhalation Toxicity - Vapors	Category 2
Reproductive Toxicity	Category 1B
Specific target organ toxicity - (repeated exposure)	Category 1
Target Organs - Central nervous system (CNS), Kidney.	

Label Elements

Signal Word
Danger

Hazard Statements
May be corrosive to metals
Fatal if inhaled
May damage the unborn child
Causes damage to organs through prolonged or repeated exposure



Precautionary Statements
Prevention
Obtain special instructions before use
Do not handle until all safety precautions have been read and understood
Use personal protective equipment as required
Do not get in eyes, on skin, or on clothing
Wash face, hands and any exposed skin thoroughly after handling
Do not eat, drink or smoke when using this product
Do not breathe dust/fume/gas/mist/vapors/spray
Use only outdoors or in a well-ventilated area
Wear respiratory protection
Response
IF exposed or concerned: Get medical attention/advice
Inhalation
IF INHALED: Remove victim to fresh air and keep at rest in a position comfortable for breathing
Immediately call a POISON CENTER or doctor/physician
Skin
Immediately call a POISON CENTER or doctor/physician
IF ON SKIN: Gently wash with plenty of soap and water
Remove/Take off immediately all contaminated clothing
Wash contaminated clothing before reuse
Storage
Store locked up
Store in a well-ventilated place. Keep container tightly closed
Disposal
Dispose of contents/container to an approved waste disposal plant
Hazards not otherwise classified (HNOC)
Very toxic to aquatic life with long lasting effects
Other hazards
WARNING! This product contains a chemical known in the State of California to cause birth defects or other reproductive harm.

3. Composition / information on ingredients

Component	CAS-No	Weight %
Mercury	7439-97-6	100

4. First-aid measures

Eye Contact Rinse immediately with plenty of water, also under the eyelids, for at least 15 minutes. Immediate medical attention is required.

Skin Contact Wash off immediately with soap and plenty of water while removing all contaminated clothes and shoes. Immediate medical attention is required.

Inhalation Move to fresh air. If breathing is difficult, give oxygen. Do not use mouth-to-mouth resuscitation if victim ingested or inhaled the substance; induce artificial respiration with a respiratory medical device. Immediate medical attention is required.

Ingestion Do not induce vomiting. Call a physician or Poison Control Center immediately.

Most important symptoms/effects No information available.
Notes to Physician Treat symptomatically

5. Fire-fighting measures

Suitable Extinguishing Media Substance is nonflammable; use agent most appropriate to extinguish surrounding fire.

Unsuitable Extinguishing Media No information available

Flash Point No information available
Method - No information available

Autoignition Temperature No information available
Explosion Limits
Upper No data available
Lower No data available
Sensitivity to Mechanical Impact No information available
Sensitivity to Static Discharge No information available

Specific Hazards Arising from the Chemical
Very toxic. Non-combustible, substance itself does not burn but may decompose upon heating to produce corrosive and/or toxic fumes. Keep product and empty container away from heat and sources of ignition.

Hazardous Combustion Products
Mercury oxide Highly toxic fumes
Protective Equipment and Precautions for Firefighters
As in any fire, wear self-contained breathing apparatus pressure-demand, MSHA/NIOSH (approved or equivalent) and full protective gear.

NFPA

Health	Flammability	Instability	Physical hazards
4	0	0	N/A

6. Accidental release measures

Personal Precautions Wear self-contained breathing apparatus and protective suit. Evacuate personnel to safe areas. Ensure adequate ventilation. Do not get in eyes, on skin, or on clothing.

Environmental Precautions Should not be released into the environment. See Section 12 for additional ecological information.

Methods for Containment and Clean Up Wear self-contained breathing apparatus and protective suit. Soak up with inert absorbent material. Keep in suitable, closed containers for disposal.

7. Handling and storage

Handling Use only under a chemical fume hood. Wear personal protective equipment. Do not get in eyes, on skin, or on clothing. Do not breathe vapors or spray mist. Do not ingest.

Storage Keep containers tightly closed in a dry, cool and well-ventilated place. Corrosives area.

8. Exposure controls / personal protection

Exposure Guidelines

Component	ACGIH TLV	OSHA PEL	NIOSH IDLH
Mercury	TWA: 0.025 mg/m³ Skin	(Vacated) TWA: 0.05 mg/m³ Ceiling: 0.1 mg/m³ (Vacated) STEL: 0.03 mg/m³ Skin (Vacated) Ceiling: 0.1 mg/m³	IDLH: 10 mg/m³ TWA: 0.05 mg/m³ Ceiling: 0.1 mg/m³

Component	Quebec	Mexico OEL (TWA)	Ontario TWAEV
Mercury	TWA: 0.025 mg/m³ Skin	TWA: 0.05 mg/m³	TWA: 0.025 mg/m³ Skin

Legend

ACGIH - American Conference of Governmental Industrial Hygienists
OSHA - Occupational Safety and Health Administration
NIOSH IDLH: The National Institute for Occupational Safety and Health Immediately Dangerous to Life or Health

Engineering Measures	Use only under a chemical fume hood. Ensure adequate ventilation, especially in confined areas. Ensure that eyewash stations and safety showers are close to the workstation location.

Personal Protective Equipment

Eye/face Protection	Wear appropriate protective eyeglasses or chemical safety goggles as described by OSHA's eye and face protection regulations in 29 CFR 1910.133 or European Standard EN166.
Skin and body protection	Wear appropriate protective gloves and clothing to prevent skin exposure.
Respiratory Protection	Follow the OSHA respirator regulations found in 29 CFR 1910.134 or European Standard EN 149. Use a NIOSH/MSHA or European Standard EN 149 approved respirator if exposure limits are exceeded or if irritation or other symptoms are experienced.
Hygiene Measures	Handle in accordance with good industrial hygiene and safety practice.

9. Physical and chemical properties

Physical State	Liquid
Appearance	Silver
Odor	Odorless
Odor Threshold	No information available
pH	No information available
Melting Point/Range	-38.87 °C / -38 °F
Boiling Point/Range	356.72 °C / 674.1 °F
Flash Point	No information available
Evaporation Rate	No information available
Flammability (solid,gas)	No information available
Flammability or explosive limits	
Upper	No data available
Lower	No data available
Vapor Pressure	0.002 mmHg @ 25 °C
Vapor Density	7.0
Relative Density	13.59 (H2O=1)
Solubility	Insoluble in water
Partition coefficient; n-octanol/water	No data available
Autoignition Temperature	No information available
Decomposition temperature	No information available
Viscosity	No information available
Molecular Formula	Hg
Molecular Weight	200.59

10. Stability and reactivity

Reactive Hazard	None known, based on information available
Stability	Stable under normal conditions.
Conditions to Avoid	Incompatible products. Excess heat.
Incompatible Materials	Strong oxidizing agents, Ammonia, Metals, Halogens
Hazardous Decomposition Products	Mercury oxide, Highly toxic fumes
Hazardous Polymerization	Hazardous polymerization does not occur.
Hazardous Reactions	None under normal processing.

11. Toxicological information

Acute Toxicity

Product Information	No acute toxicity information is available for this product
Component Information	
Toxicologically Synergistic Products	No information available

Delayed and immediate effects as well as chronic effects from short and long-term exposure

Irritation No information available

Sensitization No information available

Carcinogenicity The table below indicates whether each agency has listed any ingredient as a carcinogen.

Component	CAS-No	IARC	NTP	ACGIH	OSHA	Mexico
Mercury	7439-97-6	Not listed	Not listed	Not listed	Not listed	Not listed

Mutagenic Effects No information available

Reproductive Effects No information available.

Developmental Effects May cause harm to the unborn child.

Teratogenicity No information available.

STOT - single exposure None known
STOT - repeated exposure Central nervous system (CNS) Kidney

Aspiration hazard No information available

Symptoms / effects,both acute and delayed No information available

Endocrine Disruptor Information No information available

Other Adverse Effects The toxicological properties have not been fully investigated.

12. Ecological information

Ecotoxicity
This product contains the following substance(s) which are hazardous for the environment.

Component	Freshwater Algae	Freshwater Fish	Microtox	Water Flea
Mercury	Not listed	0.9 mg/L LC50 96 h 0.18 mg/L LC50 96 h 0.16 mg/L LC50 96 h 0.5 mg/L LC50 96 h	Not listed	5.0 µg/L EC50 = 96 h

Persistence and Degradability No information available

Bioaccumulation/ Accumulation No information available.

Mobility No information available.

13. Disposal considerations

Waste Disposal Methods Chemical waste generators must determine whether a discarded chemical is classified as a hazardous waste. Chemical waste generators must also consult local, regional, and national hazardous waste regulations to ensure complete and accurate classification.

Component	RCRA - U Series Wastes	RCRA - P Series Wastes
Mercury - 7439-97-6	U151	-

14. Transport information

DOT
- **UN-No** UN2809
- **Proper Shipping Name** MERCURY
- **Hazard Class** 8
- **Subsidiary Hazard Class** 6.1
- **Packing Group** III

TDG
- **UN-No** UN2809
- **Proper Shipping Name** MERCURY
- **Hazard Class** 8

Subsidiary Hazard Class 6.1
Packing Group III

IATA

UN-No UN2809
Proper Shipping Name MERCURY
Hazard Class 8
Subsidiary Hazard Class 6.1
Packing Group III

IMDG/IMO

UN-No UN2809
Proper Shipping Name MERCURY
Hazard Class 8
Subsidiary Hazard Class 6.1
Packing Group III

15. Regulatory information

International Inventories

Component	TSCA	DSL	NDSL	EINECS	ELINCS	NLP	PICCS	ENCS	AICS	IECSC	KECL
Mercury	X	X	-	231-106-7	-		X	-	X	X	X

Legend:
X - Listed
E - Indicates a substance that is the subject of a Section 5(e) Consent order under TSCA.
F - Indicates a substance that is the subject of a Section 5(f) Rule under TSCA.
N - Indicates a polymeric substance containing no free-radical initiator in its inventory name but is considered to cover the designated polymer made with any free-radical initiator regardless of the amount used.
P - Indicates a commenced PMN substance
R - Indicates a substance that is the subject of a Section 6 risk management rule under TSCA.
S - Indicates a substance that is identified in a proposed or final Significant New Use Rule
T - Indicates a substance that is the subject of a Section 4 test rule under TSCA.
XU - Indicates a substance exempt from reporting under the Inventory Update Rule, i.e. Partial Updating of the TSCA Inventory Data Base Production and Site Reports (40 CFR 710(B).
Y1 - Indicates an exempt polymer that has a number-average molecular weight of 1,000 or greater.
Y2 - Indicates an exempt polymer that is a polyester and is made only from reactants included in a specified list of low concern reactants that comprises one of the eligibility criteria for the exemption rule.

U.S. Federal Regulations

TSCA 12(b)

Component	TSCA 12(b)
Mercury	Section 5

SARA 313

Component	CAS-No	Weight %	SARA 313 - Threshold Values %
Mercury	7439-97-6	100	1.0

SARA 311/312 Hazardous Categorization

Acute Health Hazard Yes
Chronic Health Hazard Yes
Fire Hazard No
Sudden Release of Pressure Hazard No
Reactive Hazard No

Clean Water Act

Component	CWA - Hazardous Substances	CWA - Reportable Quantities	CWA - Toxic Pollutants	CWA - Priority Pollutants
Mercury	-	-	X	X

Clean Air Act

Component	HAPS Data	Class 1 Ozone Depletors	Class 2 Ozone Depletors
Mercury	X		-

OSHA Occupational Safety and Health Administration
Not applicable

CERCLA
This material, as supplied, contains one or more substances regulated as a hazardous substance under the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) (40 CFR 302)

Component	Hazardous Substances RQs	CERCLA EHS RQs
Mercury	1 lb	-

California Proposition 65 This product contains the following Proposition 65 chemicals:

Component	CAS-No	California Prop. 65	Prop 65 NSRL	Category
Mercury	7439-97-6	Developmental	-	Developmental

State Right-to-Know

Component	Massachusetts	New Jersey	Pennsylvania	Illinois	Rhode Island
Mercury	X	X	X	X	X

U.S. Department of Transportation

Reportable Quantity (RQ): N
DOT Marine Pollutant N
DOT Severe Marine Pollutant N

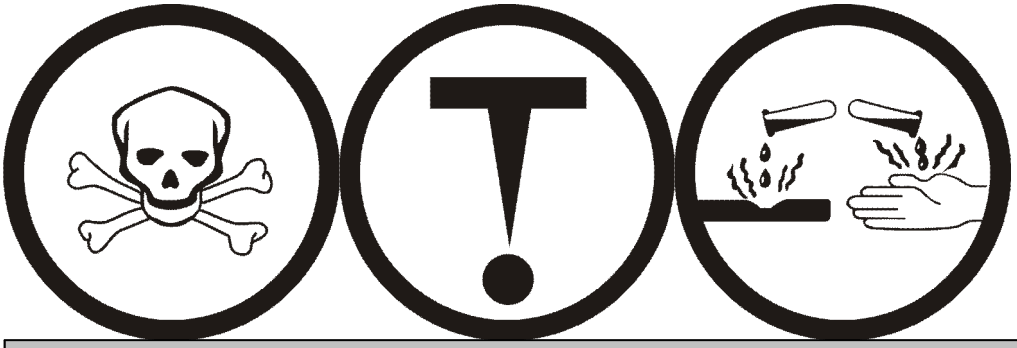
U.S. Department of Homeland Security
This product does not contain any DHS chemicals.

Other International Regulations

Mexico - Grade No information available

Canada
This product has been classified in accordance with the hazard criteria of the Controlled Products Regulations (CPR) and the MSDS contains all the information required by the CPR

WHMIS Hazard Class
D1A Very toxic materials
D2A Very toxic materials
E Corrosive material



16. Other information

Prepared By
Regulatory Affairs
Thermo Fisher Scientific
Email: EMSDS.RA@thermofisher.com

Creation Date 20-Aug-2014
Revision Date 20-Aug-2014
Print Date 20-Aug-2014
Revision Summary This document has been updated to comply with the US OSHA HazCom 2012 Standard replacing the current legislation under 29 CFR 1910.1200 to align with the Globally Harmonized System of Classification and Labeling of Chemicals (GHS)

Disclaimer

The information provided on this Safety Data Sheet is correct to the best of our knowledge, information and belief at the date of its publication. The information given is designed only as a guide for safe handling, use, processing, storage, transportation, disposal and release and is not to be considered as a warranty or quality specification. The information relates only to the specific material designated and may not be valid for such material used in combination with any other material or in any process, unless specified in the text.

End of SDS

safety data sheet

according to Regulation (EC) No. 1907/2006 (REACH), amended by 2015/830/EU

Mercurisorb-ROTH® contains silver nitrate

article number: **9461**
Version: **1.0 en**

date of compilation: 2016-05-27

SECTION 1: Identification of the substance/mixture and of the company/undertaking

1.1 Product identifier

Identification of the substance	**MERCURISORB-ROTH®**
Article number	9461
Registration number (REACH)	not relevant (mixture)

1.2 Relevant identified uses of the substance or mixture and uses advised against

Identified uses:	laboratory chemical

1.3 Details of the supplier of the safety data sheet

Carl Roth GmbH + Co KG
Schoemperlenstr. 3-5
D-76185 Karlsruhe
Germany

Telephone: +49 (0) 721 - 56 06 0
Telefax: +49 (0) 721 - 56 06 149
e-mail: sicherheit@carlroth.de
Website: www.carlroth.de

Competent person responsible for the safety data sheet	: Department Health, Safety and Environment
e-mail (competent person)	**: sicherheit@carlroth.de**

1.4 Emergency telephone number

Emergency information service	**Poison Centre Munich: +49/(0)89 19240**

SECTION 2: Hazards identification

2.1 Classification of the substance or mixture

Classification according to Regulation (EC) No 1272/2008 (CLP)

Classification acc. to GHS

Section	Hazard class	Hazard class and category	Hazard statement
3.2	skin corrosion/irritation	(Skin Corr. 1B)	H314
3.3	serious eye damage/eye irritation	(Eye Dam. 1)	H318
4.1A	hazardous to the aquatic environment - acute hazard	(Aquatic Acute 1)	H400
4.1C	hazardous to the aquatic environment - chronic hazard	(Aquatic Chronic 2)	H411

Remarks
For full text of Hazard- and EU Hazard-statements: see SECTION 16.

2.2 Label elements

Labelling according to Regulation (EC) No 1272/2008 (CLP)

Signal word **Danger**

Pictograms



Hazard statements

H314	Causes severe skin burns and eye damage.
H410	Very toxic to aquatic life with long lasting effects.

Precautionary statements

Precautionary statements - prevention

P273	Avoid release to the environment.
P280	Wear protective gloves/protective clothing/eye protection/face protection.

Precautionary statements - response

P303+P361+P353	IF ON SKIN (or hair): take off immediately all contaminated clothing. Rinse skin with water/shower.
P305+P351+P338	IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.

Precautionary statements - disposal

P501	Dispose of contents/container in accordance with local/regional/national/international regulations.

Hazardous ingredients for labelling: silver nitrate

Labelling of packages where the contents do not exceed 125 ml

Signal word: **Danger**

Symbol(s)



H314	Causes severe skin burns and eye damage.
P280	Wear protective gloves/protective clothing/eye protection/face protection.
P303+P361+P353	IF ON SKIN (or hair): take off immediately all contaminated clothing. Rinse skin with water/shower.
P305+P351+P338	IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.
P501	Dispose of contents/container in accordance with local/regional/national/international regulations.
contains:	Silver nitrate

2.3 Other hazards

There is no additional information.

SECTION 3: Composition/information on ingredients

3.2 Mixtures

Description of the mixture

Composition/information on ingredients.

Name of substance	Identifier	wt %	Classification acc. to 1272/2008/EC	Pictograms	Notes	M-Factors
Silicon dioxide	CAS No 7631-86-9 EC No 231-545-4	40 - 60			IOELV	
Silver nitrate	CAS No 7761-88-8 EC No 231-853-9 Index No 047-001-00-2	10 - < 25	Ox. Sol. 2 / H272 Skin Corr. 1B / H314 Aquatic Acute 1 / H400 Aquatic Chronic 1 / H410		GHS-HC	M-factor (acute) = 100.0

Notes

GHS-HC: Harmonised classification (the classification of the substance corresponds to the entry in the list according to 1272/2008/EC, Annex VI)
IOELV: Substance with a community indicative occupational exposure limit value

Remarks

For full text of Hazard- and EU Hazard-statements: see SECTION 16.

SECTION 4: First aid measures

4.1 Description of first aid measures



General notes

Take off immediately all contaminated clothing. Self-protection of the first aider.

Following inhalation

Provide fresh air. In all cases of doubt, or when symptoms persist, seek medical advice.

Following skin contact

After contact with skin, wash immediately with plenty of water. Immediate medical treatment required because corrosive injuries that are not treated are hard to cure.

Following eye contact

In case of contact with eyes flush immediately with plenty of flowing water for 10 to 15 minutes holding eyelids apart and consult an ophthalmologist. Protect uninjured eye.

Following ingestion

Rinse mouth immediately and drink plenty of water. Call a physician immediately. If swallowed danger of perforation of the esophagus and the stomach (strong corrosive effects).

4.2 Most important symptoms and effects, both acute and delayed

Corrosion, Cough, Risk of blindness, Gastric perforation, Risk of serious damage to eyes, Dyspnoea

4.3 Indication of any immediate medical attention and special treatment needed

none

SECTION 5: Firefighting measures

5.1 Extinguishing media

Suitable extinguishing media

Co-ordinate fire-fighting measures to the fire surroundings
water spray, foam, dry extinguishing powder, carbon dioxide (CO2)

Unsuitable extinguishing media

water jet

5.2 Special hazards arising from the substance or mixture

None.

Hazardous combustion products

In case of fire may be liberated: May produce toxic fumes of carbon monoxide if burning.

5.3 Advice for firefighters

Do not allow firefighting water to enter drains or water courses. Fight fire with normal precautions from a reasonable distance. Wear self-contained breathing apparatus. Wear full chemical protective clothing.

SECTION 6: Accidental release measures

6.1 Personal precautions, protective equipment and emergency procedures

For non-emergency personnel

Wearing of suitable protective equipment (including personal protective equipment referred to under Section 8 of the safety data sheet) to prevent any contamination of skin, eyes and personal clothing. Do not breathe dust. Avoid contact with skin, eyes and clothes.

6.2 Environmental precautions

Keep away from drains, surface and ground water. Retain contaminated washing water and dispose it.

6.3 Methods and material for containment and cleaning up

Advices on how to contain a spill

Covering of drains.

Advices on how to clean up a spill

Take up mechanically. Control of dust.

Other information relating to spills and releases

Place in appropriate containers for disposal.

Reference to other sections

Hazardous combustion products: see section 5. Personal protective equipment: see section 8. Incompatible materials: see section 10. Disposal considerations: see section 13.

SECTION 7: Handling and storage

7.1 Precautions for safe handling

Handle and open container with care.

• Measures to prevent fire as well as aerosol and dust generation

Removal of dust deposits.

Advice on general occupational hygiene

Wash hands before breaks and after work. Keep away from food, drink and animal feedingstuffs.

7.2 Conditions for safe storage, including any incompatibilities

Store in a dry place. Keep container tightly closed. Protect from sunlight.

Incompatible substances or mixtures

Observe hints for combined storage. Keep/store away from combustible materials.

Consideration of other advice

• Ventilation requirements

Use local and general ventilation.

• Specific designs for storage rooms or vessels

Recommended storage temperature: 5 - 25 °C.

7.3 Specific end use(s)

No information available.

SECTION 8: Exposure controls/personal protection

8.1 Control parameters

National limit values

Occupational exposure limit values (Workplace Exposure Limits)

Country	Name of agent	CAS No	Notation	Identifier	TWA [mg/m³]	STEL [mg/m³]	Source
GB	dust		i	WEL	10		EH40/2005
GB	dust		r	WEL	4		EH40/2005
GB	silica, amorphous	7631-86-9	i	WEL	6		EH40/2005
GB	silica, amorphous	7631-86-9	r	WEL	2,4		EH40/2005

Notation

i	Inhalable fraction
r	Respirable fraction
STEL	Short-term exposure limit: a limit value above which exposure should not occur and which is related to a 15-minute period unless otherwise specified
TWA	Time-weighted average (long-term exposure limit): measured or calculated in relation to a reference period of 8 hours time-weighted average

Relevant DNELs/DMELs/PNECs and other threshold levels

• relevant DNELs of components of the mixture

Name of substance	CAS No	End-point	Threshold level	Protection goal, route of exposure	Used in	Exposure time
silver nitrate	7761-88-8	DNEL	0,016 mg/m³	human, inhalatory	worker (industry)	chronic - systemic effects

8.2 Exposure controls

Individual protection measures (personal protective equipment)



Eye/face protection

Use safety goggle with side protection. Wear face protection.

Skin protection

• hand protection

Wear suitable gloves. Chemical protection gloves are suitable, which are tested according to EN 374. Check leak-tightness/impermeability prior to use. For special purposes, it is recommended to check the resistance to chemicals of the protective gloves mentioned above together with the supplier of these gloves.

• type of material

NBR (Nitrile rubber)

• material thickness

0,4 mm.

• breakthrough times of the glove material

>480 minutes (permeation: level 6)

• other protection measures

Take recovery periods for skin regeneration. Preventive skin protection (barrier creams/ointments) is recommended.

Respiratory protection

Respiratory protection necessary at: Dust formation. Particulate filter device (EN 143). P1 (filters at least 80 % of airborne particles, colour code: White).

Environmental exposure controls

Keep away from drains, surface and ground water.

SECTION 9: Physical and chemical properties

9.1 Information on basic physical and chemical properties

Appearance

Physical state	solid (powder)
Colour	light grey
Odour	odourless
Odour threshold	No data available

Other physical and chemical parameters

pH (value)	This information is not available.
Melting point/freezing point	not determined
Initial boiling point and boiling range	This information is not available.
Flash point	not applicable
Evaporation rate	no data available
Flammability (solid, gas)	Non-flammable
Explosive limits	
• lower explosion limit (LEL)	this information is not available
• upper explosion limit (UEL)	this information is not available
Explosion limits of dust clouds	these information are not available
Vapour pressure	This information is not available.
Density	This information is not available.
Vapour density	This information is not available.
Relative density	Information on this property is not available.
Solubility(ies)	
Water solubility	no data available
Partition coefficient	
n-octanol/water (log KOW)	This information is not available.
Auto-ignition temperature	Information on this property is not available.
Decomposition temperature	no data available
Viscosity	not relevant (solid matter)
Explosive properties	none
Oxidising properties	ingredients of the mixture: oxidising

9.2 Other information

There is no additional information.

SECTION 10: Stability and reactivity

10.1 Reactivity
This material is not reactive under normal ambient conditions.

10.2 Chemical stability
The material is stable under normal ambient and anticipated storage and handling conditions of temperature and pressure.

10.3 Possibility of hazardous reactions
Violent reaction with: Aldehydes, Alkali hydroxide (caustic alkali), Carbide, Halogenated hydrocarbons, Sodium, Strong oxidiser

10.4 Conditions to avoid
Direct light irradiation.

10.5 Incompatible materials
There is no additional information.

10.6 Hazardous decomposition products
Hazardous combustion products: see section 5.

SECTION 11: Toxicological information

11.1 Information on toxicological effects

Acute toxicity
Shall not be classified as acutely toxic.

• Acute toxicity of components of the mixture

Name of substance	CAS No	Exposure route	ATE
silver nitrate	7761-88-8	oral	1.173 $^{mg}/_{kg}$

Skin corrosion/irritation
Causes severe burns.

Serious eye damage/eye irritation
Causes serious eye damage.

Respiratory or skin sensitisation
Shall not be classified as a respiratory or skin sensitiser.

Summary of evaluation of the CMR properties
Shall not be classified as germ cell mutagenic, carcinogenic nor as a reproductive toxicant

• Specific target organ toxicity - single exposure
Shall not be classified as a specific target organ toxicant (single exposure).

• Specific target organ toxicity - repeated exposure
Shall not be classified as a specific target organ toxicant (repeated exposure).

Aspiration hazard
Shall not be classified as presenting an aspiration hazard.

Symptoms related to the physical, chemical and toxicological characteristics

• If swallowed

vomiting, nausea, If swallowed danger of perforation of the esophagus and the stomach (strong corrosive effects)

• If in eyes

causes burns, Causes serious eye damage, risk of blindness

• If inhaled

irritability, cough, Dyspnoea

• If on skin

causes severe burns, causes poorly healing wounds

Other information

None

SECTION 12: Ecological information

12.1 Toxicity

Very toxic to aquatic life. Toxic to aquatic life with long lasting effects.

Aquatic toxicity (acute)

Very toxic to aquatic organisms.

Aquatic toxicity (chronic)

May cause long-term adverse effects in the aquatic environment.

12.2 Process of degradability

Data are not available.

12.3 Bioaccumulative potential

Data are not available.

12.4 Mobility in soil

Data are not available.

12.5 Results of PBT and vPvB assessment

Data are not available.

12.6 Other adverse effects

Strongly hazardous to water.

SECTION 13: Disposal considerations

13.1 Waste treatment methods

This material and its container must be disposed of as hazardous waste. Dispose of contents/container in accordance with local/regional/national/international regulations.

Sewage disposal-relevant information

Do not empty into drains. Avoid release to the environment. Refer to special instructions/safety data sheets.

Waste treatment of containers/packagings
It is a dangerous waste; only packagings which are approved (e.g. acc. to ADR) may be used.

13.2 Relevant provisions relating to waste
The allocation of waste identity numbers/waste descriptions must be carried out according to the EEC, specific to the industry and process.

13.3 Remarks
Waste shall be separated into the categories that can be handled separately by the local or national waste management facilities. Please consider the relevant national or regional provisions.

SECTION 14: Transport information

14.1	UN number	**3260**
14.2	UN proper shipping name	**CORROSIVE SOLID, ACIDIC, INORGANIC, N.O.S.**
	Hazardous ingredients	Silver nitrate
14.3	Transport hazard class(es)	
	Class	8 (corrosive substances)
14.4	Packing group	II (substance presenting medium danger)
14.5	Environmental hazards	hazardous to the aquatic environment (silver nitrate)

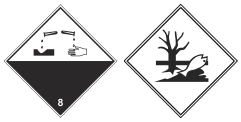
14.6 Special precautions for user
Provisions for dangerous goods (ADR) should be complied within the premises.

14.7 Transport in bulk according to Annex II of MARPOL and the IBC Code
The cargo is not intended to be carried in bulk.

14.8 Information for each of the UN Model Regulations

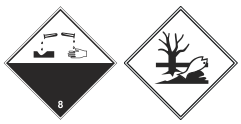
• Transport of dangerous goods by road, rail and inland waterway (ADR/RID/ADN)

UN number	3260
Proper shipping name	CORROSIVE SOLID, ACIDIC, INORGANIC, N.O.S.
Particulars in the transport document	UN3260, CORROSIVE SOLID, ACIDIC, INORGANIC, N.O.S., (contains: silver nitrate), 8, II, (E), environmentally hazardous
Class	8
Classification code	C2
Packing group	II
Danger label(s)	8 + "fish and tree"



Environmental hazards	yes (hazardous to the aquatic environment)
Special provisions (SP)	274
Excepted quantities (EQ)	E2
Limited quantities (LQ)	1 kg
Transport category (TC)	2

Tunnel restriction code (TRC)	E
Hazard identification No	80
Emergency Action Code	2X
• International Maritime Dangerous Goods Code (IMDG)	
UN number	3260
Proper shipping name	CORROSIVE SOLID, ACIDIC, INORGANIC, N.O.S.
Particulars in the shipper's declaration	UN3260, CORROSIVE SOLID, ACIDIC, INORGANIC, N.O.S., (contains: silver nitrate), 8, II, MARINE POLLUTANT
Class	8
Marine pollutant	yes (hazardous to the aquatic environment)
Packing group	II
Danger label(s)	8 + "fish and tree"



Special provisions (SP)	274
Excepted quantities (EQ)	E2
Limited quantities (LQ)	1 kg
EmS	F-A, S-B
Stowage category	B
Segregation group	1 - Acids

SECTION 15: Regulatory information

15.1 Safety, health and environmental regulations/legislation specific for the substance or mixture

Relevant provisions of the European Union (EU)

• Regulation 649/2012/EU concerning the export and import of hazardous chemicals (PIC)
None of the ingredients are listed.

• Regulation 1005/2009/EC on substances that deplete the ozone layer (ODS)
None of the ingredients are listed.

• Regulation 850/2004/EC on persistent organic pollutants (POP)
None of the ingredients are listed.

• Restrictions according to REACH, Annex XVII
None of the ingredients are listed.

• List of substances subject to authorisation (REACH, Annex XIV)

None of the ingredients are listed.

• Seveso Directive

2012/18/EU (Seveso III)				
No	**Dangerous substance/hazard categories**	**Qualifying quantity (tonnes) for the application of lower and upper-tier requirements**		**Notes**
E1	environmental hazards (hazardous to the aquatic environment, cat. 1)	100	200	56)

Notation

56) Hazardous to the Aquatic Environment in category Acute 1 or Chronic 1

• Limitation of emissions of volatile organic compounds due to the use of organic solvents in certain paints and varnishes and vehicle refinishing products (2004/42/EC, Deco-Paint Directive)

VOC content 0 %

• Directive on industrial emissions (VOCs, 2010/75/EU)

VOC content 0 %

Directive 2011/65/EU on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS) - Annex II

None of the ingredients are listed.

Regulation 166/2006/EC concerning the establishment of a European Pollutant Release and Transfer Register (PRTR)

None of the ingredients are listed.

Directive 2000/60/EC establishing a framework for Community action in the field of water policy (WFD)

None of the ingredients are listed.

15.2 Chemical Safety Assessment

Chemical safety assessments for substances in this mixture were not carried out.

SECTION 16: Other information

Abbreviations and acronyms

Abbr.	Descriptions of used abbreviations
ADN	Accord européen relatif au transport international des marchandises dangereuses par voies de navigation intérieures (European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterways)
ADR	Accord européen relatif au transport international des marchandises dangereuses par route (European Agreement concerning the International Carriage of Dangerous Goods by Road)
Aquatic Acute	hazardous to the aquatic environment - acute hazard
Aquatic Chronic	hazardous to the aquatic environment - chronic hazard
ATE	Acute Toxicity Estimate
CAS	Chemical Abstracts Service (service that maintains the most comprehensive list of chemical substances)
CLP	Regulation (EC) No 1272/2008 on classification, labelling and packaging of substances and mixtures
CMR	Carcinogenic, Mutagenic or toxic for Reproduction
DMEL	Derived Minimal Effect Level

Abbr.	Descriptions of used abbreviations
DNEL	Derived No-Effect Level
EC No	The EC Inventory (EINECS, ELINCS and the NLP-list) is the source for the seven-digit EC number, an identifier of substances commercially available within the EU (European Union)
EH40/2005	EH40/2005 Workplace exposure limits (http://www.nationalarchives.gov.uk/doc/open-government-licence/)
EINECS	European Inventory of Existing Commercial Chemical Substances
ELINCS	European List of Notified Chemical Substances
EmS	Emergency Schedule
GHS	"Globally Harmonized System of Classification and Labelling of Chemicals" developed by the United Nations
IMDG	International Maritime Dangerous Goods Code
index No	the Index number is the identification code given to the substance in Part 3 of Annex VI to Regulation (EC) No 1272/2008
MARPOL	International Convention for the Prevention of Pollution from Ships (abbr. of "Marine Pollutant)
M-factor	means a multiplying factor. It is applied to the concentration of a substance classified as hazardous to the aquatic environment acute category 1 or chronic category 1, and is used to derive by the summation method the classification of a mixture in which the substance is present
NLP	No-Longer Polymer
Ox. Sol.	oxidising solid
PBT	Persistent, Bioaccumulative and Toxic
PNEC	Predicted No-Effect Concentration
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals
RID	Règlement concernant le transport International ferroviaire des marchandises Dangereuses (Regulations concerning the International carriage of Dangerous goods by Rail)
Skin Corr.	corrosive to skin
Skin Irrit.	irritant to skin
STEL	short-term exposure limit
TWA	time-weighted average
VOC	Volatile Organic Compounds
vPvB	very Persistent and very Bioaccumulative
WEL	workplace exposure limit

Key literature references and sources for data

- Regulation (EC) No. 1907/2006 (REACH), amended by 2015/830/EU
- Regulation (EC) No. 1272/2008 (CLP, EU GHS)

List of relevant phrases (code and full text as stated in chapter 2 and 3)

Code	Text
H272	may intensify fire; oxidiser
H314	causes severe skin burns and eye damage
H318	causes serious eye damage
H400	very toxic to aquatic life
H410	very toxic to aquatic life with long lasting effects

Code	Text
H411	toxic to aquatic life with long lasting effects

Disclaimer

The above information describes exclusively the safety requirements of the product and is based on our present-day knowledge. The information is intended to give you advice about the safe handling of the product named in this safety data sheet, for storage, processing, transport and disposal. The information cannot be transferred to other products. In the case of mixing the product with other products or in the case of processing, the information on this safety data sheet is not necessarily valid for the new made-up material.

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NORTH AMERICA

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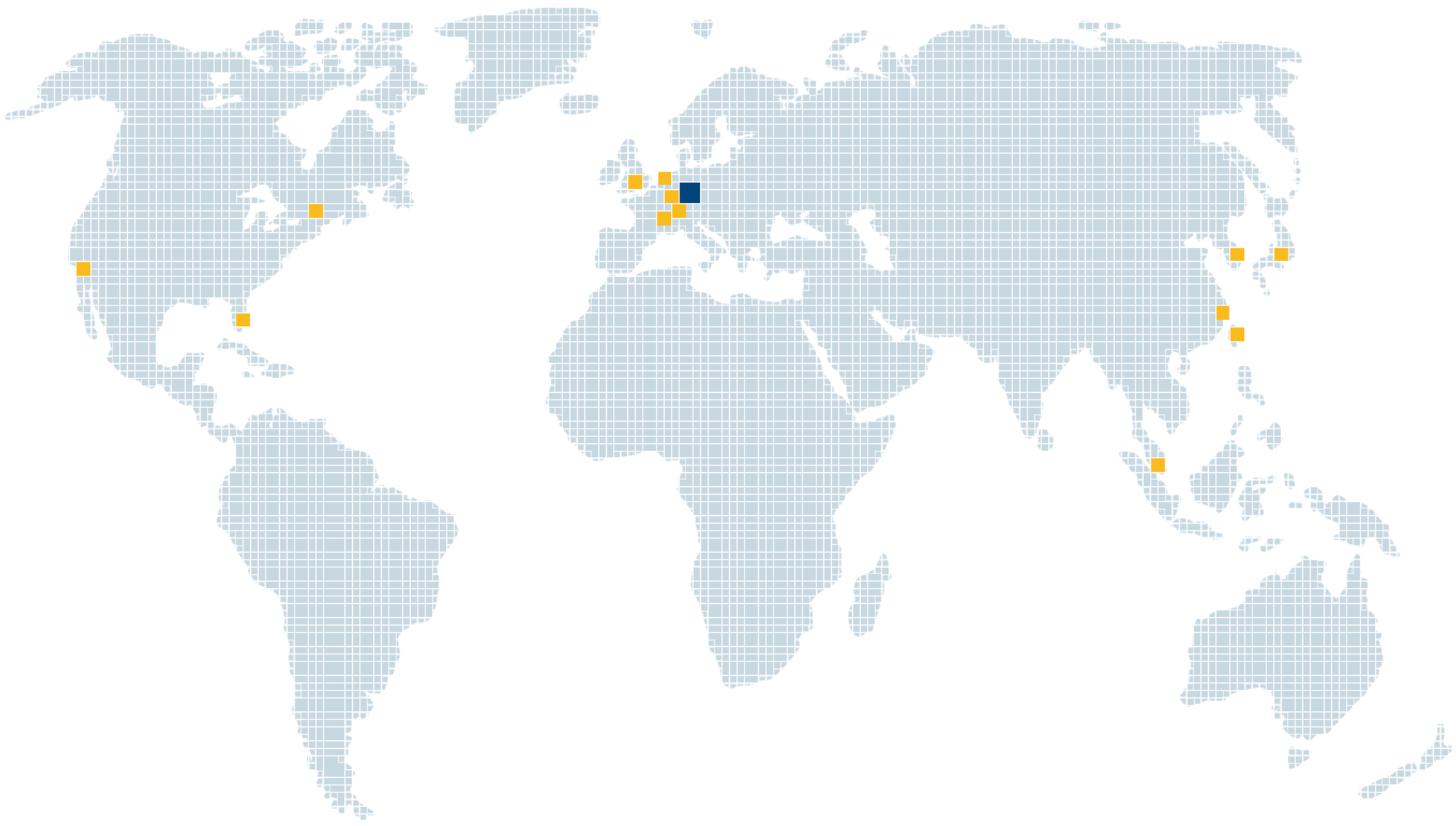
EUROPE

- Germany
- United Kingdom
- France
- Switzerland
- Netherlands

ASIA

- Japan
- Korea
- China
- Singapore
- Taiwan



■ Headquarters ■ Sites



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PREVENTIVE MAINTENANCE



Mask/Bond Aligners

MA/BA Gen4

Manual Mask/Bond Aligner

Rev03 20-03

READ THIS MANUAL PRIOR TO PERFORMING ANY TASK!

Preventive Maintenance

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This manual is a user documentation of SUSS MicroTec Lithography GmbH (in the following "manufacturer") and allows safe and efficient use of the mask aligner MA/BA Gen4.

Prior to working on this product, the personnel must have thoroughly read and understood these instructions and, furthermore, know and observe officially recognized rules regarding occupational health and safety. The basic prerequisite for safe working is compliance with all the safety and handling instructions stated in this manual and the safety and installation manual of the tool.

Figures in this manual are for the fundamental understanding and can deviate from the actual design of the tool.

English is the original language of this manual.

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Service

Our customer service is pleased to provide further technical information.

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1 WARNING and SAFETY PRECAUTIONS

1.1 General Safety Information



Before installation and operation of the equipment following safety information has to be read carefully!

NOTICE!

The chapter "Safety Precautions" contains information the operator must know and understand in order to avoid the risk of personal and equipment damage.

This section describes general safety precautions and procedures which must be observed and followed by all persons working with the equipment covered by this manual.

After a thorough review by qualified safety personnel, the user should generate specific safety procedures with regard to particular application and configuration of the equipment and local codes. Operators must be thoroughly familiar with these procedures which should also be posted in an accessible location so that all equipment operators are exposed to the information on a continuing basis.

In addition to the specific safety precautions detailed in this section, anyone working with or in close proximity to the equipment described in this manual should observe adequate precautions and safe operating practices generally applicable to the operation of semiconductor production and processing equipment.

1.2 Intended Use

NOTICE!

Other than the intended use of the machine will lead to a loss of warranty!



WARNING!

Risk for Personal Injury and Material Damage!

Equipment of this type may cause serious personal injury or material damage if it is not used or operated in the correct manner, or if unqualified personnel have access to it.
The same applies if the equipment has been installed incorrectly or has not been maintained sufficiently, or if consumables, accessories, spare parts or software is used that is not authorized by the supplier, or if components will be removed.

► Only operate the system in a technically perfect condition and in compliance with the operating instructions.

► Disruptions, especially those that may affect safety, must be promptly remedied by authorized personnel.

The system described in this manual has been manufactured according to the technical standards, safety regulations, SEMI-standards and EC guidelines.

If not installed properly or not used as directed, dangerous situations or damage might occur.

Changes or modifications to the machine without prior written permission by the supplier will void warranty and will void the user's authority to operate the equipment.

Any unauthorized changes or modifications to the system or use of incompatible accessories would void all warranties as well as SUSS liability. Consult SUSS MicroTec Lithography GmbH before implementation of any change or modification. Quote also system type and serial number when making inquiries.

Processes:

- Photolithographic system for automated 1:1 direct projection of structures from a photo mask to photo-sensitive coated substrates.
- Manual or automatic alignment of structures on the substrate to the mask.

Substrates:

Following substrate sizes and shapes are able to be processed:

- Round substrates (wafer) from 2 in. to 200 mm
- Square substrates from 2 in. to 6 in.

Components/ Use:

- As light source a closed UV source is used together with adapted exposure optics.
  Only exposure lamps released by SUSS for the mask aligner and the corresponding lamp house must be used.
- Running the lamp in the machine is only permitted in combination with the SUSS lamp power supply. The adjustment procedure for lamp cooling for the corresponding lamp type provided by SUSS must be followed.

- Any other use of the machine than as a photo-lithographic or bond aligning system or of its components is not intended by design. Therefore any other use of the machine must be agreed with SUSS MicroTec Lithography GmbH in advance and must be specifically released by SUSS.
- The machine must only operated as a whole. Removal of individual parts for separated operation or machine operation with removed components is not allowed.
- Enclosures and covers are necessary for save operation. Any use without enclosure or removed covers is not permitted.

Software:

- Software is an integral component of the system. Software which is not originally intended for use in this system and not tested and released for the system by SUSS MicroTec Lithography could pose a risk for functionality, process performance and material handling.
- Installation of additional software without prior written permission by SUSS contradicts the intended use of the machine.

Avoidance of Hazard:

- Only if intendedly used within a closed lamp house no specific hazard by the lamp will arise for the user.
- Sufficient ventilation of lamp house, lamp power supply and the whole machine has to be guaranteed to avoid overheating and subsequent damage and hazards.
- If in special cases the machine shall be used for applications with increased safety requirements this has to be considered during installation by additional safety precautions at installation site.

Maintenance/ Service:

- In case of installation, operation, changing of operational conditions, maintenance-, inspection- and service work all protective procedures described in the user manual have to be followed.
- You are advised to make use of the support and services offered by the competent SUSS MicroTec lithography service center with regard to planning, installation, commissioning and servicing.
- If working with chemicals follow all local regulations, laws, guidelines and safety data sheets (SDS).

Contact:

For planing, installation and service consult your local SUSS representation. For latest contact information go to www.suss.com.

1.3 Minimum User Requirements

Ensure that:

- the operator is equipped with his/her appropriate personal protective equipment.
- the user does not change or modify the system without the prior written permission of the manufacturer.
- the user replaces defect system components immediately and only by original spare and wear parts.
- the operator runs the system only with all installed covers and working interlocks.

- service and maintenance work will be carried out only by qualified and adequately trained personnel.
- all personnel working with or near the equipment have received all safety information concerning the machine and that they are properly trained on the safety requirements of the machine.
- all persons working with the system are properly trained for the operation with the system.
- the user respects all safety information provided in this manual and in all additionally applicable safety and local preparation information which are delivered by SUSS MicroTec Lithography GmbH or to which SUSS has pointed out to.
- the user does not remove, modify, cover or change any content or the readability of all safety signs and labels which are located at or in the machine.
  No additional labels are allowed to be placed to the machine which could reduce the attention to the safety labels provided by SUSS MicroTec Lithography or which could reduce the effectivity of the labels.

1.4 Qualified Personnel

Qualified personnel are persons, who on account of the training and instruction they have received and their experience and knowledge of relevant standards, specifications, accident prevention regulations and operating conditions, have been authorized by those responsible for the safety of the system to carry out any necessary work and who are able to recognize possible dangers.

Qualified personnel have to avoid accidents during electric work and repair or during maintenance work. All personnel shall wear or use personnel protective equipment which is required for save work performance.

All system users are advised to become familiar with the contents of these safety instructions prior to operating the system. They also should have read and understood the operating instructions.

In addition, always comply with local health and safety regulations and company safety requirements regarding safe usage of equipment. Knowledge of the first aid and the local rescue facilities is also required.

OSHA (Occupational Safety & Health Administration) Definition:

"Qualified" means one who, by possession of a recognized degree, certificate, or professional standing, or who by extensive knowledge, training and experience, has successfully demonstrated his ability to solve or resolve problems relating to the subject matter, the work, or the project.

1.5 Signs and Safety Precautions

The terms DANGER, WARNING, CAUTION and NOTICE are used to indicate special dangerous situations or special information that have to be followed.

Safety Related Terms and Signs:

Following safety related terms and signs are used:



DANGER!

This safety related term consisting of symbol and signal word DANGER indicates an imminent hazardous situation which, if not avoided, could result in death or serious personal injury.



WARNING!

This safety related term consisting of symbol and signal word WARNING indicates a potential hazardous situation which, if not avoided could result in minor or moderate personal injury.



CAUTION!

This safety related term consisting of symbol and signal word CAUTION indicates a potential hazardous situation which, if not avoided could result in death or serious personal injury.



NOTICE!

This safety related term consisting of symbol and signal word NOTICE indicates a potential hazardous situation which, if not avoided could result in material or environmental damage
or
draws attention to special technical product information which may not be immediately obvious even to qualified personnel.

The format of the warnings in the user manual and on the safety labels conform to following standards:

- DIN ISO 38864 + ISO 7010
- ANSI Z-535

Warning Signs:

Following warning signs are used in this manual:

	General warning symbol (explanation is always necessary)
	Electric shock hazard
	Crush or pinch point hazard
	Intensive light and potential eye damage hazard • with UV insert: invisible ultraviolet light • with IR insert: invisible infrared light
	Hot surface hazard
	Inhalation hazard
	Chemical hazard
	Fire hazard
	Displosion hazard
	Heavy load hazard

Prohibition and mandatory signs:

Following prohibition and mandatory signs are used in this manual:

	Strong magnet; non-ionizing radiation Persons with pacemakers or implanted defibrilators must keep back
	Wear eye protection
	Wear face protection
	Wear hand protection
	Lift with two persons
	Read manual

Indication Signs:

Indication signs point to the content of an adjacent text and do not function as safety signs.
Indication signs enable quick identification of text passages and accelerate the search for information.

Following indication signs are used in this manual:

Sign	Description
1. 2.	This sign represents one step of an action sequence.
▸	This sign represents a one-step instruction.
⇨	This sign points to the result of an instruction.
	Reference to another paragraph or another document.
Button ***[xy]***	Appearance of hardware keys
Function key ***[xy]***	Appearance of software keys
"Tab xy"	Appearance of GUI-elements

1.6 Training and Qualification

1.6.1 Standard Training Recommendation

We recommend performing of training for qualified persons before they are allowed to perform electrical work at the equipment.
We recommend a refresher training at regular basis (at least every 3 years)
The training shall take place in practice and/ or in lesson format.
The training shall be documented.

The training of a qualified person shall include following topics:

- safety relevant labor practices including the right selection and use of personal protective equipment (PPE)
- skills and methods that are necessary to identify open conducting parts from other parts of the electrical equipment.
- skills and methods that are necessary to determine the nominal voltage of the open conducting parts and to determine the minimum distance and the corresponding voltage a qualified person will be exposed to.
- options to perform the job safely.
- options to de-energize the system and all electrical components safely (logout/tagout).

1.6.2 Additional Training Recommendation

Additional training options that are recommended for work at electrical equipment:

- NEC (EN60204)
- National Electrical Safety Code (ANSI C2)
- Correct use and careful handling of personal protection equipment
- Correct use of test and measurement equipment
- Work permit and approval procedures
- Correct clothing for electric arc protection
- First aid course at least every 3 years

1.6.3 Tasks and Related Training Requirements

Operation of a manual mask/ bond aligner:

- Knowledge of how to handle process material safely.
- Knowledge of the microscope alignment process in the machine.
- Understanding the exposure process.
- Understanding the presentation of the process status in the user interface.

Start-up and shut-down of manual mask/ bond aligner:

- Knowledge of how to start the machine and the UV lamp.
- Knowledge of how to select and start alignment and exposure programs.
- Knowledge of how to handle photo masks safely during loading and unloading
- Knowledge how to select and install the correct tooling (chuck, mask holder, upper substrate holder) for the intended task.
- Understanding the parameters to be programmed and the inherent risk of damage to material or equipment caused by improper combination of tooling and program.
- Understanding how to identify potential problems with the machine.

Performance of light measurement and adjustment:

- Knowledge of how to use the SUSS MicroTec light measurement probes.
- Practice of preparing measurement protocols.
- Understanding the potential hazard originating from UV-radiation.
- Knowledge of how to adjust lamp power at the CIC
- Knowledge of how to adjust light uniformity using the lamp positions adjustment - and in complex situations also the lens positions.

Configure or program processes:

- Knowledge of how to use the mask/ bond aligner for configuration and programming.
- Understanding the parameters to be programmed and the inherent risk of damage to material or equipment caused by a wrong process.

Perform safety checks:

- Understanding the hazards caused by UV radiation, by a hot UV lamp, by mechanical movements and by electrically energized parts - also the understanding of how to avoid all these hazards.
- Understanding how all interlock and safety functions of the machine are working.
- Knowledge of how to check the safety on the machine and how to defeat and reinstall interlocks.
- Practice in filling of safety check reports.

Exchange of UV-lamp:

- Special training for exchanging the exposure lamp: i.e. handling of the lamp, performing electrical connections to the lamp, checking and adjusting lamp positions, checking of lamp cooling, ability to identify degraded mirrors.

Service task of UV-LED light source:

The optional UV-LED light source does not contain any user serviceable parts.



CAUTION!

Performance Hazard!
Never disassemble the UV-LED light source unit. Mechanical assembly is crucial for light shaping and light uniformity

Perform general trouble shooting and maintenance:

- Special training for maintenance access points
- Understanding machine states and processes
- Experience in using the service program (ServiceGUI)
- Knowledge in handling of cleaning agents - including flammable liquids - and grease
- Detailed knowledge of mechanical machine components

Perform service tasks:

- Special training for service by a SUSS MicroTec Lithography trainer.
- The optional UV-LED light source does not contain any user serviceable parts.

1.7 Recommended Safety Equipment

The operator of the facility has to take care that following safety equipment as a minimum requirement is available at installation site of the equipment:

Mandatory:

Fire protection equipment including fire extinguisher

Protective equipment:
- UV-Safety Goggles
- Safety Gloves



Safety Gloves
Media- and heat-resistant safety gloves protect hands from aggressive media, mechanical, thermal and radiation dangers.



UV-Safety Goggles
Safety goggles protect eyes from flying parts, splashing media and hazardous radiation.

1.8 PPE according to NFPA 70E

Technical personal who is exposed to the danger of an electric arc is bound to wear his/her PPE (Personal Protective Equipment) according to NFPA70E.

NOTICE!
These requirements are only valid in the USA and only obligatory for exports into this country.

e.g. according to NFPA70E following PPE is necessary:

- for protection against electric arc approved long-sleeved clean room top.
- for protection against electric arc approved clean room trousers
- protective helmet • for protection against electric arc approved face shield.
- leather or rubber gloves and shoes



NOTICE!
For the currently valid requirements read and observe the current NFPA70E-Standards.

1.9 Forseeable Misuse

Reasonably foreseeable misuse means:

- Use of the mask aligner for alignment and exposure of substrate sizes which are not specified within the sales contract.
- Operation of the machine with bypassed safety circuits. • Use of media which are not specified within the sale contract, section ‚Safety References‘.
- Use of non-authorized external power sources.

- Use of software which is not authorized by SUSS MicroTec Lithography GmbH.
- Use of accessory parts which are not authorized by SUSS MicroTec Lithography GmbH.



CAUTION!

Danger of Serious Machine Damage !

Because of use of non authorized accessory parts or software!

► Only use accessory parts which are authorized by SUSS MicroTec Lithography GmbH to avoid damage of the equipment.

► Software is an integral part of the system. Software which is not originally designated for the use with this equipment and which is not tested and authorized for the system by SUSS MicroTec Lithography may bear the risk for functionality, process performance and material handling.

► Installation of additional software is only allowed with written permission of SUSS MicroTec.

1.10 Transport and Installation



CAUTION!

Ergonomic Hazard!

Risk of damage and injury of the spine by lifting of heavy objects.

► Always use corresponding tools for lifting of heavy loads.

► Always move with the required number of persons.

Load	Support
<18 kg	1 person
18-32 kg	2 persons
32-55 kg	3 persons
>55 kg	Fork lift
Mask aligner chassis	4 persons + additional tool
Base frame	4 persons + additional tool
CIC	2 persons
Alignment stage	2 persons

NOTICE!

All basic work concerning installation, transport, assembly, maintenance and repair have to be performed by qualified service personnel of SUSS MicroTec Lithography GmbH.

Observe:

- technical data and information according to the order specification concerning intended use (assembly, electrical connection, ambientand operating conditions).
- common installation and safety conditions.
- local, system-specific requirements • correct use of tools and transport devices.
- commitment of installation responsible persons to provide suitable safety procedures according to VGB 4 §7 and $8 of German accident prevention regulations for all staff.

This user manual contains instructions which the user has to follow during the intended use of the machine.

Transport-, assembly-,operation- and maintenance instructions and other technical data (in instructions, in product documentation or at the product itself) which are not pointed out especially have to be observed as well, to avoid errors which could lead directly or indirectly to serious personnel or material damage.

1.11 Maintenance and Service

Specific maintenance and service tasks in connection with the safety instructions are defined in the maintenance and service manual.

NOTICE!

Maintenance and service work must only be performed by qualified and technically trained persons.

NOTICE!

Only use accessories, spare parts, software and consumables which are authorized by SUSS MicroTec to avoid personal injury or damage of the system. Parts and Software which are authorized by SUSS MicroTec are compatible with the machine. Non-authorized materials and software can cause serious machine damage or damage of process material.

If malfunction arrives because of parts or software which has not been approved by SUSS, the plant operator has to accept full responsibility on the required service work.

NOTICE!

Ensure a minimum lighting level of 300 lux (30 fc (US-unit)) in all maintenance areas.

Check on a regular basis all media pipes and fittings for leakage and strong sit. Perform maintenance work according to the **Manual for Preventive Maintenance**.
Before re-installation check if all safety covers are correctly installed and that the safety interlocks work correctly.

WARNING!

Working without Service Skills!

Risk of Injury/ Risk of Machine Damage!

- ► Only service personnel is allowed to operate the system if the system is in service mode.
- ► Call for a service technician to terminate the service conditions if you only have operator rights.

1.12 Disposal of Waste

Make sure that contaminated material is disposed according to local and environmental laws and regulations.

Besides we recommend to contact a waste management expert.

Material Separation:

Dispose as special waste:

- Contaminated and used tubes
- All electric /electronic parts (boards)

Following components bring into a recycling process:

- Plastic parts
- Metals (stainless steel, aluminum)

Waste Product:

There are no standard EU regulations for disposal of chemicals or residues.
Chemical residues are special waste. Its disposal is regulated in corresponding laws and regulations. Each individual EU Member State has its own laws and regulations.

We recommend to contact responsible authorities or accredited waste disposal departments for advice.

Packaging Materials:

Disposal according to official regulations.

- Contaminated packaging has to be disposed in a similar manner as the contaminant.
- Non-contaminated packaging can be treated or recycled as domestic waste (if not determined differently by official authorities).

1.13 Safety Hazards

This section describes specific safety hazards or potential hazards which may be associated with the use of this equipment, the possible consequences of human interaction with the hazard and the method(s) for avoiding the hazard.

Hazards described in this section are:

- Electrical hazards by potentially lethal voltages or electric current.
- Mechanical hazards by moving machinery parts.
- Mechanical hazards by exploding UV-lamp bulbs

- Thermal hazards by hot machine parts
- Thermal hazards by hot lamps
- Chemical hazards by specific materials or agents (e.g. contamination, by spill of mercury)
- Non-Ionizing Radiation Hazards (UV, Halogen lamps,...)
- Hazards after extraordinary events.

1.13.1 Electrical Hazards

Protection against electrical hazards is provided in general by enclosed, grounded cabinets for electrical parts using hazardous voltages. (e.g. lamp house, power supply for electronics and computer). All boxes and cabinets are equipped with warning labels for electrical hazards. If covers or connections are removed there is a risk of electric shock.



DANGER!

High Voltage!

Risk of Death by Electric Shock!

► Do not remove any cover as long electric voltage is present.

► Non-professional work inside the computers and the machine can cause electric shock.

► For maintenance work switch off the equipment.

► Follow the lockout/tagout procedures.



DANGER!

High Voltage!

Danger of Electric Shock!

► Ground the equipment!

► Never remove grounding cables from the equipment!



DANGER!

Dangerous Voltage inside the Machine!

Risk of Death by Electric Shock!

► When removing internal components (e.g. power supplies) from the equipment observe the warning labels (on the component or in the schematics).

► Make sure that the respective device has been discharged.

- In case of any fuse replacement use fuses only of the same type and with the same load as the replaced fuse.
- Never use auxiliary fuses.
- Never short circuit the fuse block.

If any electrical problem occurs, turn the machine off and notify a supervisor or maintenance staff immediately.

Safe Work during Maintenance of the Equipment:

- Maintenance, adjustment etc. on the electrical system must be performed by specifically qualified personnel only
- Only perform work at a fully de-energized („electrical cold“) equipment.
- Always observe the inhouse safety instructions and the lockout/tagout procedures.
- It should never be necessary for the operator to open the cover of an electrical portion of this machine.

1.13.2 Mechanical Hazards

Improper operation of the machine may result in serious injury.

Moving Parts:

The equipment has moveable parts (wafer transport systems, prealigner, alignment stage etc.) These hazard areas are labeled with warning labels.

- Moveable parts could catch foreign material e.g. clothing, fingers, hair,cables etc.
- Fingers could be crushed.



WARNING!

Crushing Hazard!

Risk of injury for hands and fingers by machine parts in actions.

► Keep all doors (if present) closed and do not remove any cover.

► Do not grab into running machine.

► Switch off the equipment for maintenance work.

Pressurized Lamps:

If equipped with a lamp house that uses pressurized UV lamps, improper handling of an UV lamp may result in injury from fragments of an exploding pressurized lamp.



WARNING!

Risk of Explosion!

UV lamps are highly pressurized. They can explode if mistreated causing serious injuries by fragments.

► Touch only when wearing face shield and gloves.

► Avoid rude handling.

► If not in use store it in its original box.

- Details see *Chapter 1.14 “Safe Handling of UV-Lamps to Avoid Mechanical and Chemical Hazards” on page 30*

Compressed Gases:

The machine uses compressed gases (CDA, Nitrogen) for many functions. Compressed air has the potential of harming people if abused or in cause of a fierce leak.

Do not lacerate pneumatic tubes or disconnect a pressurized tube! Always make sure that the gas supplies are switched off prior to work at the pneumatic system.

1.13.3 Thermal Hazards

Lamp House for Pressurized UV Lamps:

Thermal hazards will result from contact with heated parts of the equipment and may arise by premature opening of the lamp house door. During normal operation the upper exhaust duct of the lamp house on the back of the machine can attain the temperature of about 70°C. The UV lamp bulb and sockets are extremely hot when ON. After switching OFF the lamp needs cool down time and the interior of the lamp house needs continual cooling.



WARNING!

Risk of Burns!

The lamp and its surrounding are extremely hot - even after switched off the lamp.

► Do not touch the components.

► Wait until the surface has been cooled down below 40°C.

► Always wear heat resistant gloves.

1.13.4 Heavy Loads Hazards

Many system components are heavier than one person can safely lift without assistance e.g.:

- Machine chassis
- Base frame
- Alignment stage
- Lamp house



CAUTION!

Ergonomic Hazard!

Risk of damage and injury of the spine by lifting of heavy objects.

► Always use corresponding tools for lifting of heavy loads.

► Always move with the required number of persons.

An overview over tools and the required number of persons for carrying heavy machine components you find in *Chapter 1.10 “Transport and Installation” on page 18*

1.13.5 Noise Emission Hazards

The sound level measured in operator and maintenance areas is well below 70dB(A). No hazard is caused by noise.

1.13.6 Radiation Hazards by Non-Ionizing Radiation

1.13.6.1 UV Light

UV light is invisible for the human eye and can cause severe eye damages and skin burn.

Depending on the used wave length range the UV light is only accompanied by a low amount of visible light.



WARNING!

Risk of Eye Damage and Skin Burns!

Invisible high energy UV light may damage eyes or skin.

- ► Do not work on the machine if covers are removed.
- ► When performing light uniformity checks always wear UV protective glasses and cover your skin.
- ► Increased awareness is required when using short-wave UV250 or UV 300 light or when using 365 nm wavelength only.
- ► Increased awareness is required when the optional UV-LED light source is used with 365 nm wavelength exclusively, because this radiation is completely invisible to the human eye.



Safety Gloves
Media- and heat-resistant safety gloves protect hands from aggressive media, mechanical, thermal and radiation dangers.



UV-Safety Goggles
Safety goggles protect eyes from flying parts, splashing media and hazardous radiation.

If the UV-LED Lamp House is installed, three wavelengths (365 nm, 405 nm, 436 nm) intensities can be adjusted independently. While 405 nm and 435 nm are still visible as deep blue, the 365 nm radiation is invisible.

If this wavelength is selected and activated solely, very intense UV-light is emitted, which may be undetectable by the human eye. This can cause a potential dangerous situation which must be countered by adequate instructions to the operators.

1.13.7 Chemical Hazards

1.13.7.1 Chemicals Used or Produced by the Machine

Mercury (Hg)

The UV lamp contains a small amount of toxic mercury (Hg) Hg enclosed in an intact lamp bulb will not affect humans or the environment.

If a UV lamp breaks or bursts, counter measures to contain the mercury content are to be taken immediately.

Broken cold lamp:

If broken the cold lamp spills liquid mercury which must be caught:

- collect visible droplets by suction with a syringe or vacuum device.
- following clean up - including invisible remaining - shall be done using a mercury absorbing agent like sulfur powder or a specialized Hg-catcher like Mercurysorb by Carl Roth.

Explosion of a hot lamp:

- The mercury content will mostly being blown away as vapor very quickly.



WARNING!

Risk of Poisoning! Mercury is Very Toxic!

Incorporated mercury can result in chronic heavy disease!

► Avoid inhalation of mercury vapors!

► Immediately remove spilled mercury with recommended procedures and agents.

Procedure in case of lamp explosion:

1. Immediately switch of power for the lamp and the machine.
2. DO NOT switch off the exhaust system for the lamp. Suction is the most effective way to remove mercury vapors.
3. DO NOT open the lamp housing.
4. Immediately evacuate the immediate area of the machine.
5. Ventilate the room.
6. Wait at least 30 minutes before returning to the machine.
7. Remove glass fragments, bulb sockets and potential mercury residue, deposited inside the lamp house. Wear appropriate personal equipment such as Latex gloves and goggles.
8. Decontaminate the empty lamp house as described above for liquid mercury spillage.
9. Check exhaust lines and filters (if present) for Hg-contaminations. If necessary replace such parts
10. Wipe optics very gently using lint free paper, which is slightly dampened by a residue free liquid.
11. Treat all debris as well a the materials used in the cleanup as hazardous waste and dispose off accordingly.



NOTICE!

Follow local rules and laws for Hg waste.

Disposal of used lamps:

- Hg lamps are hazardous waste.
- They must be disposed according to local rules and laws.

- If possible, used lamps should be returned to the original supplier for recycling.
- Shipping by air only when declared as dangerous goods (UN2809) together with an IATA shipper‘s declaration and specially packed.

Ozone (O_3)

The UV lamps used in the mask aligner produce ozone especially directly after switch-on. A correctly adjusted exhaust for the lamp house provides for quick evacuation of the ozone. The measured values for the ozone concentration with correct exhaust is well below the limits accepted by OSHA.

- Operate the lamp only with correctly working exhaust.
- Use exhaust even for short operation of the lamp.

NOTICE!

To avoid exposure to ozone adjust the exhaust flow for the lamp house to the correct settings.
Never use the lamp without exhaust.

1.13.7.2 Use of Toxic or Secret Process Materials (Substrates, Resists)

When using toxic or company confidential materials (e.g. GaAs), the system's user has to make sure that his personnel is supplied with the necessary safety instructions and Safety Data Sheets to run the system in a safe way.

NOTICE!

It is the user’s responsibility to mark all containers and cassettes containing toxic materials with appropriate labels and warning signs.

1.13.7.3 Working with Cleaning Agents

Cleaning agents like isopropyl alcohol (IPA) are flammable solvents and must be used in accordance with Federal, State and local requirements. Proper precautions must be taken in the storage, use and disposal of this cleaning agent, which should be treated as hazardous materials.

- Only use in well-ventilated areas.
- Do not us in the vicinity ignition sources such as flames and sparks.



WARNING!

Highly Flammable Media!

Risk of burning because of highly flammable media!
► Keep away from ignition sources/hot surfaces.
► Wear personal protective equipment.
► Observe and comply with the corresponding safety data sheet.



WARNING!

Irritating Media!

Health hazard caused by contacting or inhaling of irritating media!

► Avoid eye and skin contact.

► Do not inhale.

► Wear personal protective equipment.

► Observe and comply with the corresponding safety data sheet.



Safety Gloves

Media- and heat-resistant safety gloves protect hands from aggressive media, mechanical, thermal and radiation dangers.



UV-Safety Goggles

Safety goggles protect eyes from flying parts, splashing media and hazardous radiation.



NOTICE!

All information concerning safety must be read and understood by the personnel who work with or in vicinity of the equipment before operation of the equipment.



NOTICE!

Components of the mask aligner - especially optical parts - only clean with IPA and DI water.

1.13.7.4 Working with other Chemicals

- When using other chemicals always wear recommended personal protective equipment (safety goggles, gloves, face shields etc.) in accordance with the chemicals you are handling.
- Consider and observe the corresponding Safety Data Sheets.

1.13.8 Increased Hazards after Extraordinary Events

Following an extraordinary event - heavy malfunction of equipment, overheating, seismic event, etc. - the equipment may be damaged without evidence.

- Do not run the machine without prior careful checks by service technicians.
- Follow the instructions in maintenance and service manual.
- If equipped with a lamp house for UV lamps, check that the UV lamp is undamaged.
- If a chiller is used, check if liquid has been spilled.

1.14 Safe Handling of UV-Lamps to Avoid Mechanical and Chemical Hazards

UV-lamps have a high internal pressure.
Hot lamps must not exposed to high temperature fluctuations.
Lamps must not exposed to mechanical pressure.

- Only open the lamp house if the lamp has been cooled down.
- Never touch lamp at its glass bulb. Only touch it at its ends.



WARNING!

Risk of Explosion!

UV lamps are highly pressurized. They can explode if mistreated causing serious injuries by fragments.
► Touch only when wearing face shield and gloves.
► Avoid rude handling.
► If not in use store it in its original box.



Safety Gloves
Media- and heat-resistant safety gloves protect hands from aggressive media, mechanical, thermal and radiation dangers.



UV-Safety Goggles
Safety goggles protect eyes from flying parts, splashing media and hazardous radiation.



NOTICE!

Each lamp destruction results also in emission of mercury.
Details concerning emission of mercury are described in section „Chemical Hazards“.

Rules for save handling of the lamp:

- Only transport and store the lamp in the original supplier‘s box.
- Only operate the lamp with a SUSS power supply which is optimized for the lamps.
- Only use lamps which are authorized form SUSS for the corresponding power supply.
- Respect the maximum life time of the lamp. It is specified in the lamp data sheet.
- Only open the lamp house after cool-down of the lamp.
- Set the cooling data carefully according to the manual.
- After lamp exchange check all electrical contacts and renew if necessary.
- Ensure that the cooling nozzle is adjusted correctly to the lamp socket.
- Check the lamp socket for discoloring. It is a sign for insufficient cooling. Check cooling if necessary.
- Avoid any mechanical stress to the bulb.
- Touch the lamp only at its ends (sockets), Never touch the bulb.

- Respect the orientation and polarity of the lamp during installation:
  - Standard: cathode (-) up
  - 5000 W lamps and dUV HgXe 500 W: cathode (-) down
- If changing the lamp type select the new lamp type in the menu of the lamp power supply BEFORE installation of the lamp.
- Read and respect the manual of the lamp power supply.

1.15 Safety Hazards during Operation, Maintenance and Service

Dangerous situations may arise if certain precautions and procedures are not strictly followed.

A description of the special interlocks and their functionality which are integrated in the SUSS system you find in *Chapter 1.17 “Safety Circuits of the Equipment” on page 42*

Type of Alarm Display	Description
Warnings	The warnings indicate dangers which may arise during installation, maintenance or operation of the equipment. Warning labels are positioned as close as possible to the potential hazard area or its safety cover inclusive the outer covers.
Alarm Messages GUI	Temporary dangerous situations during specific equipment conditions are able to be displayed in the user GUI.
Acoustic Alarm	Current dangerous conditions which require quick action are generated as acoustic alarm.
Signal Lamp (if the system is equipped with)	The signal lamp serves as display for the equipment condition for the personnel working with the equipment. The signal lamp is attached to the base frame. Detailed information concerning function of the signal lamp (if applicable) you find in the corresponding chapter of the equipment documentation.

1.15.1 Warnings and Warning Labels

All safety hazards of the equipment which are known by SUSS MicroTec Lithography GmbH at the time of effecting this manual are indicated with warning labels at the equipment in close vicinity of the hazard.
These warnings indicate dangers which may arise during installation, maintenance or operation of the equipment.

These warnings contain:

- one or more symbols or pictograms
- a clear keyword to identify the accident level.
- a description of the hazard and its possible consequence.
- a hint concerning the prevention of the hazard

NOTICE!

Do not remove or damage any warning label.
Use only cleaning agent IPA, because aggressive solvents may destroy the labels.
Immediately substitute any unreadable warning label (can be ordered from SUSS MicroTec)
Warning labels serve for the safety of the user!

1.15.2 Additional Safety Warnings

Lamp Power Supply CIC:

- Acoustic alarm
- Indicator lamps
- Display

The CIC shows its status with an 8-digit display and some indicator lamps.
If cooling fails the alarm of both display modes and an additional acoustic alarm will be used in combination.
Detailed description you find in the user manual of the CIC.

1.15.3 Possible Hazards in the Mask Aligner

Following overview drawings show the positions of possible hazards in the machine:

Legend concerning the positions of hazards:

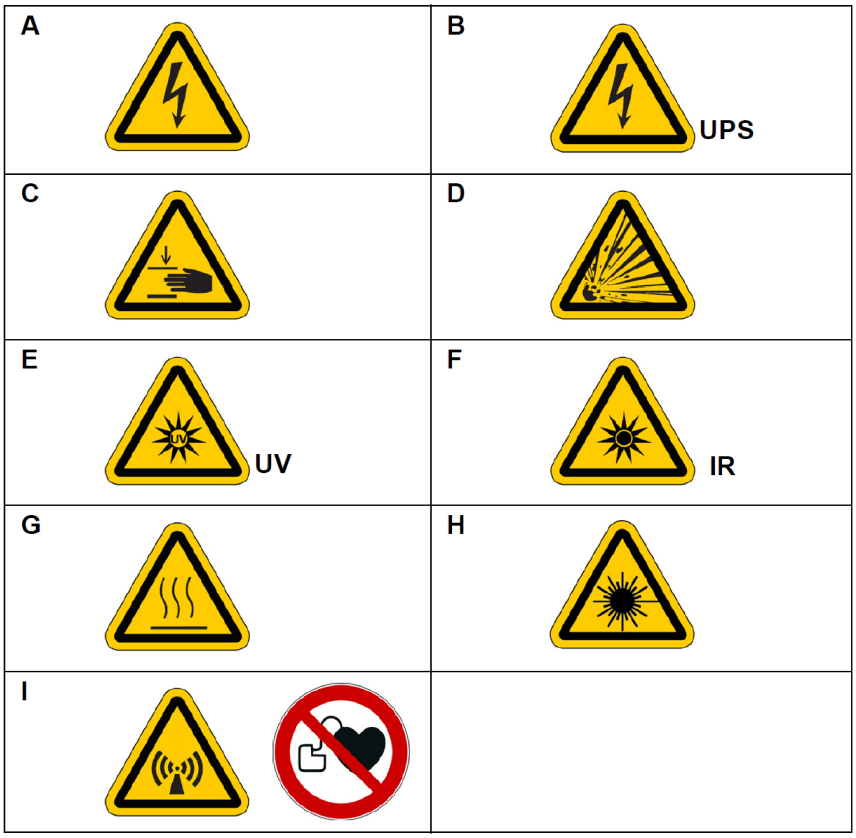


Fig. 1 - 1: Legend of Hazards

1.15.3.1 Front View

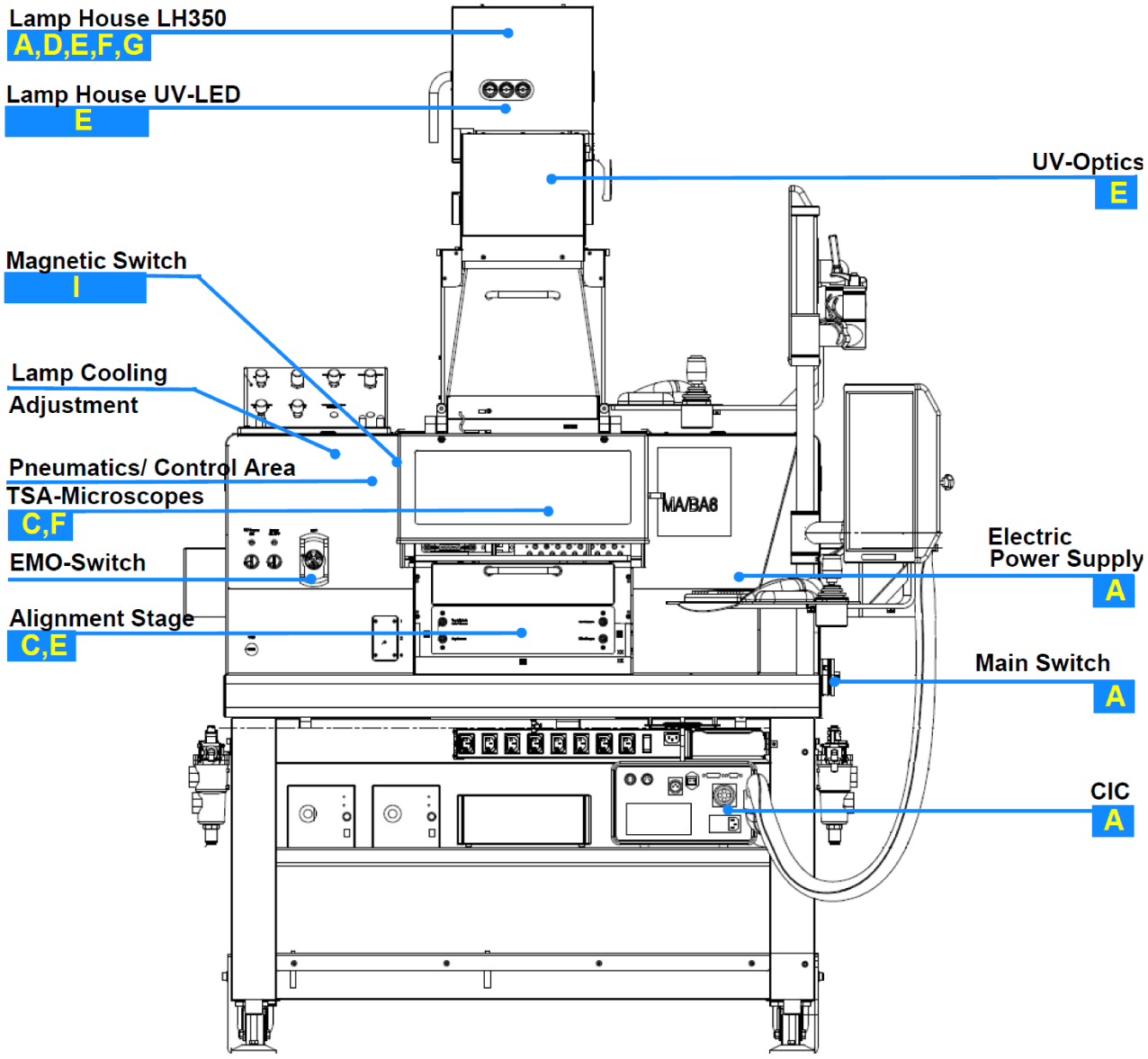


Fig. 1 - 2: MA/BA Gen4 Front View

1.15.3.2 Side View

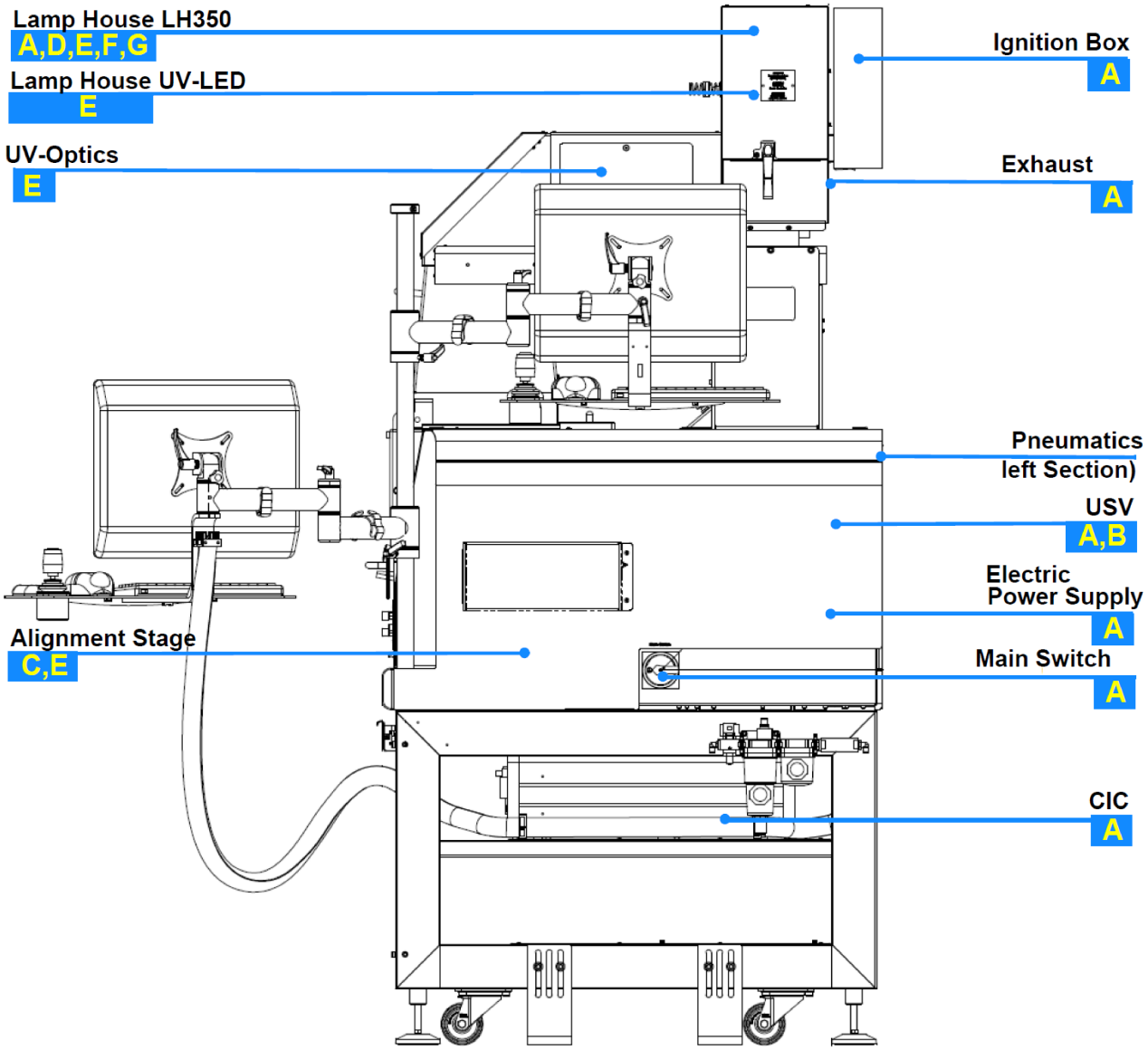


Fig. 1 - 3: MA/BA Gen4 Side View

1.16 Lockout/Tagout Procedure

Lockout/Tagout are planned safety procedures for shut-off the energy supply from industrial machines and equipment during maintenance and service work.
These procedures protect the workers from hazards coming from running machines or electric current.

Requirements:

- The lockout device/procedure should be in accordance with SEMI S2 and legal requirements (and for the USA with OSHA CFR (Code of Federal Regulations) Title 29, Part1910 sections 147 and 331-335)).
- The customer has to provide the possibility to centrally switch off the gas and media supply (vacuum, CDA, nitrogen etc) for service and maintenance work.

Lockout/Tagout for:

- safe work during maintenance, cleaning, repair
- prevention of personal injury
- prevention of material damage
- protection against own mistakes and mistakes from others.
- every visible and clear sign for locking of a machine

Lock and Tags:



Fig. 1 - 4: Example for Locks and Tags

WARNING!

Electric, Pneumatic and Thermal Hazards!

Risk of Personnel and Material Damage!

► Never try to operate switches, valves or separators for energy supply if they are locked or tagged accordingly.

1.16.1 Electrical Work - Voltage Types According to SEMI S2

TYPE 1: Equipment is fully de-energized (electrical „cold“)

TYPE 2: Equipment is energized. Energized circuits are covered or insulated. Electrical work is performed at a remote position to preclude accidental shock.

TYPE 3: Equipment is energized. Energized circuits are exposed and accidental contact is possible.
Potential exposures are less than 30 V RMS. 42.4 V peak, 60 V DC or 240 VA in dry location.

TYPE 4: Equipment is energized. Energized circuits are exposed and accidental contact is possible.
Potential exposure is greater than 30 V RMS, 42.4 V peak, 60 V DC, 240 VA or radio frequency (rf) able to result in hazardous voltages or energies.

Apply for maintenance: All work has to be done with completely de-energized („electrically cold“) equipment.
Condition Type 1 according to SEMI S2 has to be established.

The following procedure has to be implemented in order to safely perform relevant maintenance or service tasks of Type 1 and to ensure that the equipment is isolated from each possibly dangerous energy.

All equipment shall be isolated from all energy sources as described in the following sections and locked out or tagged out to protect against accidental or inadvertent operation when such operation could cause injury to personnel.
Make no attempt to operate any switch, valve, or other energy isolating device when it is locked or tagged out.

1.16.2 Responsibility

- Appropriate employees e.g. technicians, operation manager shall be instructed in the safety significance of the lockout/tagout procedure.
- Each new employee whose work operations is or may be in the area shall be instructed in the purpose and use of the lockout/tagout procedure.
- It is the manager’s responsibility to ensure that all appropriate employees are trained.
- The technicians are responsible for the correct realization for the lockout/tagout procedure before starting the maintenance work.

1.16.3 Preparation

► Locate and identify all isolating devices, (switch(es), valves or other isolating devices) relevant to the machine.

► Notify all affected employees that a lockout/tagout procedure is going to be utilized and the reason therefore.

The authorized employee shall know the type and magnitude of energy that the equipment utilizes and shall understand the hazards thereof.

1.16.4 Electrical Energy Isolation

Shut Down Procedure

Shut it down by the normal shut down procedure:

1. Switch off electrical power using the main switch on the machine
2. Unplug the supply cord at the facility outlet.
3. Ground (short circuit) the machine frame.
4. Check voltage free state: After ensuring that no personal are exposed, the voltage - free state (deadness) has to be checked.

NOTICE!

If the equipment is installed in the USA:
The circuit breaker in the supply area must not be installed more than 20 Feet (6 m) away from the operator station.

NOTICE!

Service work at electrical systems is only allowed to be performed by qualified personnel.
Covers of the electrical systems must not be opened by the operator.

In case of electrical problems:

► Switch off machine
► inform supervisor or technician.

Stored electrical energy:

Stored electrical energy which is able to be at risk for the operator has to be transferred into save condition:

- De-energize the capacitors and
- Short and ground circuit all highly-capacitive elements.

Stored non-electrical energy:

Stored non-electrical energy in components which could activate electrical circuits have to be blocked, discharged or de-activated to exclude any accidental activation of electrical circuits.

Examples for stored non-electrical energies are pneumatically controlled components which could set electrical valves.

Protection against unintentional switch-on:

1. All switches which are switched off have to be protected against unintentional switch-on, if possible with mechanical locks.
   If locks are not available, choose an alternative approved method to prevent unintentional switch-on. Additionally install a tag.

2. Identify pressure switches with warning labels or with similar methods to protect against unintentional built-up of pressure.
   For this:

   - check the pressure-free condition of the equipment with suitable measuring devices.

Grounding and short-circuit:

1. Ground and short circuit all components to be handled. The grounding/ short circuiting devices mist be connected to the grounding equipment first and then the components are to be grounded.

2. Attach the grounding/ short circuiting devices so that they are visible at the machine (if possible).
   If not, they have to be attached as near as possible to the machine.

3. Take appropriate measures (jumper, grounding) prior to beginning work, if wires are to be cut or interrupted.

4. Check that the grounding/ short circuiting devices, cables, connectors fit and that they are suitable for the short circuit stress at the installation position.

5. Ensure that all grounding and short circuit measures remain effective during work.
   If grounding and short circuit shall be removed for measurement or testing, take appropriate measures for security.

6. Cover/ barrier powered adjacent components:
   If components adjacent to the work location cannot be switched off, they must have appropriate covers or barriers. Notice and comply with the regulations according to „working adjacent to powered components“. In general - working in close proximity of powered components (> 30 V RMS or 42,2 V peak) is only allowed, if any access to powered components is limited by the appropriate covers or barriers.

Check zero-potential:

After ensuring that no personnel is in danger, the zero-potential state has to be checked at all connections in the vicinity of the machine.

- The checking devices have to be conform to inhouse regulations.
- Check transportable checking devices and voltmeters directly before and after use.

1.16.5 Pneumatic Energy Isolation

Switch-off of pressure supply for CDA and nitrogen for maintenance work:

1. Disconnect the supply for CDA and nitrogen. Use the main shut-off for this purpose.
2. Protect all shut-off options for CDA and nitrogen against unintentional switch-on, optionally with mechanical locks.
3. Mark all pressure valves with tags, labels or other proven methods to prevent accidental re-pressurization of the media supply.
4. If lockable valves are available at installation site, switch them off, lock and tag-out.
5. Disconnect the supply tubing from the valves outlet to permit dissipation of any stored pneumatic energy.
6. Check the depressurized state of the system by checking the main gauges.



NOTICE!

The user shall provide the possibility at supply end to close the media supply (vacuum, CDA, nitrogen) during maintenance and service work.

1.16.6 Thermal Energy Isolation

- Ensure that no danger comes from thermal energy stored inside the machine - especially in the lamp house.
- Wait until any part of the equipment that has been heated during the process had sufficient time to cool down to 40°C or lower.
- During the cool down time, keep cooling and exhaust running.



WARNING!

Hot Surfaces!

Danger of Burning!

► Do not touch hot components.

► Wait until the surface has cooled down below 40°C.

1.16.7 Lockout/Tagout Check List

Use following check list for lockout/tagout procedures for circuits or the equipment:

	Work Step	Done
1	Identify all sources of electrical energy for the equipment or circuits in questions.	☐
2	Disable backup energy sources such as generators and batteries.	☐
3	Identify all shut-offs for each energy source.	☐
4	Notify all personnel that equipment and circuitry must be shut off, locked out and tagged out.	☐
5	Shut off energy sources and main switch.	☐
6	Lock switchgear in the OFF position. (Each worker should apply his or her individual lock).	☐
7	Apply a tag and prevent it from removing.	☐
8	Test equipment and circuitry to make sure they are de-energized. This must be done by a qualified person.*	☐
9	Deplete stored energy by bleeding, blocking, grounding etc.	☐
10	Apply a tag to alert other workers that an energy source or piece of equipment has been locked out.	☐
11	Make sure everyone is safe and accounted for before equipment and circuits are unlocked and turned back on. Note that only a qualified person may determine when it is safe to re-energize circuits.	☐

* OSHA defines a „qualified person“ as someone who has received mandated training on the hazards and on the construction and operation of equipment involved in a task.

1.16.8 Restoring Machine to Normal Operation

Following items have to be observed before restoring machine to normal operation:

Perform tests and do visual checks:

A qualified person has to perform tests and visual checks to ensure that all interlocks are active and set to normal operation so that the equipment can set safely to normal operation.

Warn personnel:

Warn personnel that could be exposed to danger before switch-on of the machine.

Remove locks and tags:

Remove all locks and tags from the equipment. Only the person who did the locks/tags must remove them.

Exception: If a staff member is not available (change of shift, vacation) the locks/tags are allowed to be removed by a different operator. The supervisor of the original operator has to watch the procedure and make sure that all locks and tags will be returned to the originally responsible operator.

1.17 Safety Circuits of the Equipment

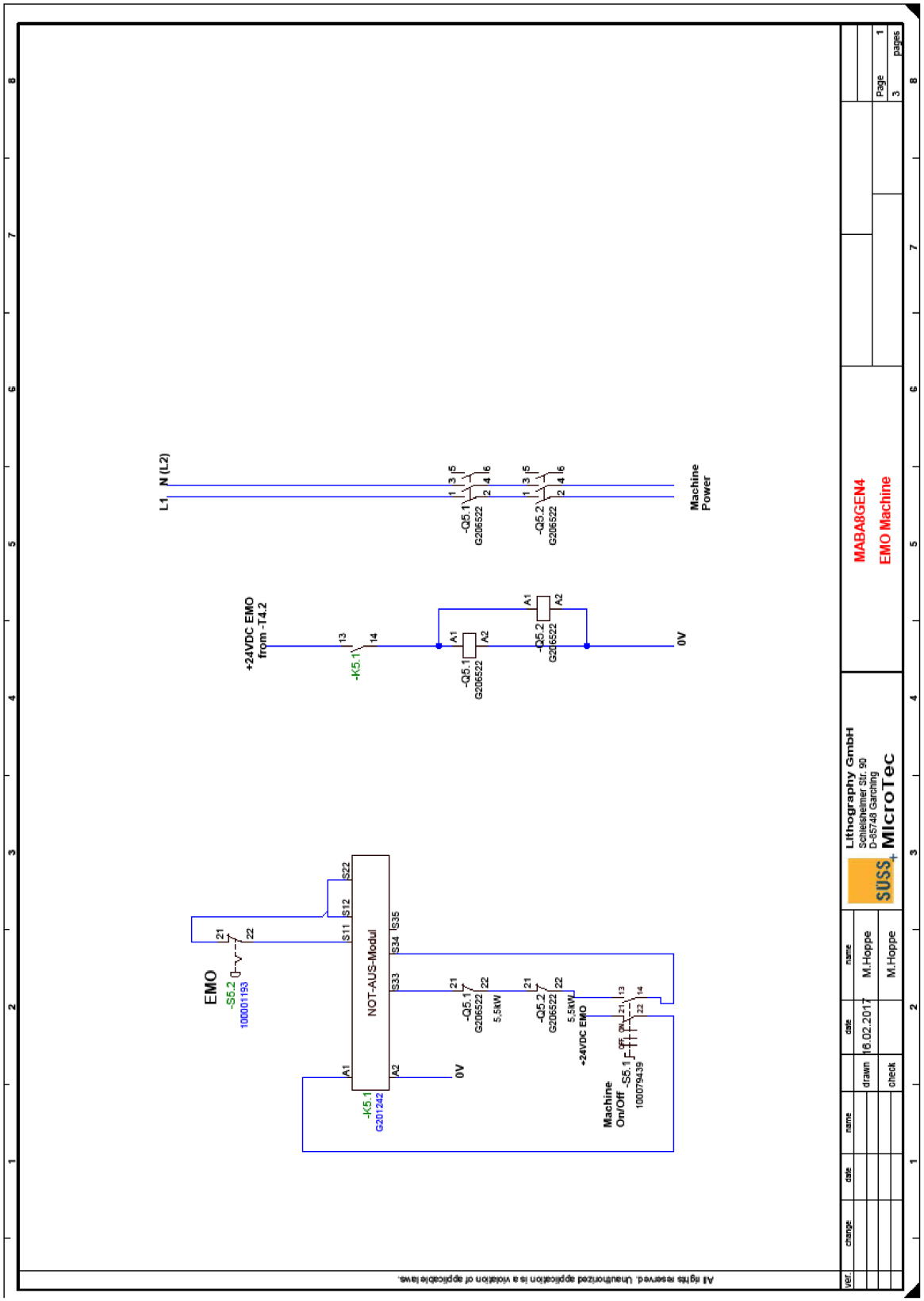
The mask aligner is equipped with several safety circuits for switch-off or warning in case of emergency.

The design of customer specific equipment is determined by the individual process requirements and the customer requirements.

Safety Circuit	Short Description	Mode of Operation
EMO	Switch-off of the machine except the computer.	If the EMO button (S5.2) is pressed the emergency- off module (K5.1 & K6.1) will switch off via relay (Q5.1 & Q5.2) the current to the machine and to the power supply of the UV-light source. The computer will remain energized for data saving reasons (option with UPS).
Flow Control Lamp Cooling	If the pressure of the CDA supply falls below the defined limit the lamp power supply (CIC) will be switched off after a defined delay. An optional flowmeter in the exhaust will also cause a shutdown.	If the pressure of the CDA supply controlled by the flowmeter (BP33.1) falls below a given limit, a delay (K.2 - K6.3) will become active. If at the end of the delay the measured pressure is still below the limit, the power for the UV-light source will be switched off via emergency-off module (K6.1) and the relays (Q6.1 & Q6.2).
Lamp House-Door Switch	If the locked door is opened the UV-light source will be switched off by triggering with the door switch.	If the lamp house door is opened, the switch (S7.1) will be opened. The power of the UV-light source will be switched off via emergency-off module (K6.1) and the relays (Q6.1 & Q6.3)

Safety Circuit	Short Description	Mode of Operation
Front UV-Protection	If the cover at the front of the optics tube is opened the shutter will remain in closed position/ the UVlight source will be switched off.	If the safety sensor (S7.3) is released the shutter opener (KP33.2) will be locked or the signal for shutter opening will be interrupted.
UV-Protection Optics	If the cover for access to the optics is opened the shutter will remain in closed position/ the UV-light source will be switched off.	If the safety sensor (S7.3) is released the shutter opener (KP33.2) will be locked or the signal for shutter opening will be interrupted.
UV-Protection/ UV-LED Light source	If the lamp house is moved backwards away from its required position, the UV-light source will be switched off or cannot be switched on.	If the safety sensor (S7.3) is released the power for the UV-LED light source will be switched off.

1.17.1 EMO


L1
N (L2)
-Q5.1
G206522
-Q5.2
G206522
Machine
Power
+24VDC EMO
from -T4.2
-K5.1
0V
EMO
-S5.2
100001193
NOT-AUS-Modul
-K5.1
G201242
5,5kW
+24VDC EMO
Machine
On/Off
-S5.1
100079439
MABA8GEN4
EMO Machine
Lithography GmbH
Schleißheimer Str. 90
D-85748 Garching
MicroTec
M.Hoppe
16.02.2017
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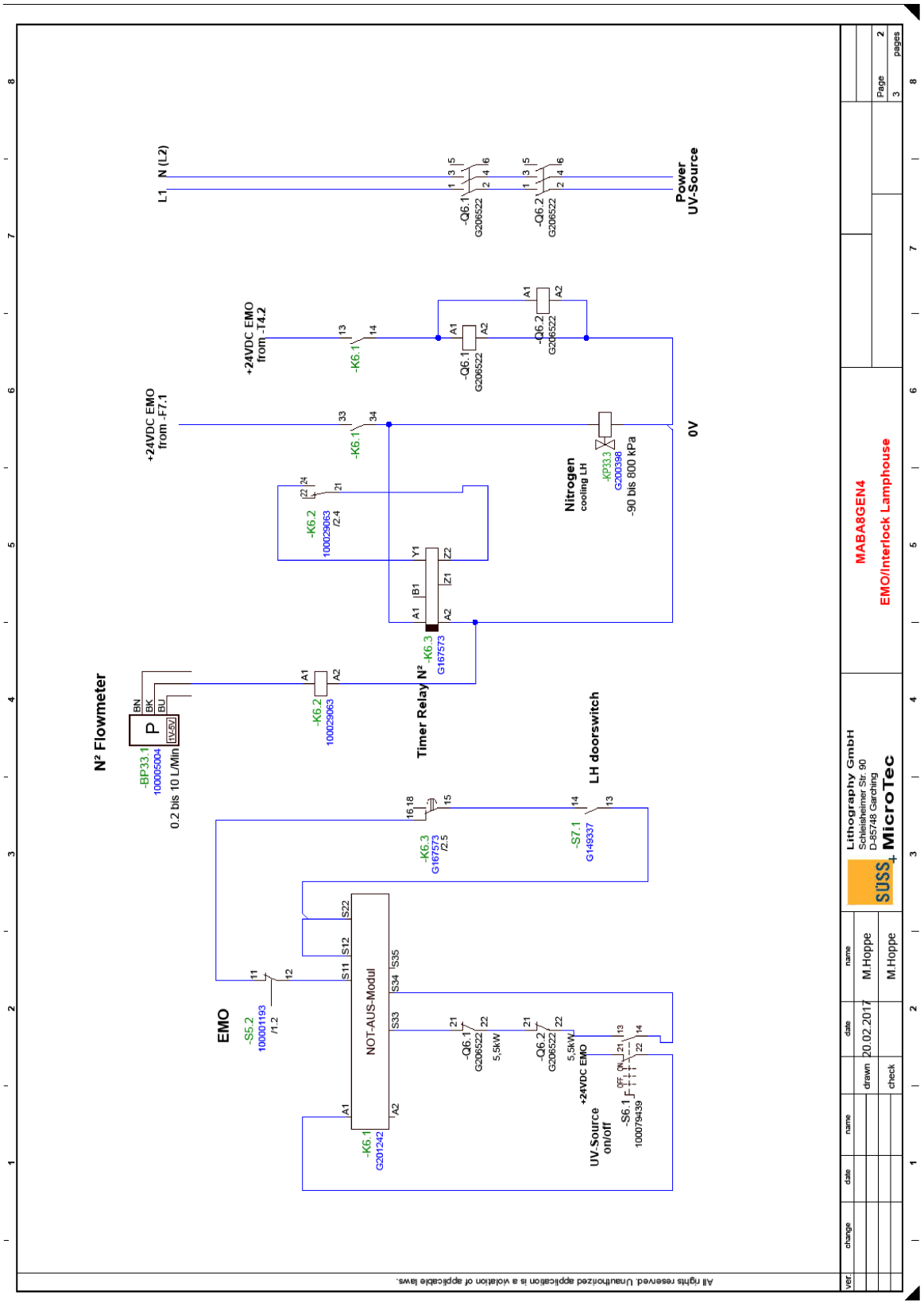
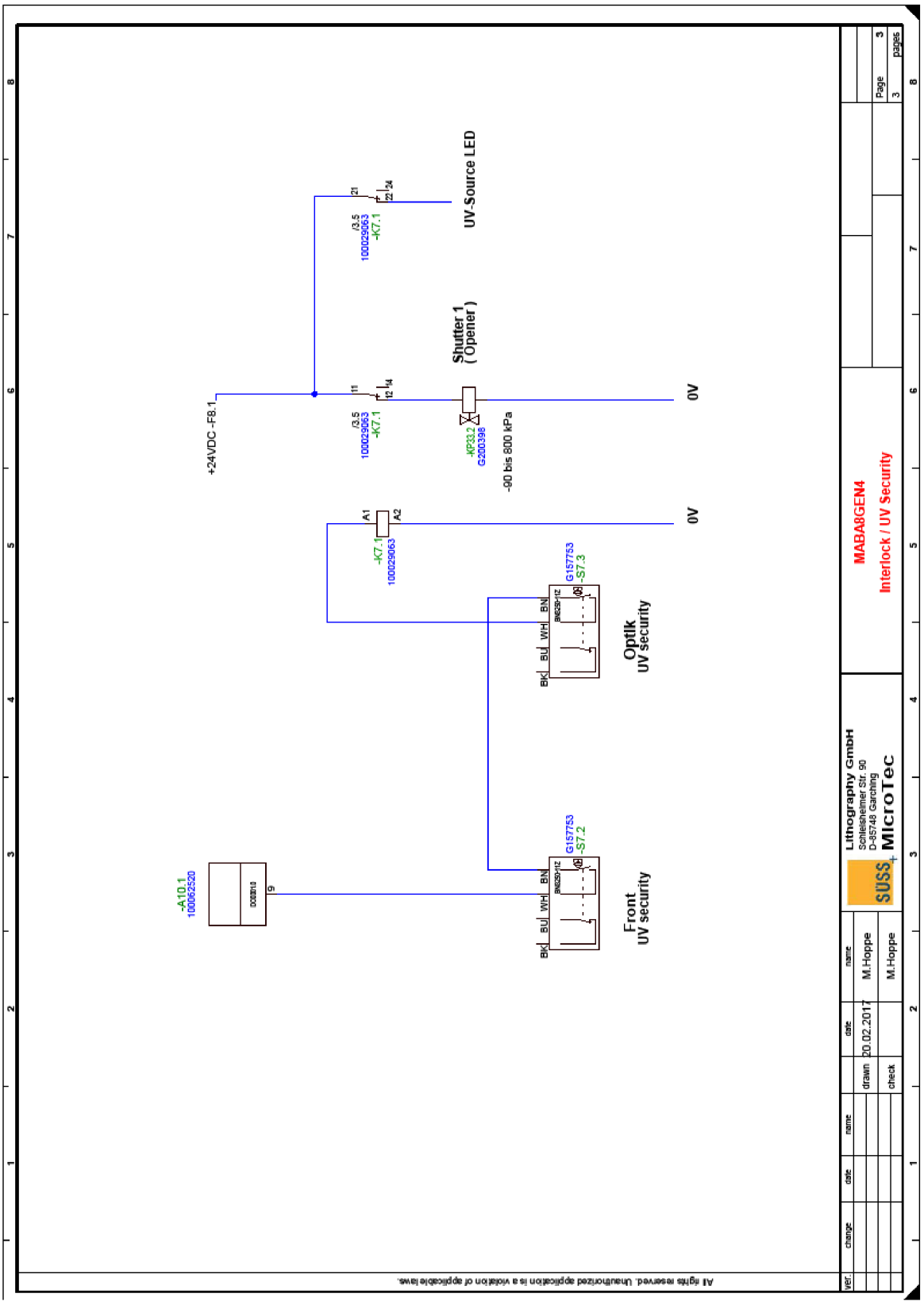
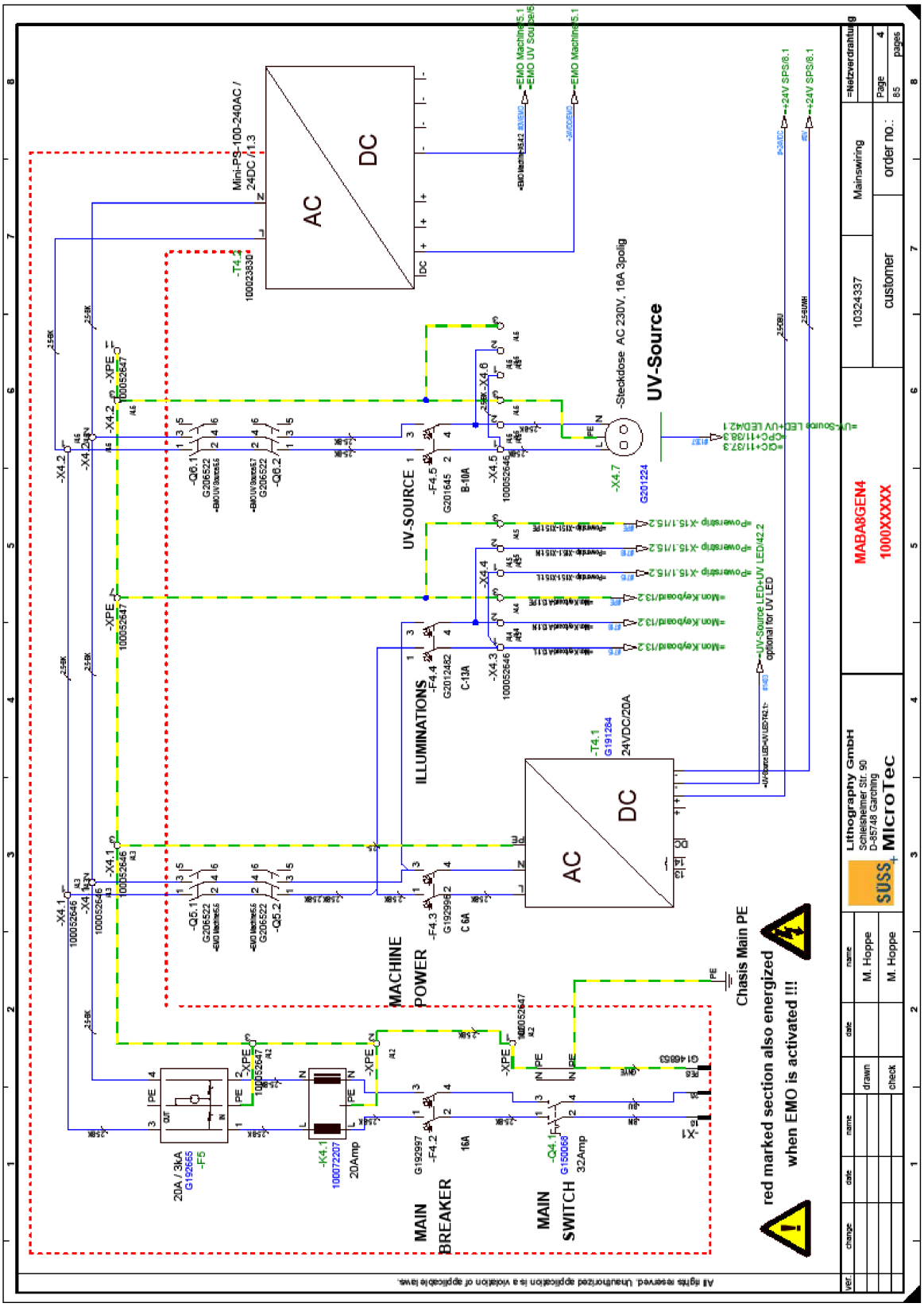
1.17.2 EMO Lamp House Door and Lamp Cooling



1.17.3 UV-Protection/Optics



1.17.4 Main Circuits



1.18 Decontamination, Relocation and Decommissioning

For relocations or periods of decommissioning, potentially contaminated parts, modules or the complete tool need to be decontaminated before storage or transport of those parts modules or the complete tool. Contaminations can be caused by process chemistry (e.g. Coater) or cleaning agents. Shreds of substrates or other materials, if containing hazardous substances, may also cause contaminations of parts of the tool.

For parts/ tools having been in contact with potential hazardous substances the decontamination procedure additionally includes:

- application of the guideline of SEMI S12 - Environmental, Health and Safety Guideline for Manufacturing Equipment Decontamination or equivalent.
- application of local regulations (place of use).
- application of transport regulations
- application of local regulations of the target location (destination).

1.18.1 Recommended Procedure

1. Remove all hazardous energies (full disconnect, lockout/tag-out). - If present, drain all chemicals (media) and cooling or heating liquids (treat and dispose of according local requirements).

2. Disconnect the UPS-battery (lead gel type). On longer periods of decommissioning these batteries should be taken out of the tool and stored in a safe location.

3. Remove all potential hazardous parts (e.g. Hg-lamps, substrates residues). Based on IATA and other regulations, mercury vapor lamps shall not be left in the tool for transport.

4. Clean the part/ the tool (as for regular maintenance).

5. Rinse all parts that have been in contact with process chemicals (e.g. tanks, pumps, tubes, valves, fittings, filter, exhaust lines; residues in other areas e.g. drip pans) according SEMI S12.
   Recommended rinsing media is IPA, in some cases acetone (contact SUSS Service for details).
   Finally rinse with DI-water, followed by drying of all parts (if necessary use CDA).
   Filters or parts may be completely removed (document such filters or parts accordingly).

6. Check the part / tool before packaging.

The decontamination and its result shall be available as documented information.

NOTICE!

SUSS will not accept part or tools without the RMA - EHS form as proof for hazard free material.

For assistance please contact the local SUSS Service (*http://www.suss.com/en/service.html*) Regular fees may apply).

1.18.2 Re-Installation

After the time of decommissioning, after repair, overhaul or upgrade of parts or complete tools may be reinstalled and reactivated for further use, it is recommended to employ SUSS Service for this tasks.

In any case, a full safety check needs to be performed before bringing a previously decommissioned tool back into normal operation (similar or same as commissioning of a new tool, refer to the tool manual).

1.18.3 Reuse, Rcycling or Disposal

After its useful lifetime and after proper decontamination, SUSS may take back complete tools or other parts of the machine (transport costs to be carried by the tool owner). Those tools or parts may be worked up, modified or upgraded for reuse or given to recycling. Parts where recycling appears not feasible may be given for disposal by a licensed business partner.

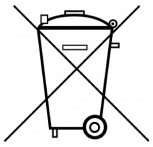


Fig. 1 - 5: WEEE-Mark

Alternatively, parts or the complete tool may be handed over to a local recycling or waste management company. Please note that in various regions specific regulations exist for these matters (e.g. material related, transport related). In the EU, all electrical and electronic parts marked with the “WEEE-Mark” need to be collected separately.

If the tool is to be dismantled on site it is recommended to employ an experienced or licensed service provider with this task, SUSS Service may also assist (regular service fees will apply).

If to be sent back to SUSS, parts (components, modules) or complete tools (machines) shall be announced to SUSS or to the direct recipient before shipment. SUSS or others may not accept a shipment without comprehensive decontaminations documentation (for repairs the RMA EHS form shall be used. For taking back complete tools, also for trading back used machines, please contact SUSS ReMan (*http://www.suss.com/en/products-solutions/products/remanufactured-equipment.html*).

NOTICE!

Parts, components or tools that are not operational anymore are not to be regarded as waste but as economic goods (intended for fail analysis, repair and reuse or recycling).
Those items shall be indicated in shipment documents accordingly.

Packaging material provided with the tool is not contaminated with hazardous substances and can be directed to reuse or recycling according to local requirements.
If desired, SUSS may take back packaging material (transport cost to be carried by the end tool owner).

1.18.4 Materials of Construction, RoHS, WEEE, REACH

SUSS machines by themselves are not in the scope of the EU-RoHS, WEEE or similar directives, however and while aiming for voluntary alignment with those directives, declarations for materials may be given in the product documentations (either on the tool computer or as CD – section 12 Docu / 02 Appendix / Material_Information).

Regarding material processed on SUSS machines (product of the customer) SUSS MicroTec hereby declares that products and materials handled or processed by any SUSS MicroTec equipment will not be contaminated with hazardous or restricted substances.

Concerning the EU-REACH-Directive, at present, SUSS is not providing substances (chemicals) into the market. SUSS is especially not providing process chemicals that may be used with our machines. Machinery or equipment from SUSS or parts thereof may classify as ‘articles’ within the context of the directive. However, so far none of these ‘articles’ have been identified as ‘intentionally releasing’ substances nor as containing ‘Substances of Very High Concern’ (SVHC) or other dangerous substances in quantities or concentrations requiring registration, information or other actions.

2 MAINTENANCE PLANS

2.1 Safety at Maintenance

WARNING!

Risk for Personal Injury and Material Damage!

Equipment of this type may cause serious personal injury or material damage if it is not used or operated in the correct manner, or if unqualified personnel has access to it.



Before maintanance and operation of the equipment following safety information has to be read carefully!

NOTICE!

The chapter "Safety Precautions" contains information the operator must know and understand in order to avoid the risk of personal and equipment damage.

NOTICE!

Only especially trained personnel is allowed to perform maintenance work described in this manual.

NOTICE!

Any service work described in this manual is only allowed to be performed by service technicians of SUSS MicroTec or by persons especially trained for this work by SUSS MicroTec.

2.2 Maintenance Intervals

For safety reasons and in order to avoid fault events, maintenance work has to be carried out completely and in regular intervals.

To ensure continued optimum performance and a long operating life, proper routine maintenance and care are absolutely necessary. During operation be alert to behavior or changes in operation, or process results or to any unusual machine noises. They may be symptomatic for problems which could damage the machine if left uncorrected.

An appropriate and sustainable maintenance plan guarantees a long operation period and reduces down time.

The maintenance work listed in this manual is a manufacturer recommended plan based on longtime experience in components design, assembly and operation of the equipment.

The listed maintenance intervals are based on a „normal“ use of the system. If abnormal operating conditions prevail - like crumbling, dusty or extra heavy substrates, ambiance charged with solvent fume etc. the corresponding maintenance tasks have to be intensified adequately. Cleaning and greasing intervals have to be adapted to the intensity of use and environmental conditions as well.

The intervals of the maintenance tasks are given in absolute time and are based in principle on a 3-shifts-per-day work. Even if a machine is used less than 1 shift per day, not time interval should be extended more than 3-times the recommended time. Safety related checks should not be extended anyway.

2.3 Overview of Maintenance and Service Work

2.3.1 Table of Intervals

Intervals/Shifts	3 Shifts, 7 Days/ Week
3	**daily**
20	**weekly**
100	**monthly**
500	**semi-annually**
1000	**annually**
2000	**every 2 years**
4000	**every 4 years**

2.3.2 Maintenance Work

Assembly	Action	Chapter	Interval	Shifts	Time (Min)
Pneumatics	Check Pressure Values	3.1.1	daily	3	5
Chuck	Inspection and Cleaning	3.2.1	daily	3	5
Mask Holder	Mask Holder	3.4.1	daily	3	5
Mask Holder	Functional Test of the Spacers	3.4.1	daily	3	5
Vibration Isolation	Functional Test	3.1.2	weekly	20	5
TSA-/BSA-Micro-scope	Inspection of Contrast, Cleanliness of the Optics	3.5.1	weekly	20	10

Assembly	Action	Chapter	Interval	Shifts	Time (Min)
Shutter	Functional Test	3.6.1	weekly	20	5
UV-Lamp/ UV-LED	Measurement of Light Intensity	3.6.2/ 3.7.1	weekly	20	15
Vertical Tube	Functional Test of Manual Movement	3.6.3	weekly	20	5
WEC-Head	Functional Check of the Mechanics	3.2.2	monthly	100	15
Mask Holder	Cleaning of the Spacers	3.4.1	monthly	100	15
UV-Lamp	Measurement of Light Uniformity	3.6.2	monthly	100	15
UV-Lamp (only 500W)	Measurement of Exhaust Temperature	3.6.6	monthly	100	40
Exposure Optics	Inspection and Cleaning	3.6.8/ 3.7.4	monthly	100	240
UV-LED Light Source	Check of Cooling Fans/ Interlock	3.7.1	monthly	100	60
UV-LED Light Source	Check of LEDS	3.7.1	monthly	100	30
UPS	Battery Check	3.8.1	monthly	100	5
EMO	Functional Test	3.9.1	monthly	100	5
Interlocks	Functional Test of all Interlocks	3.9.2	monthly	100	10

2.3.3 Service Work

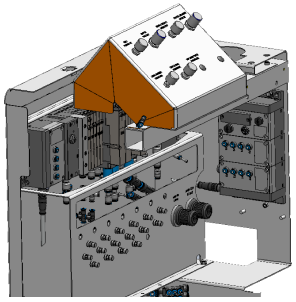
Assembly	Action	Chapter	Interval	Shifts	Time (Min)
WEC-Head	Checking of Parallelism	3.2.2	semi-annually	500	120
Alignment Stage, X/Y	Cleaning and Greasing of Spindles and Guidings	3.4.2	semi-annually	500	30
Alignment Stage, Θ-Axis	Cleaning and Greasing of Theat-Guidings	3.4.3	semi-annually	500	5
TSA-Focussing Unit	Inspection of the Focussing Movement	3.5.2	semi-annually	500	120
BSA-Focussing Unit	Inspection of the Focussing Movement	3.5.3	semi-annually	500	120
Microscope Stage	Cleaning and Greasing of Guidings	3.5.4	semi-annually	500	30
Microscope Stage	Tensioning of the Tooth Belt	3.5.5	semi-annually	500	60
Shutter	Cleaning and Greasing of Shutter Sliding Block	3.6.1	semi-annually	500	30
Lamp Adapter	Exchange of Corroded Cables	3.6.4	semi-annually	500	20
Pneumatics	Check Lock Nuts of the Throttles	3.1.3	annually	1000	5
WEC-Head	Inspection and Sensor Adjustment	3.2.2	annually	1000	
WEC-Head	Cleaning and Greasing of Brake Piston	3.2.2	annually	1000	

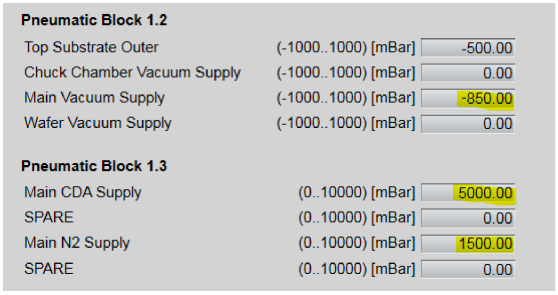
Assembly	Action	Chapter	Interval	Shifts	Time (Min)
Z-Axis	Cleaning and Greasing of Friction Drive/ Ball Cage	3.3.1	annually	1000	60
Shutter	Exchange and Factory Overhaul	3.6.1	annually	1000	30
Lamp Manipulator	Greasing of Manipulator Axes	3.6.5	annually	1000	10
UV-Optometer	Factory Calibration	3.6.7/ 3.7.3	annually	1000	--
WEC-Head	Exchange and Overhaul	3.2.2	every 2 years	2000	--
Microscope Stage	Exchange of the Tooth Belts (4 Pieces)	3.5.5	every 4 years	4000	120
UV-Lamp	Exchange		after 600 operating hours		60

3 COMPONENTS in MAINTENANCE OVERVIEW

3.1 Pneumatics

3.1.1 Pneumatics





MAINTENANCE TASK:	***Check Pressure Valves*** **(GUI: Service View/Pneumatics)**
Requirements:	Machine is pneumatically connected and operable
Tools:	--
Grease/ Cleansing Material:	--
Spare Parts:	--
Target State:	Reference values for maintenance: • CDA: 5 +/- 0.2 bar • Vacuum: < - 0.8 bar • Nitrogen: 1.5 +/- 0.2 bar
Interval/Shifts:	***daily/3***
Time (Min):	***5***

3.1.2 Vibration Isolation

MAINTENANCE TASK:	***Functional Test: Deflection of the base plate up and down***
Requirements:	Machine is pneumatically connected and operable
Tools:	--
Grease/ Cleansing Material:	--
Spare Parts:	--

MAINTENANCE TASK:	*Functional Test: Deflection of the base plate up and down*
Target State:	Stable position of the base plate will be re-established without over-shoot. No periodic swinging
Interval/Shifts:	***weeky/20***
Time (Min):	***5***

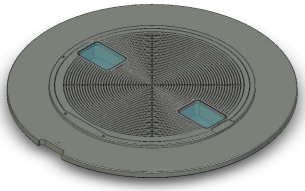
3.1.3 Pneumatics Block



MAINTENANCE TASK:	*Check Lock Nuts of the Throttles*
Requirements:	--
Tools:	--
Grease/ Cleansing Material:	--
Spare Parts:	--
Target State:	Lock nuts of all throttles are fixed.
Interval/Shifts:	***annually/1000***
Time (Min):	***5***

3.2 Wedge Error Compensation Head

3.2.1 Chuck

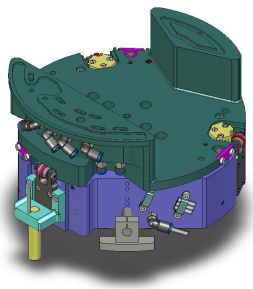


Caution!

The surface is Teflon-coated. Clean only with Isopropanol. Never use Aceton or Cyclopentanon!

MAINTENANCE TASK:	***Inspection and Cleaning of the Surface***
Requirements:	--
Tools:	--
Grease/ Cleansing Material:	• Isopropanol • Lintfree tissues • CDA/ Nitrogen
Spare Parts:	--
Target State:	Free of contamination (resist) and scratches No damage of vacuum seal (for vacuum contact chucks)
Interval/Shifts:	***daily/ 3***
Time (Min):	***5***

3.2.2 WEC-Head



MAINTENANCE TASK:	***Functional Check of the Mechanics***
Requirements:	Machine is pneumatically connected and operable.
Tools:	--
Grease/ Cleansing Material:	--
Spare Parts:	--

MAINTENANCE TASK:	***Functional Check of the Mechanics***
Target State:	With centric, steadily increasing pressure: • the head enters without shuttering or tilting • the head comes out without shuttering At the moment of switching of the WEC-sensor the centric force should amount to 8 N ± 0.5 N.
Interval/Shifts:	***monthly/ 100***
Time (Min):	***15***

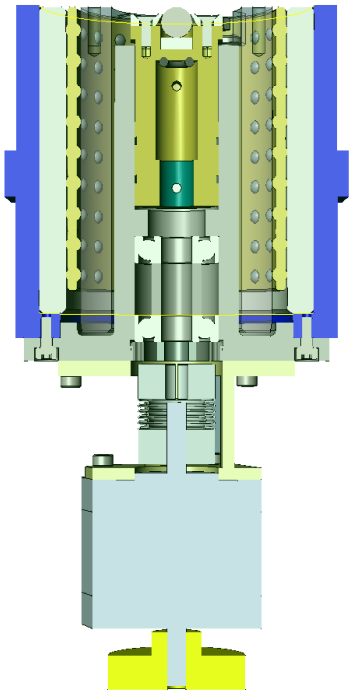
MAINTENANCE TASK:	***Checking of Parallelism***
Requirements:	Machine is pneumatically connected and operable.
Tools:	Distance measurement device (e.g. Heidenhain)
Grease/ Cleansing Material:	--
Spare Parts:	--
Target State:	• Parallelism during WEC-movement within specification • Repeatability of position accuracy in alignment-, exposure-, proximity gap
! NOTICE!	Adjustment only by SUSS Service
Interval/Shifts:	***semi-annually/ 500***
Time (Min):	***120***

MAINTENANCE TASK:	***Inspection and Sensor Adjustment***
Requirements:	Machine is pneumatically connected and operable.
Tools:	--
Grease/ Cleansing Material:	--
Spare Parts:	--
Target State:	Sensor adjustment retraction depth ino level sensor WEC: 1 mm
! NOTICE!	Adjustment only by SUSS Service
Interval/Shifts:	***annually/ 1000***
Time (Min):	

MAINTENANCE TASK:	***Cleaning and Greasing of Brake Piston***
Requirements:	Machine is switched off.
Tools:	--
Grease/ Cleansing Material:	Grease Leitz # 310
Spare Parts:	--
Target State:	Free of contamination and deposit
! NOTICE!	Adjustment only by SUSS Service
Interval/Shifts:	***annually/ 1000***
Time (Min):	

MAINTENANCE TASK:	***Exchange and overhaul***
Requirements:	Machine is switched off.
Tools:	Distance measurement device (e.g. Heidenhain)
Grease/ Cleansing Material:	--
Spare Parts:	possibly exchange of WEC-head
Target State:	Newly adjusted, fully functional WEC-head
! NOTICE!	Exchange only by SUSS Service
Interval/Shifts:	***every 2 years/ 2000***
Time (Min):	

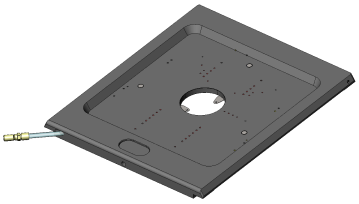
3.3 Z-Axis



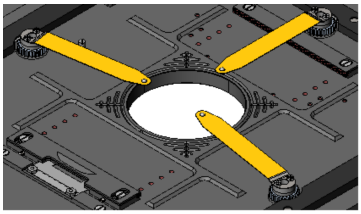
MAINTENANCE TASK:	*Cleaning and Greasing of Friction Drive/ Ball Cage*
Requirements:	--
Tools:	--
Grease/ Cleansing Material:	Grease OPTAPLUS A035
Spare Parts:	--
Target State:	Clean guidings, free moving
! NOTICE!	Adjustment only by SUSS Service
Interval/Shifts:	***annually/ 1000***
Time (Min):	***15***

3.4 Alignment Stage

3.4.1 Mask Holder



MAINTENANCE TASK:	*Inspection and Cleaning of the Surface*
Requirements:	--
Tools:	--
Grease/ Cleansing Material:	• Isopropanol • Lint free tissues • CDA/ Nitrogen
Spare Parts:	--
Target State:	Mask contact area free of contamination (resist) and particles.
Interval/Shifts:	***daily/ 3***
Time (Min):	***5***

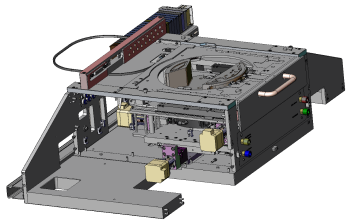


MAINTENANCE TASK:	*Functional Test of the Spacers*
Requirements:	--
Tools:	--
Grease/ Cleansing Material:	--
Spare Parts:	--
Target State:	Spacers free of contamination Cylinder without vacuum/ pressure leakage Distanc of spacers to the mask 1-2mm

MAINTENANCE TASK:	*Functional Test of the Spacers*
Interval/Shifts:	***daily/ 3***
Time (Min):	***5***

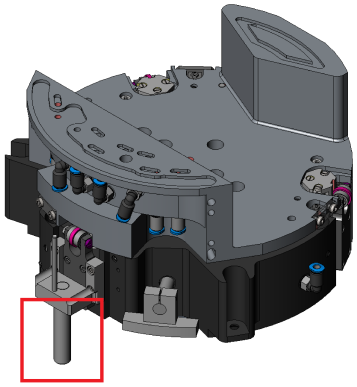
MAINTENANCE TASK:	*Cleaning of the Spacers*
Requirements:	--
Tools:	--
Grease/ Cleansing Material:	• Isopropanol • Lint free tissues • CDA/ Nitrogen
Spare Parts:	--
Target State:	Proximity balls free of contamination
Interval/Shifts:	***monthly/ 100***
Time (Min):	***15***

3.4.2 Alignment Stage, X/Y



MAINTENANCE TASK:	*Cleaning and Greasing of Spindles and Guidings*
Requirements:	--
Tools:	--
Grease/ Cleansing Material:	Grease ISOFLEX NBU15. Apply very thinly!
Spare Parts:	--
Target State:	Spindles and guidances are free of contamination and old grease.
! NOTICE!	Maintenance only by SUSS Service
Interval/Shifts:	***semi-annually/ 500***
Time (Min):	***30***

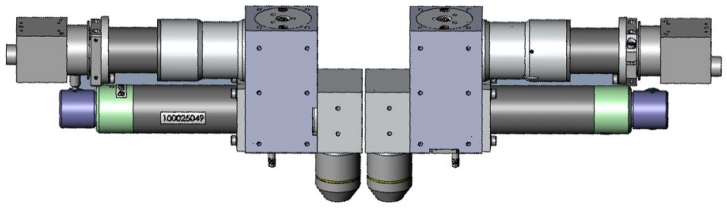
3.4.3 Alignment Stage, Rotation Axis (Θ)



MAINTENANCE TASK:	*Cleaning and Greasing of Theta-Guiding*
Requirements:	--
Tools:	--
Grease/ Cleansing Material:	Grease Leitz 310 or light oil
Spare Parts:	--
Target State:	free of contamination and old grease.
! NOTICE!	Maintenance only by SUSS Service
Interval/Shifts:	***semi-annually/ 500***
Time (Min):	***5***

3.5 Microscopes

3.5.1 TSA-/BSA-Microscopes Complete: Image Quality



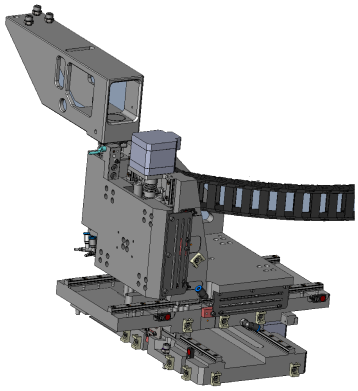
TSA-Microscope



BSA-Microscope

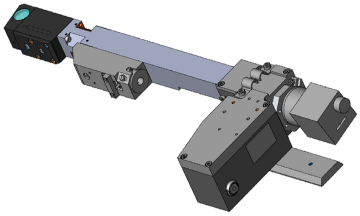
MAINTENANCE TASK:	***Inspection of Contrast, Cleanliness of the Optics Cleaning of the Objective Front Lens (if necessary)***
Requirements:	Machine is switched on.
Tools:	Blank, clean wafer
Grease/ Cleansing Material:	N2-blow IPO or DI-water soaked lint-free tissues
Spare Parts:	--
Target State:	Image of the wafer is free of dust or particles and with good contrast
! NOTICE!	Cleaning of the inner microscope optics only by SUSS
Interval/Shifts:	***weekly/ 20***
Time (Min):	***10***

3.5.2 TSA Focussing Unit



MAINTENANCE TASK:	*Inspection of the Focussing Movement*
Requirements:	Machine is switched on.
Tools:	--
Grease/ Cleansing Material:	--
Spare Parts:	--
Target State:	X/Y-movement is carried out parallel to the mask 5x objective remains focussed over the whole area
! NOTICE!	Adjustment only by SUSS service
Interval/Shifts:	***semi-annually/ 500***
Time (Min):	***120***

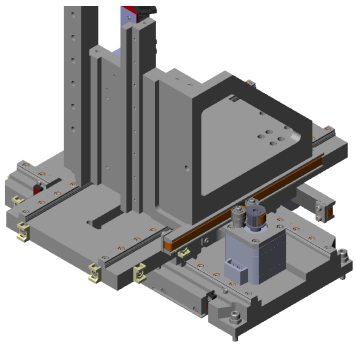
3.5.3 BSA Focussing Unit



MAINTENANCE TASK:	*Inspection of the Focussing Movement*
Requirements:	Machine is switched on.
Tools:	--
Grease/ Cleansing Material:	--
Spare Parts:	--
Target State:	Focussing perpendicular to the mask surface

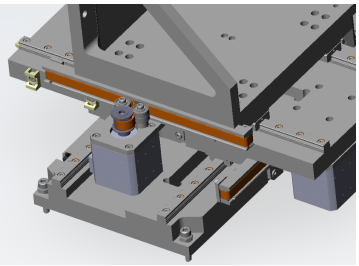
MAINTENANCE TASK:	*Inspection of the Focussing Movement*
! NOTICE!	Adjustment only by SUSS service
Interval/Shifts:	***semi-annually/ 500***
Time (Min):	***120***

3.5.4 Microscope Stage



MAINTENANCE TASK:	*Inspection of the Focussing Movement*
Requirements:	Machine is switched on.
Tools:	--
Grease/ Cleansing Material:	--
Spare Parts:	--
Target State:	Focussing perpendicular to the mask surface
! NOTICE!	Adjustment only by SUSS service
Interval/Shifts:	***semi-annually/ 500***
Time (Min):	***120***

3.5.5 Tooth Belt

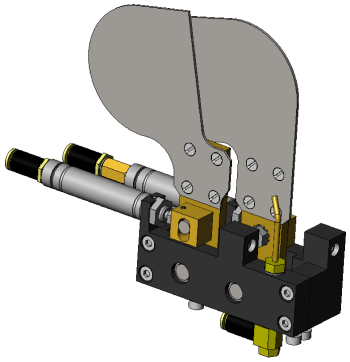


MAINTENANCE TASK:	***Tensioning of the Tooth Belt***
Requirements:	--
Tools:	--
Grease/ Cleansing Material:	--
Spare Parts:	--
Target State:	--
! NOTICE!	Adjustment only by SUSS service
Interval/Shifts:	***semi-annually/ 500***
Time (Min):	***60***

MAINTENANCE TASK:	***Exchange of the Tooth Belts (4 Pieces)***
Requirements:	--
Tools:	--
Grease/ Cleansing Material:	--
Spare Parts:	New tooth belt
Target State:	--
! NOTICE!	Exchange only by SUSS service
Interval/Shifts:	***every 4 years/ 4000***
Time (Min):	***120***

3.6 Exposure Unit LH350

3.6.1 Shutter

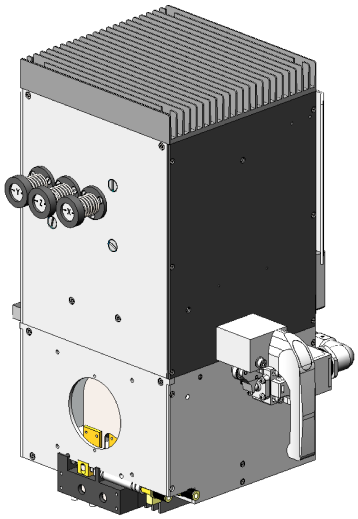


MAINTENANCE TASK:	***Functional Test*** ***Re-adjust Shutter Components (if necessary)***
Requirements:	Machine is switched on.
Tools:	--
Grease/ Cleansing Material:	--
Spare Parts:	--
Target State:	Free movement Check that shutters overlap at the end of exposure cycle (no flash!)
Interval/Shifts:	***weekly/ 20***
Time (Min):	***5***

MAINTENANCE TASK:	***Cleaning and Greasing og Shutter Sliding Block***
Requirements:	--
Tools:	--
Grease/ Cleansing Material:	Grease BARRIERTA L 55/2 High Temp
Spare Parts:	--
Target State:	Easy going movement
NOTICE!	Maintenance only by SUSS service.
Interval/Shifts:	***semi-annually/ 500***
Time (Min):	***30***

MAINTENANCE TASK:	*Exchange and Factory Overhaul*
Requirements:	--
Tools:	--
Grease/ Cleansing Material:	Fully functioning shutter with easy going movement
Spare Parts:	--
Target State:	Image of the wafer is free of dust or particles and with good contrast
! NOTICE!	Exchange only by SUSS service
Interval/Shifts:	***annually/ 1000***
Time (Min):	***30***

3.6.2 Lamp House/ UV Lamp



Caution!

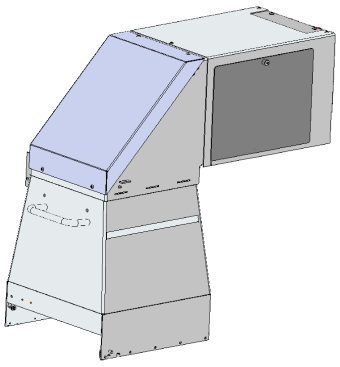
Respect all information of the lamp supplier concerning the life time of the lamp!

MAINTENANCE TASK:	*Measurement of Light Intensity*
Requirements:	Lamp and power supply are switched on.
Tools:	UV-Optometer and light measuring probe(s)
Grease/ Cleansing Material:	--
Spare Parts:	Lamp
Target State:	Lamp runs with optimum intensity. Light uniformity is adjusted.

MAINTENANCE TASK:	*Measurement of Light Intensity*
! NOTICE!	• See also ***[Querverweis fehlt!! 3.6.6 Lamp Cooling]*** • Consider information in the manual for the power supply.
Interval/Shifts:	***weekly/ 20***
Time (Min):	***15***

MAINTENANCE TASK:	*Measurement of Light Uniformity*
Requirements:	Lamp and power supply are switched on.
Tools:	UV-Optometer and light measuring probe(s)
Grease/ Cleansing Material:	--
Spare Parts:	Lamp
Target State:	Lamp runs with optimum intensity. Light uniformity is adjusted.
! NOTICE!	• See also 3.6.6 Lamp Cooling • Consider information in the manual for the power supply.
Interval/Shifts:	***monthly/ 100***
Time (Min):	***15***

3.6.3 Vertical Lens Tube



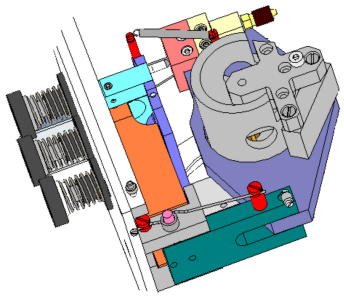
MAINTENANCE TASK:	*Functional Test of Manual Movement*
Requirements:	--
Tools:	--
Grease/ Cleansing Material:	--

MAINTENANCE TASK:	*Functional Test of Manual Movement*
Spare Parts:	--
Target State:	Uniform, easy going movement, good lock function
Interval/Shifts:	***weekly/ 20***
Time (Min):	***15***

3.6.4 Lamp Adapter

MAINTENANCE TASK:	*Inspection of Lamp Adapter Cables* **Exchange of Corroded Cables**
Requirements:	--
Tools:	--
Grease/ Cleansing Material:	--
Spare Parts:	--
Target State:	Strong fit, not oxidized
! NOTICE!	Exchange only by SUSS service.
Interval/Shifts:	***semi-annually/ 500***
Time (Min):	***20***

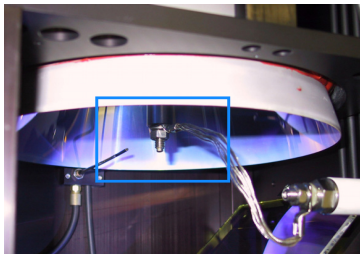
3.6.5 Lamp Manipulator



MAINTENANCE TASK:	*Greasing og Manipulator Axes*
Requirements:	--
Tools:	--
Grease/ Cleansing Material:	--
Spare Parts:	--
Target State:	Easy going axes

MAINTENANCE TASK:	*Greasing og Manipulator Axes*
! NOTICE!	Maintenance only by SUSS service.
Interval/Shifts:	***annually/ 1000***
Time (Min):	***10***

3.6.6 Lamp Cooling 500W Lamp



Caution!

Correct cooling is critical for lamp life time and to avoid lamp explosion!
Ensure that the cooling nozzle is adjusted correctly!

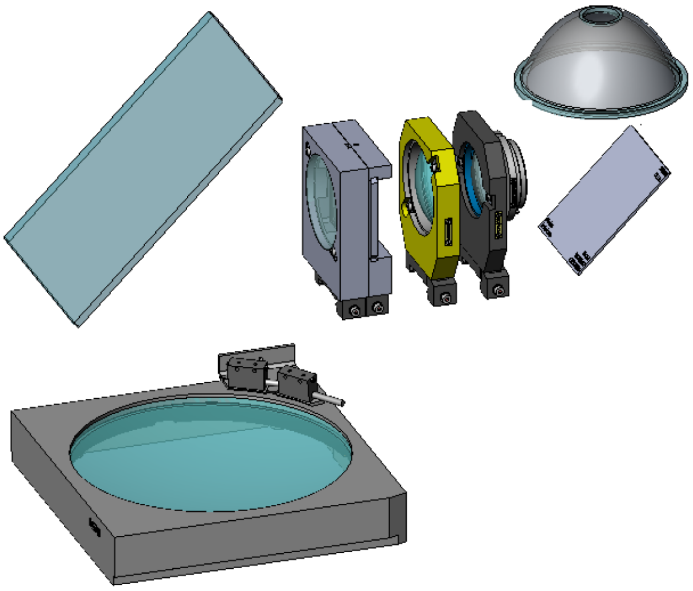
MAINTENANCE TASK:	*Measurement of Exhaust Temperature*
Requirements:	Lamp is operable
Tools:	Temperature measurement device
Grease/ Cleansing Material:	--
Spare Parts:	--
Target State:	Specified cooling data (lamp socket cooling, exhaust temperature) must be kept within specs (table see installation manual)
Interval/Shifts:	***monthly/ 100***
Time (Min):	***40***

3.6.7 UV-Optometer



MAINTENANCE TASK:	***Factory Calibration***
Requirements:	--
Tools:	--
Grease/ Cleansing Material:	--
Spare Parts:	--
Target State:	According to the supplier the sensors and the UV-meter have to be re-calibrated every year.
NOTICE!	Sensors and UV-meter have to be calibrated at SUSS
Interval/Shifts:	***annually/ 1000***
Time (Min):	***Internal SUSS Service***

3.6.8 Exposure Optics - Complete



Caution!
Danger of Damage of the Optics!
Follow the Sequence!

MAINTENANCE TASK:	***Inspection and Cleaning***
Requirements:	--
Tools:	--
Grease/ Cleansing Material:	Cleaning information see below
Spare Parts:	--
Target State:	Clean optics, without visible film or other contamination
Interval/Shifts:	***monthly/ 100 (depending on the environmental condition more often)***
Time (Min):	***240***

3.6.8.1 Cleaning Information

- Wear gloves when using solvents.
- Use lint-free tissues or cotton swabs for cleaning.
- Use filtered, dry air/nitrogen blown through an antistatic nozzle to remove dust.
- Use a mild liquid soap, 1% in water and Isopropanol as cleaning agent.

NOTICE!
Do not use plastic accessories for cleaning. They could be dissolved in alcohol.
Do not use acetone for optical surfaces. The coating could be dissolved and destroyed.

Dust:

- Blow off any dust.
- Twist a lens tissue around a swab and soak in alcohol.
- With the optics in one direction with a gentle figure eight motion.
- Repeat with alcohol swabs.
- For larger surfaces use a lint free tissue.

Fingerprints, Oil, Water Spots:

- Always clean immediately!
- Blow off any dust.
- Twist a lens tissue around a swab and soak in soap solution.
- With the optics in one direction with a gentle figure eight motion.
- Rinse with deionized water.
- Repeat with fresh alcohol swab.
- Blow dry with nitrogen.

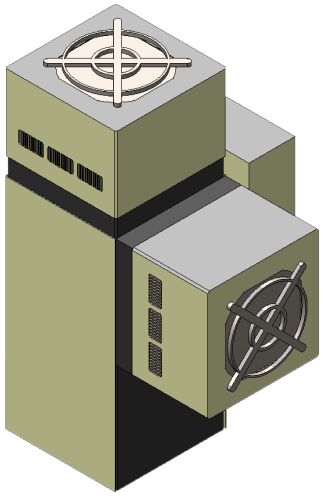
Coated Optics: e.g. optical film, aluminum coating

Delicate Optics: e.g. UV aluminum mirrors

- Clean most safely with non contact cleaning methods.
- Blow off any dust.
- Prepare clean containers with soap solution, deionized water and alcohol.
- Rinse the optics in the soap solution, then in the deionized water until no soap remains.
- Finally rinse with alcohol.

3.7 Exposure Unit Lamp House with UV-LED Light Source

3.7.1 Lamp House



MAINTENANCE TASK:	***Check of Cooling Fans/ Interlock***
Requirements:	--
Tools:	--
Grease/ Cleansing Material:	--
Spare Parts:	--
Target State:	All fans (2 LSU fans plus controller box fan) run without noise. Stop one single fan (e.g. with a pen) --> Trial to turn ON the light must fail.
Interval/Shifts:	***monthly/ 100 (depending on the environmental condition more often)***
Time (Min):	***60***

MAINTENANCE TASK:	***Check of LEDs***
Requirements:	LEDs are switched on.
Tools:	Pinhole stop Piece of paper
Grease/ Cleansing Material:	--
Spare Parts:	--
Target State:	All i-line and g/h-line LEDs are working and are displayed on the paper screen
Interval/Shifts:	***monthly/ 100***
Time (Min):	***30***

MAINTENANCE TASK:	*Measurement of Light Intensity*
Requirements:	LEDs are switched on.
Tools:	UV-Optometer and light measuring probe(s)
Grease/ Cleansing Material:	--
Spare Parts:	--
Target State:	LEDs run with optimum intensity. Light uniformity is adjusted.
Interval/Shifts:	***monthly/ 100***
Time (Min):	***15***

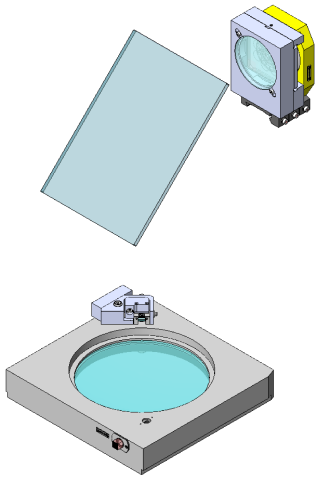
3.7.2 Vertical Lens Tube

Chapter 3.6.3 “Vertical Lens Tube” on page 70

3.7.3 UV-Optometer

Chapter 3.6.7 “UV-Optometer” on page 73

3.7.4 Exposure Optics - Complete



Caution!

Danger of Damage of the Optics!
Follow the Sequence!

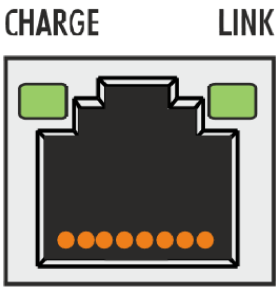
MAINTENANCE TASK:	***Inspection and Cleaning***
Requirements:	--
Tools:	--
Grease/ Cleansing Material:	Cleaning information (*Chapter 3.6.8 “Exposure Optics - Complete” on page 74*)
Spare Parts:	--
Target State:	Clean optics, without visible film or other contamination
Interval/Shifts:	***monthly/ 100 (depending on the environmental condition more often)***
Time (Min):	***240***

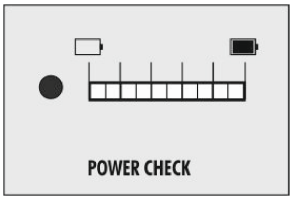
3.7.4.1 Cleaning Information

Chapter 3.6.8.1 “Cleaning Information” on page 74

3.8 UPS-Module and Battery

3.8.1 Battery





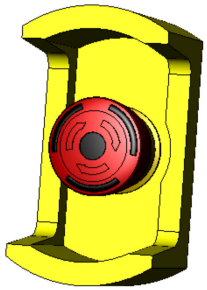
MAINTENANCE TASK:	***Battery Check***
Requirements:	--
Tools:	--
Grease/ Cleansing Material:	--
Spare Parts:	--
Target State:	The battery reaches its maximum loading condition all 10 LEDs at the battery are illuminated.
Interval/Shifts:	***monthly/ 100***
Time (Min):	***5***

3.8.2 Fuse

MAINTENANCE TASK:	***Exchange Blown Fuses***
Requirements:	The display is blinking if a fuse in the battery pack is defective or not inserted
Tools:	--
Grease/ Cleansing Material:	--
Spare Parts:	10A fuse
Target State:	Display is NOT blinking
Interval/Shifts:	***In case of a blown fuse following a short circuit***
Time (Min):	***1***

3.9 Safety System Checks

3.9.1 EMO Switch



MAINTENANCE TASK:	*Functional Test*
Requirements:	--
Tools:	--
Grease/ Cleansing Material:	--
Spare Parts:	--
Target State:	The equipment will be switched off following activation of the EMO button. IPC and PLC will be switched off, except an UPS (option) is built in. Restart is possible only after retraction of the activated EMO button.
Interval/Shifts:	***monthly/ 100***
Time (Min):	***5***

3.9.2 Interlocks

MAINTENANCE TASK:	*Functional Test of all Interlocks*
Requirements:	The machine is switched on, the lamp is operable
Tools:	--
Grease/ Cleansing Material:	--
Spare Parts:	--
Target State:	An alarm sounds once the cooling flow of the lamp socket cooling is de-adjusted. The lamp is switched off immediately once the upper part of the LH350 is swung open. The shutter will be closed or cannot be opened once: • the cover for the optics access will be opened. • the front UV-protection will be opened.

MAINTENANCE TASK:	*Functional Test of all Interlocks*
Interval/Shifts:	*monthly/ 100*
Time (Min):	*10*

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SUSS MicroTec - First Line Contacts

	Service	Parts / Logistics	Technical Support
	** Request for service engineer* ** Quotation for service visit*	** Quotation for spare parts* ** Spare parts order* ** Billing*	** Technical advice during tool down* ** Parts identification* ** point of contact for application support*
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Old Generation Tools SMT Reman Oberschleissheim - MA150RH/ML/CC - MA14/16/56/100 - MJB3, 21, 45, 55 - MA56, 25,26 - MA1006, RA120	**service.smtr@suss.com** Phone: +49 89 32007 - 567 Fax: +49 89 32007 - 555	**service.smtr@suss.com** Phone: +49 89 32007 - 551 Fax: +49 89 32007 - 555	**service.smtr@suss.com** Phone: +49 89 32007 - 550 Fax: +49 89 32007 - 555

Note: To ease procedures please always provide the equipment and serial number.

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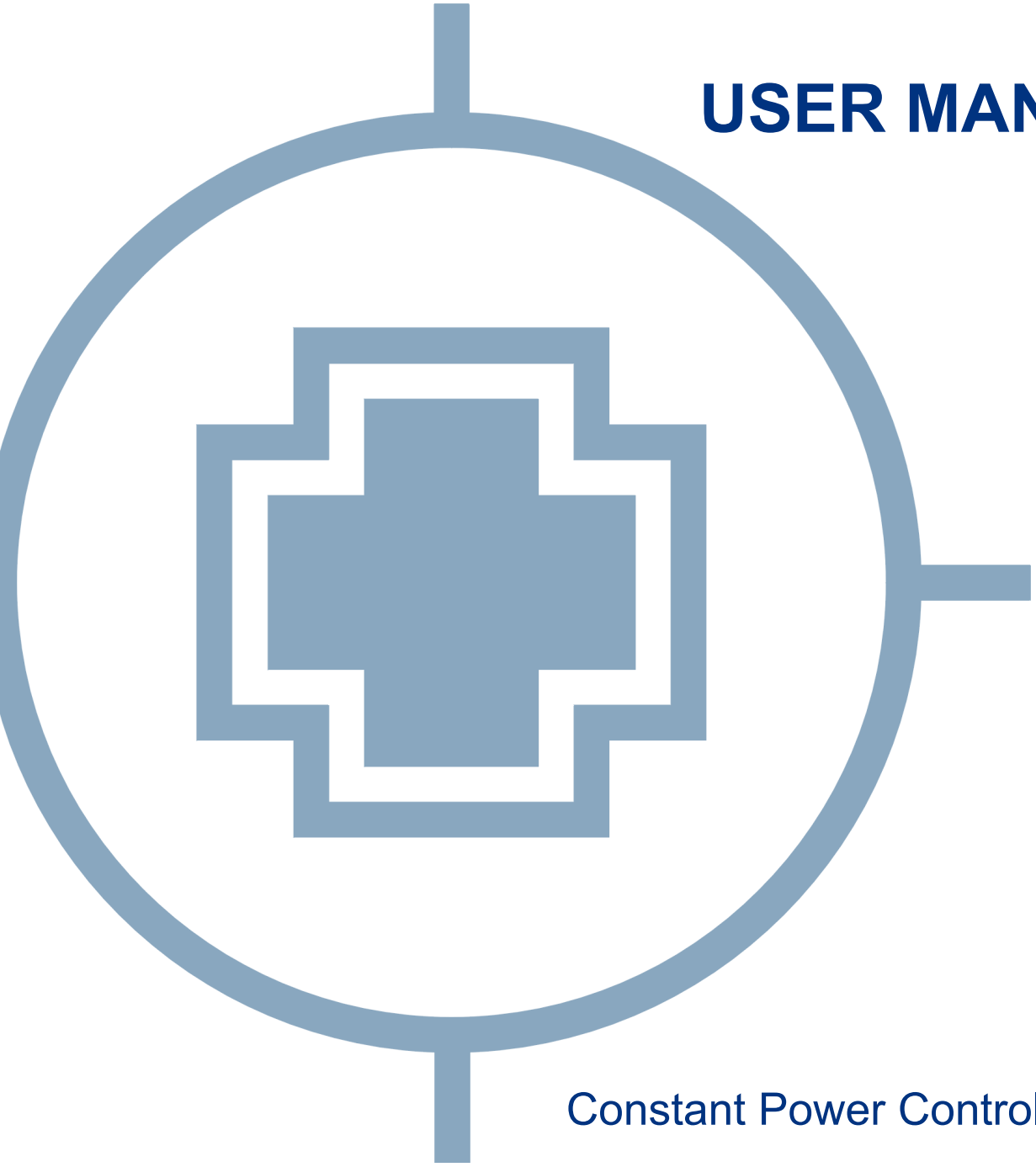
USER MANUAL



Constant Power Controller

CPC200/350

Rev04/19-03

D40 10300477

www.suss.com

SÜSS MicroTec

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Although believed to be accurate, SUSS MicroTec assumes no responsibility for any errors, omissions, or inaccuracies.

SUSS MicroTec also reserves the right to modify the product, substitute components by equivalent or similar parts or change functions or controls without notification in the manual or elsewhere.

The product must be installed properly, used as directed and operated by trained and authorized personnel only. Any use or application deviating from the designated and intended use can cause hazards.
For a description of the designated use see also the section “Intended Use of the Product”

The contents of this product documentation shall not become part of or modify any existing legal agreement or commitment. All warranty stipulations and obligation by SUSS are contained in the sales contract. Contractual stipulations are neither extended nor limited by this product documentation.

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This manual is available in the following formats:
Cleanroom printed and electronic .pdf-format (CD-ROM).

1. WARNINGS AND SAFETY HAZARDS



This manual contains information which the user must know and understand to eliminate or reduce the risk of accidental injuries.

Suss MicroTec equipment is designed to protect the user against all possible hazards. After review by qualified safety personnel, the user should generate a specific safety procedure with regard to the particular application of the equipment and local codes. The user must make certain the operators are familiar with the procedure. The safety procedure should also be posted in a conspicuous location so that all equipment operators are exposed to the information on a continuing basis.
Do not attempt to handle or operate a Constant Power Controller (CPC) before completely reading and understanding this notice.
Contact SUSS MicroTec if you are uncertain of hazards associated with these devices.

1.1. Electrical Precautions

If the covers or connectors are removed from the CPC, dangerous voltages will be exposed. When all of the covers, cables and connectors are in place, there is no danger from these voltages.
The igniter produces starting voltages of up to 30 kV and electromagnetic radiation interference which are hazardous to personnel and sensitive instrumentation.
Exercise appropriate care in the handling of high voltages. Do not touch any conductive parts during operation.
The CPC must never be installed or operated in an explosive or volatile atmosphere. Never use the CPC near flammable gases or liquids. No potential isolation is provided between line input and output. Accidentally earthing of an output terminal by direct contact or arcing to GND can damage the device (no warranty indemnification).
The unit is designed for case mounting. Due observation of electrical safety and RFI suppression code requirements is mandatory in all applications. The electrical system should be supervised by qualified personnel only so it should never be necessary for the operator to open the cover of the electrical portion of the device. If any problems occur with the CPC, turn the machine off and notify your supervisor or maintenance immediately.
Extreme care must be taken when testing the device. On no account may earthed testing instruments or meters be used for this purpose!



Caution!

Never open the housing while the power line is connected!



Caution!

Mains supply must be fused according to local safety regulations.
SUSS MicroTec recommends 2-pole fuse (L+N). The appropriate fuse value can be calculated as:

I fuse > 1,85 x P lamp/ U-line

1.2. Intended Use of the CPC200/350

The CPC 200/350 is designed to operate as a smart power supp- ply/ regulator for high pressure UV lamps installed in a SUSS
lamp housing. Any other use has to be verified in advance cooperating with SUSS technician and/ or with the lamp manufacturer. Otherwise the operational safety of the system cannot be guaranteed by SUSS MicroTec

1.3. High Pressure Lamps

The light source for the concentrated ultraviolet illumination required to expose the wafer is a high pressure lamp. Special precautions must be taken when working with these lamps

1.3.1. Lamp Explosion

Since these exposure lamps operate at extremely high pressure, explosion is highly likely, if the lamps are handled or operated wrongly. The lamps may

fail because of improper cooling, improper setting of the power supply, use without taking account of the manufacturer´s guidelines, etc.. Additionally, some high pressure lamps, even when cold, are still above atmospheric pressure and should be handled with protective face shields and gloves.



Caution!

Careful handling of the lamp and proper operation of the equipment will substantially reduce the likeliness of lamp explosions. Safety instructions of the lamp manufacturer must be followed.

The lamp housing is designed to minimize damage to the interior of the equipment and to prevent possible injury to the operator should a lamp explosion occur.



All assemblies and protective covers must be in place during operation of the machine. Some of these lamps contain hazardous elements such as mercury. If a lamp should break, avoid touching the fragments and/or breathing the vapor.

If the lamp explodes, we recommend the following course of action:

- Turn off power of the supply and machine immediately.
- Do not turn off exhaust system.
- Evacuate the immediate area of the machine to prevent inhalation of mercury vapor.
- Wait at least 20 minutes before returning.

Mercury residue and glass shards deposited inside the lamp housing should only be handled when wearing rubber gloves, goggles, and a proper face mask. The best way to remove mercury is by suction cleaning - the suction of a syringe or vacuum device is very effective (do not use lungs). After noticeable amounts of mercury are removed, gently wipe optics with lint free paper that is slightly dampened by a residue free liquid. Materials used in the cleanup should be treated as hazardous waste and disposed of accordingly.

1.4. Exhaust Requirements

High pressure lamps produce heat as well as ozone because of interaction of the radiation emitted a wavelength of 250 nm with oxygen. Ozone attacks the mucous membranes of the respiratory system, producing symptoms similar to pneumonia.
The effects are cumulative. The smaller wattage lamps, must be operated in a properly ventilated area only. Larger wattage lamps must be exhausted using exhaust pipes. Also the sockets of larger lamps must be cooled by a flow of nitrogen. The cooling requirements for special lamps are specified in a table which is part of the SUSS machine manual.

1.5. Eye and Skin Safety

The ultraviolet light produced by these lamps can cause erythema of skins (similar to sunburn) and conjunctivitis. In addition, the large infrared output can cause retinal burns resulting in blindness.
Every SUSS mask aligner is equipped with light guards,
and the high pressure lamp and exposure path are enclosed. The mask aligner may not be operated unless all of these protective covers and devices are in place

2. TECHNICAL SPECIFICATION

2.1. Characteristics

Constant Power Controller CPC 200 / 350 R with Remote Control for DC Mercury Lamps

with POWER FACTOR CORRECTOR (PF >0,95) in compliance with
DIN EN 61 000 - 3 - 2, Class C

- µP control for various parameter
- Flicker-free operation
- Higher lamp service time
- Constant light output during lamp service time by power regulation
- Higher light intensity than conventional ballasts
- Compact shape, low weight
- Input Voltage 90 - 264V
- Electrical power adjustment
- Lamp switched ON signal
- Device switched ON signal
- End of service live detection with signal
- Version as stand-alone unit and accessory equipment
- Serial Interface RS232 for remote control and monitoring
- Lamp Hour Counter

2.2. Electric Supply

The power supply can be operated with mains voltage from 90 V to 264 V.

2.3. Machine Configuration

2.3.1. CPC with LH350



Fig.2-1: CPC with LH350

2.3.2. Installation CPC with LH350

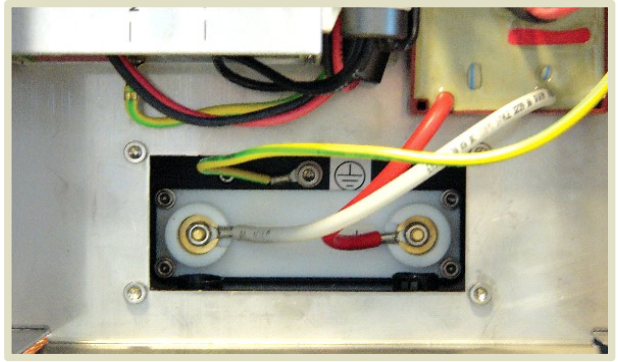
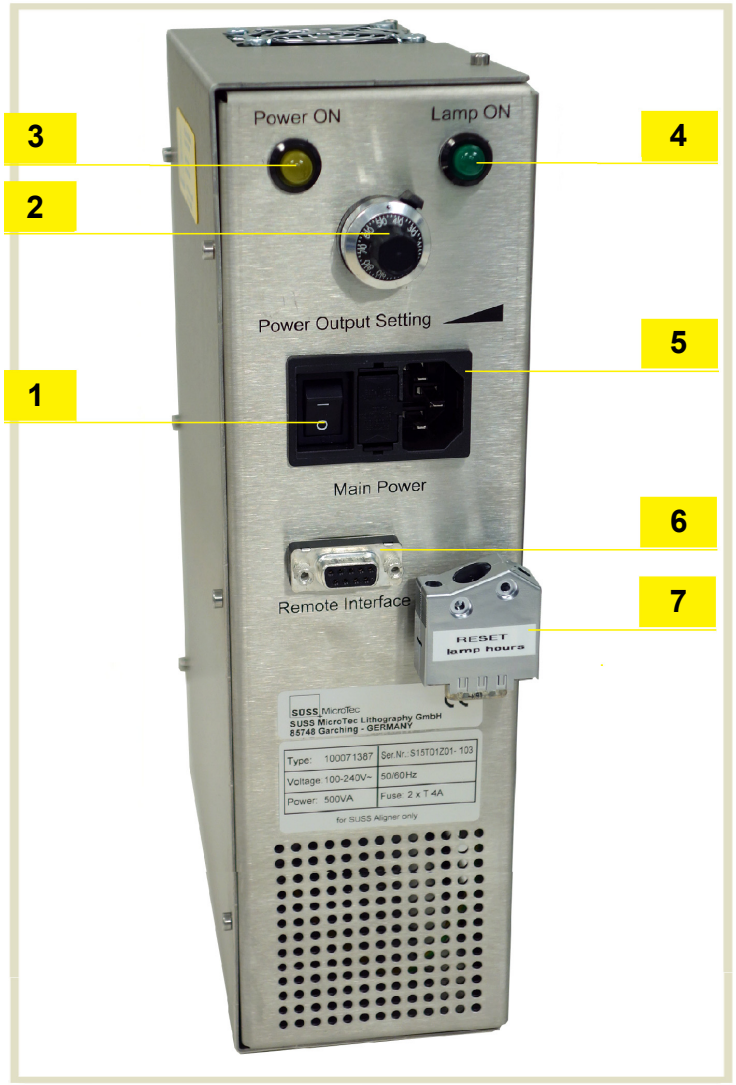


Fig.2-2: Installation of CPC

2.4. Lamps

Details see chapter 6.2 Lamp Data

2.5. Control and Annunciator Panel



1 Power Switch
The power switch is used to turn the device on and off. If there is no remote control cable attached, the lamp is turned on by using the power switch

2 Wattage Adjustment
For manual adjustment of wattage a linear potentiometer with a locking device is attached. It does not show any function if the remote control cable is connected.

3 Power ON - LED
The LED displays that the device is turned on.

4 Lamp ON - LED
The LED displays that the exposure lamp is on.

5 Mains Voltage Connector
The poser input module consists of an IEC-connector, a power switch and a fuse holder

6 Interface Remote Control/ Reset Lamp Hours
The 9-pin Sub-D connector is used for remote control of the CPC (i.e. via the control of SUSS MJB4) Without remote connection this connector is used for zeroing the lamp hour counter by connecting a bridge plug

7 Bridge Plug
For zeroing the lamp hour counter (only without remote control).

2

3. OPERATION

3.1. Remote Control

The CPC can be remote controlled by the remote control interface via a special connected serial port. If connecting the remote control cable, the remote control mode of the CPC is automatically chosen. The functions „Lamp On“, „Lamp OFF“, „Wattage adjustment“ (within the limits specified by the manufacturer), „Lamp hour counter“ and various error messages can be controlled or transmitted via the interface (i.e. with SUSS MJB4).

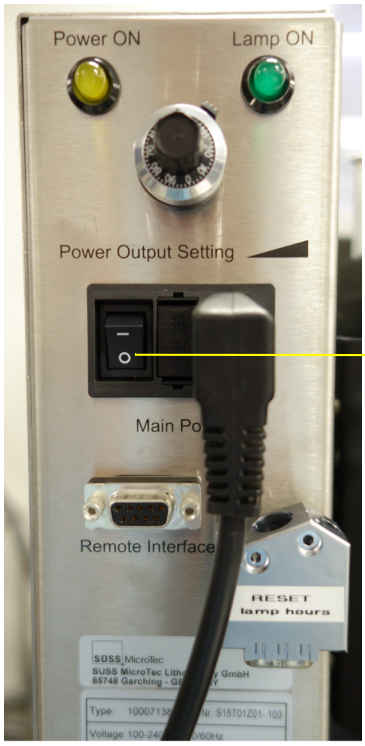
3.2. Manual Operation

If no remote control cable is connected, the device is in manual mode. If the power switch is turned ON, the lamp will be automatically ignited. The potentiometer can now be used to adjust the wattage within the limits specified by the manufacturer.
The potentiometer can be locked in the chosen position.

The lamp can be operated with the following wattages:

Potentiometer position	CPC200R	CPC350R
	output at lamp in Watt (W)	output at the lamp in Watt (W)
0	150	300
10	155	310
20	165	320
30	175	335
40	190	355
50	205	370
60	220	390
70	235	415
80	250	430

3.3. Reset Lamp Hours without Remote Control

	• Turn main power OFF [1]
	• Connect bridge plug to remote interface jack. [2] • Turn power ON and wait until both LEDs will stop flashing [3] • Turn power OFF [1] and unplug main power cord and bridge plug. [2]

4. INSTALLATION

4.1. Assembly Instruction

Refer to Figures 2-1 and 2-2.

- Unscrew the covering plate of the terminal studs of the LH350
- Unscrew the cover of the CPC
- Install the CPC to the LH350 (with four screws M4x8mm)
- Connect the earthing cable (gn/ye) to the earthing point on top between the terminal studs (with one screw M4 and a contact washer)
- Connect the plus cable (red) to the plus terminal stud (right) (with a nut M4 and a contact washer)
- Connect the minus cable (white) to the minus terminal stud (left) (with a nut M4 and a contact washer)
- Install the cover of the CPC
- Plug in the power cord of the CPC (and remote cable if available)

5. TROUBLE SHOOTING

LED Status	Meaning	Possible Action
Yellow LED ON	Main power ist turned ON, UV-lamp is OFF	
Green LED ON	UV-lamp is powered on, normal operation	
Green LED flashing	Lamp hours reached, lamp remains ON	Replace the lamp and zero the lamp hour counter (see chapter 4.3)
Yellow LED flashing	UV-lamp voltage is too high or lamp wattage could not be reached. Lamp is powered OFF. Possible problems:	
	• End of life voltage reached	Replace the lamp
	• Resistance is too high	Check all lamp cables and its connections.

6. TECHNICAL DATA

6.1. CPC200/350

Mains voltage, Function range	90 - 264V
Line frequency	47 - 63Hz
Power factor	>95 @ 230V, >0,97@115V
Earth leakage current 230V, 50/60Hz	< 0,7mA
Lamp voltage range	70- 135V
Open circuit voltage	300V
Output power tolerance	+/- 5%
Storage temperature	-20 - +85°C
Protection	Thermal cut off @ 80°C heat sink temperature, restart @ 50°C, Short circuit protected, open circuit protection, ignition time limitation, Output cut off @ U=300V after 3s (depending on lamp)
Efficiency	0,9 @ 230V, 0,85 @115V type.
Ambient temperature inside	max. 60°C, forced cooling necessary
Maximum dimensions	LWH 287x191x92 (accessory equipment) LWH 287x191x102 (stand-alone- device)
Ignition	Hot restrike 25kV

6.2. Lamp Data

	CPC200	**CPC350**
Lamp with part number	G191806 Osram HBO 200 W	G146049 Osram HBO 350 W G182538 Ushio USH-350DS
Starting current	6 A	8.5 A
Min. wattage	150 W	300 W
Max. wattage	300 W	430 W
End of life voltage	77 V	83 V
Lamp hours	1000 h	600 h

7

7. SERVICE INFORMATION

Should difficulties arise with the use or operation of your Constant Power Controller CPC and if you are unable to solve the problem, you can receive further assistance at the SUSS MicroTec office which processed your order or is currently handling your account. They can give you specific instructions on whom to contact to get additional help or answer any questions.

Be prepared to provide the following information (if available):

- Your company name, address, telephone number, and the name of the responsible individual whom we may contact, if we have technical questions about the problem.
- Model, serial number and SW-revision of the equipment.
- A list of associated equipment and a description of the electrical connections.
- A brief description of the problem.

SUSS MicroTec - First Line Contacts

	Service	Parts / Logistics	Technical Support
	** Request for service engineer* ** Quotation for service visit*	** Quotation for spare parts* ** Spare parts order* ** Billing*	** Technical advice during tool down* ** Parts identification* ** point of contact for application support*
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Note: To ease procedures please always provide the equipment and serial number.

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Customer Care Center Sternenfels: Sasa Getlicher, sasa.getlicher@suss.com, +49 7045 41 - 254



Constant Intensity Controller

CIC1200 Gen2

for Exposure Lamps

Rev00 21-01

READ THIS MANUAL PRIOR TO PERFORMING ANY TASK!

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This manual is a user documentation of SUSS MicroTec Lithography GmbH (in the following "manufacturer") and allows safe and efficient use of the constant intensity controller CIC1200 Gen2.

Prior to working on this product, the personnel must have thoroughly read and understood these instructions and, furthermore, know and observe officially recognized rules regarding occupational health and safety. The basic prerequisite for safe working is compliance with all the safety and handling instructions stated in this manual and the safety and installation manual of the tool.

Figures in this manual are for the fundamental understanding and can deviate from the actual design of the tool.

English is the original language of this manual.

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Service

Our customer service is pleased to provide further technical information.

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Phone	+49 89 32007 0
Email	info@suss.com
Internet	www.suss.com

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1 WARNING and SAFETY PRECAUTIONS

1.1 General Safety Information



Before installation and operation of the equipment following safety information has to be read carefully!

NOTICE!

The chapter "Safety Precautions" contains information the operator must know and understand in order to avoid the risk of personal and equipment damage.

This section describes general safety precautions and procedures which must be observed and followed by all persons working with the equipment covered by this manual.

After a thorough review by qualified safety personnel, the user should generate specific safety procedures with regard to particular application and configuration of the equipment and local codes. Operators must be thoroughly familiar with these procedures which should also be posted in an accessible location so that all equipment operators are exposed to the information on a continuing basis.

In addition to the specific safety precautions detailed in this section, anyone working with or in close proximity to the equipment described in this manual should observe adequate precautions and safe operating practices generally applicable to the operation of semiconductor production and processing equipment.

1.2 Intended Use

NOTICE!

Other than the intended use of the machine will lead to a loss of warranty!



WARNING!

Risk for Personal Injury and Material Damage!

Equipment of this type may cause serious personal injury or material damage if it is not used or operated in the correct manner, or if unqualified personnel have access to it.
The same applies if the equipment has been installed incorrectly or has not been maintained sufficiently, or if consumables, accessories, spare parts or software is used that is not authorized by the supplier, or if components will be removed.

► Only operate the system in a technically perfect condition and in compliance with the operating instructions.

► Disruptions, especially those that may affect safety, must be promptly remedied by authorized personnel.

The system described in this manual has been manufactured according to the technical standards, safety regulations, SEMI-standards and EC directives.

If not installed properly or not used as directed, dangerous situations or damage might occur.

Changes or modifications to the machine without prior written permission by the supplier will void warranty and will void the user's authority to operate the equipment.

Any unauthorized changes or modifications to the system or use of incompatible accessories would void all warranties as well as SUSS liability. Consult SUSS MicroTec Lithography GmbH before implementation of any change or modification. Quote also system type and serial number when making inquiries.

Components/ Use:

- The CIC1200 Gen2 must be integrated into the SUSS equipment and shall only be used with the specified lamp houses and lamps. (see *Table on page 24*).
- The CIC1200 Gen2 must not be operated until the final machinery into which it is to be incorporated has been completed and declared as in conformity with applicable safety provisions.
- Any other use or modification of the CIC, the ignition unit or the original SUSS lamp house has to be verified in advance with SUSS MicroTec Lithography. Otherwise the safety of the system can not be ensured.
- Enclosures and covers are necessary for save operation. Any use without enclosure or removed covers is not permitted.

Software:

- Software is an integral component of the system. Software which is not originally intended for use in this system and not tested and released for the system by SUSS MicroTec Lithography could pose a risk for functionality, process performance and material handling.
- Installation of additional software without prior written permission by SUSS contradicts the intended use of the machine.

Maintenance/ Service:

- In case of installation, operation, changing of operational conditions, maintenance-, inspection- and service work all protective procedures described in the user manual have to be followed.
- You are advised to make use of the support and services offered by the competent SUSS MicroTec lithography service center with regard to planning, installation, commissioning and servicing.
- If working with chemicals follow all local regulations, laws, guidelines and safety data sheets (SDS).

Contact:

For planing, installation and service consult your local SUSS representation. For latest contact information go to www.suss.com.

1.3 Minimum User Requirements

Ensure that:

- the operator is equipped with his/her appropriate personal protective equipment.
- the user does not change or modify the system without the prior written permission of the manufacturer.
- the user replaces defect system components immediately and only by original spare and wear parts.
- the operator runs the system only with all installed covers and working interlocks.
- service and maintenance work will be carried out only by qualified and adequately trained personnel.
- all personnel working with or near the equipment have received all safety information concerning the machine and that they are properly trained on the safety requirements of the machine.
- all persons working with the system are properly trained for the operation with the system.
- the user respects all safety information provided in this manual and in all additionally applicable safety and local preparation information which are delivered by SUSS MicroTec Lithography GmbH or to which SUSS has pointed out to.
- the user does not remove, modify, cover or change any content or the readability of all safety signs and labels which are located at or in the machine.
  No additional labels are allowed to be placed to the machine which could reduce the attention to the safety labels provided by SUSS MicroTec Lithography or which could reduce the effectivity of the labels.

1.4 Qualified Personnel

Qualified personnel are persons, who on account of the training and instruction they have received and their experience and knowledge of relevant standards, specifications, accident prevention regulations and operating conditions, have been authorized by those responsible for the safety of the system to carry out any necessary work and who are able to recognize possible dangers.

Qualified personnel have to avoid accidents during electric work and repair or during maintenance work. All personnel shall wear or use personnel protective equipment which is required for save work performance.

All system users are advised to become familiar with the contents of these safety instructions prior to operating the system. They also should have read and understood the operating instructions.

In addition, always comply with local health and safety regulations and company safety requirements regarding safe usage of equipment. Knowledge of the first aid and the local rescue facilities is also required.

OSHA (Occupational Safety & Health Administration) Definition:

"Qualified" means one who, by possession of a recognized degree, certificate, or professional standing, or who by extensive knowledge, training and experience, has successfully demonstrated his ability to solve or resolve problems relating to the subject matter, the work, or the project.

1.5 Signs and Safety Precautions

The terms DANGER, WARNING, CAUTION and NOTICE are used to indicate special dangerous situations or special information that have to be followed.

Safety Related Terms and Signs:

Following safety related terms and signs are used:



DANGER!

This safety related term consisting of symbol and signal word DANGER indicates an imminent hazardous situation which, if not avoided, could result in death or serious personal injury.



WARNING!

This safety related term consisting of symbol and signal word WARNING indicates a potential hazardous situation which, if not avoided could result in minor or moderate personal injury.



CAUTION!

This safety related term consisting of symbol and signal word CAUTION indicates a potential hazardous situation which, if not avoided could result in death or serious personal injury.



NOTICE!

This safety related term consisting of symbol and signal word NOTICE indicates a potential hazardous situation which, if not avoided could result in material or environmental damage
or
draws attention to special technical product information which may not be immediately obvious even to qualified personnel.

Warning Signs:

Following warning signs are used in this manual:

	General warning symbol (explanation is always necessary)
	Electric shock hazard
	Intensive light and potential eye damage hazard
	Heavy load hazard

Prohibition and mandatory signs:

Following prohibition and mandatory signs are used in this manual:

	Wear eye protection
	Lift with two persons
	Read manual

Indication Signs:

Indication signs point to the content of an adjacent text and do not function as safety signs.
Indication signs enable quick identification of text passages and accelerate the search for information.

Following indication signs are used in this manual:

Sign	Description
1. 2.	This sign represents one step of an action sequence.
▸	This sign represents a one-step instruction.
⇨	This sign points to the result of an instruction.
	Reference to another paragraph or another document.
Button ***[xy]***	Appearance of hardware keys
Function key ***[xy]***	Appearance of software keys
"Tab xy"	Appearance of GUI-elements

1.6 Training and Qualification

1.6.1 Standard Training Recommendation

We recommend performing of training for qualified persons before they are allowed to perform electrical work at the equipment.
We recommend a refresher training at regular basis (at least every 3 years)
The training shall take place in practice and/or in lesson format.
The training shall be documented.

The training of a qualified person shall include following topics:

- safety relevant labor practices including the right selection and use of personal protective equipment (PPE)
- skills and methods that are necessary to identify open conducting parts from other parts of the electrical equipment.
- skills and methods that are necessary to determine the nominal voltage of the open conducting parts and to determine the minimum distance and the corresponding voltage a qualified person will be exposed to.
- options to perform the job safely.
- options to de-energize the system and all electrical components safely (logout/tagout).

1.6.2 Additional Training Recommendation

Additional training options that are recommended for work at electrical equipment:

- NEC (EN60204-1)
- National Electrical Safety Code (ANSI C2)
- Correct use and careful handling of personal protection equipment
- Correct use of test and measurement equipment
- Work permit and approval procedures
- Correct clothing for electric arc protection
- First aid course at least every 3 years

1.7 Recommended Safety Equipment

The operator of the facility has to take care that following safety equipment as a minimum requirement is available at installation site of the equipment:

Mandatory: Fire protection equipment including fire extinguisher

1.8 PPE according to NFPA 70E

Technical personal who is exposed to the danger of an electric arc is bound to wear his/her PPE (Personal Protective Equipment) according to NFPA70E.

NOTICE!
These requirements are only valid in the USA and only obligatory for exports into this country.

e.g. according to NFPA70E following PPE is necessary:

- for protection against electric arc approved long-sleeved clean room top.
- for protection against electric arc approved clean room trousers
- protective helmet
- for protection against electric arc approved face shield.
- leather or rubber gloves and shoes



NOTICE!

For the currently valid requirements read and observe the current NFPA70E-Standards.

1.9 Forseeable Misuse

Reasonably foreseeable misuse means:

- Operation of the machine with bypassed safety circuits.
- Use of media which are not specified within the sale contract, section ‚Safety References'.
- Use of non-authorized external power sources.
- Use of software which is not authorized by SUSS MicroTec.
- Use of accessory parts which are not authorized by SUSS MicroTec.

CAUTION!

Danger of Serious Machine Damage !

Because of use of non authorized accessory parts or software!

► Only use accessory parts which are authorized by SUSS MicroTec Lithography GmbH to avoid damage of the equipment.

► Software is an integral part of the system. Software which is not originally designated for the use with this equipment and which is not tested and authorized for the system by SUSS MicroTec Lithography may bear the risk for functionality, process performance and material handling.

► Installation of additional software is only allowed with written permission of SUSS MicroTec.

1.10 Transport and Installation

CAUTION!

Ergonomic Hazard!

Risk of damage and injury of the spine by lifting of heavy objects.

► Always use corresponding tools for lifting of heavy loads.

► Always move with the required number of persons.

NOTICE!

All basic work concerning installation, transport, assembly, maintenance and repair have to be performed by qualified service personnel of SUSS MicroTec Lithography GmbH.

Observe:

- technical data and information according to the order specification concerning intended use (assembly, electrical connection, ambient and operating conditions).
- common installation and safety conditions.
- local, system-specific requirements
- correct use of tools and transport devices.
- commitment of installation responsible persons to provide suitable safety procedures according to the respective country regulations.

This user manual contains instructions which the user has to follow during the intended use of the machine.

Transport-, assembly-,operation- and maintenance instructions and other technical data (in instructions, in product documentation or at the product itself) which are not pointed out especially have to be observed as well, to avoid errors which could lead directly or indirectly to serious personnel or material damage.

1.11 Disposal of Waste



Make sure that contaminated material is disposed according to local and environmental laws and regulations.



Besides we recommend to contact a waste management expert.

Material Separation:

Dispose as special waste:

- Contaminated and used tubes
- All electric /electronic parts (boards)

Following components bring into a recycling process:

- Plastic parts
- Metals (stainless steel, aluminum)

Waste Product:

There are no standard EU regulations for disposal of chemicals or residues.
Chemical residues are special waste. Its disposal is regulated in corresponding laws and regulations. Each individual world wide state has its own laws and regulations.

We recommend to contact responsible authorities or accredited waste disposal departments for advice.

Packaging Materials:

Disposal according to official regulations.

- Contaminated packaging has to be disposed in a similar manner as the contaminant.
- Non-contaminated packaging can be treated or recycled as domestic waste (if not determined differently by official authorities).

1.12 Safety Hazards

This section describes specific safety hazards or potential hazards which may be associated with the use of this equipment, the possible consequences of human interaction with the hazard and the method(s) for avoiding the hazard.

Hazards described in this section are:

- Electrical hazards by potentially lethal voltages or electric current.
- Mechanical hazards by exploding UV-lamp bulbs

- Thermal hazards by hot lamps
- Non-ionizing radiation hazards (UV, Halogen lamps, UV-LED light sources)
- Hazards after extraordinary events.

1.12.1 Electrical Hazards

Protection against electrical hazards is provided in general by enclosed, grounded cabinets for electrical parts using hazardous voltages. (e.g. lamp house, power supply for electronics and computer). All boxes and cabinets are equipped with warning labels for electrical hazards. If covers or connections are removed there is a risk of electric shock.

General Electrical Safety Precautions:

- The CIC1200 Gen2 is designed according IEC/EN/UL 61010-1. Hazardous voltages are present at connectors and inside the power supply as well as at the ignition unit or inside the lamp house.
- The CIC1200 Gen2 shall only be serviced by qualified SUSS technicians.
  There are no user related Type 3 or Type 4 tasks (referring to SEMI S22).
- Do not attempt to open, modify or alter the CIC. Use of unapproved components can result in fire or electric shock.



WARNING!

High Voltage!

Risk of Death by Electric Shock!
Voltage is still present to the CIC when the host machine (e.g. mask aligner) is deactivated but in „stand by“.

► Never open covers of the CIC, the ignition unit or the lamp house while the power line is connected. The CIC and ignition unit do not contain user serviceable parts.

► For maintenance work switch off the equipment.

► Follow the lockout/tagout procedures.

Fuse Replacement

Where necessary, deactivate and lock-off the host machine and remove machine covers or panels to access the rear of the CIC (see chapter 4.2. CIC1200 Rear Panel).

With some of the host machines it may be necessary to move the CIC. Disconnect the supplying appliance coupler, remove clamps and fixings and where necessary remove other connectors. Then carefully move and lift the equipment.



NOTICE!

Heavy Object!

Never move or lift with one person only. Get help, use proper lifting aids and ensure safe standing postures.

Open and remove the fuse holder clip. Replace the fuses only of the same type and with the same load as the replaced fuse (see chapter 2. TECHNICAL SPECIFICATION CIC1200).

If any problem occurs with the power supply, turn the equipment off and notify your supervisor or maintenance immediately.

Additional Warnings and Safety Precautions

Following additional warnings and safety precautions are related to hazards originated by the host machine (e.g. mask aligner). The CIC1200 Gen2 is intended to be incorporated into. They shall be regarded as a general information only.



NOTICE!

Read Instructions!

For details refer to the manuals of the specific host machine. Fail to comply with safety precautions stated in those manual may result in severe injury as well as substantial damage to property!

Additional Electrical Hazards

Protection against electrical hazards is provided by closed, grounded cabinets for the electrical devices. The CIC, the ignition unit inside the Lamp House and the lamp house shall only be serviced by qualified SUSS technicians. User related Type 3 or Type 4 tasks may be involved (referring to SEMI S22).

The voltages and currents required to run a high pressure lamp are hazardous. The ignition voltage generated in the ignition unit of the lamp house rises up to 20-30KV and the open circuit potential can range to some 100V.

When performing any maintenance on the UV-lamp or lamp house, always make sure that the power line is disconnected and locked-off at the energy isolation device.

The voltage applies to the lamp must comply with the lamp manufacturers recommendations, otherwise an explosion may occur. Also correct lamp orientation is crucial (see lamp data sheets and SUSS machine manuals for proper lamp orientation).



WARNING!

Electrical Voltage inside!

The ignition unit is a complex electrical component producing high voltage pulses for lamp ignition.

- ► Repair must be done by SUSS trained experts only.
- ► Using unapproved parts can result in fire or electrical shock.
- ► Never open covers of the CIC, the ignition unit or the lamp house while the power line is connected.



DANGER!

High Voltage!

The lamp operates (starts) under high voltage. Voltage is still present to the CIC when the host machine (e.g. mask aligner) is switched off, but in „stand by“. All power to the systems must be completely disconnected before servicing CIC or the lamp house.

1.12.2 Radiation Hazards by Non-Ionizing Radiation

UV Light

UV light is invisible for the human eye and can cause severe eye damages and skin burn.

Depending on the used wave length range the UV light is only accompanied by a low amount of visible light.



WARNING!

Risk of Eye Damage and Skin Burns!

Invisible high energy UV light may damage eyes or skin.

- ► Do not work on the machine if covers are removed.
- ► When performing light uniformity checks always wear UV protective glasses and cover your skin.
- ► Increased awareness is required when using short-wave UV 250 or UV 300 light (if applicable) or when using 365 nm wavelength only.
- ► Increased awareness is required when the optional UV-LED light source is used with 365 nm wavelength exclusively, because this radiation is completely invisible to the human eye.

Protective equipment:
- UV-Safety Goggles
- Safety Gloves

1.13 Safe Handling of UV-Lamps to Avoid Mechanical and Chemical Hazards

UV-lamps have a high internal pressure.
Hot lamps must not exposed to high temperature fluctuations.
Lamps must not exposed to mechanical pressure.

- Only open the lamp house if the lamp has been cooled down.
- Never touch lamp at its glass bulb. Only touch it at its ends.



WARNING!

Risk of Explosion!

UV lamps are highly pressurized. They can explode if mistreated causing serious injuries by fragments.

► Touch only when wearing face shield and gloves.

► Avoid rude handling.

► If not in use store it in its original box.



Safety Gloves
Media- and heat-resistant safety gloves protect hands from aggressive media, mechanical, thermal and radiation dangers.



UV-Safety Goggles
Safety goggles protect eyes from flying parts, splashing media and hazardous radiation.



NOTICE!

Each lamp destruction results also in emission of mercury.
Details concerning emission of mercury are described in section „Chemical Hazards“.

Rules for save handling of the lamp:

- Only transport and store the lamp in the original supplier‘s box.
- Only operate the lamp with a SUSS power supply which is optimized for the lamps.
- Only use lamps which are authorized form SUSS for the corresponding power supply.
- Respect the maximum life time of the lamp. It is specified in the lamp data sheet.
- Only open the lamp house after cool-down of the lamp.
- Set the cooling data carefully according to the manual.
- After lamp exchange check all electrical contacts and renew if necessary.
- Ensure that the cooling nozzle is adjusted correctly to the lamp socket.
- Check the lamp socket for discoloring. It is a sign for insufficient cooling. Check cooling if necessary.
- Avoid any mechanical stress to the bulb.
- Touch the lamp only at its ends (sockets), Never touch the bulb.

- Respect the orientation and polarity of the lamp during installation:
  - Standard: cathode (-) up
  - 5000 W lamps and dUV HgXe 500 W: cathode (-) down
- If changing the lamp type select the new lamp type in the menu of the lamp power supply BEFORE installation of the lamp.
- Read and respect the manual of the lamp power supply.

1.14 Safety Hazards during Operation, Maintenance and Service

1.14.1 Warnings and Warning Labels

All safety hazards of the equipment which are known by SUSS MicroTec Lithography GmbH at the time of effecting this manual are indicated with warning labels at the equipment in close vicinity of the hazard.
These warnings indicate dangers which may arise during installation, maintenance or operation of the equipment.

These warnings contain:

- one or more symbols or pictograms
- a clear keyword to identify the accident level.
- a description of the hazard and its possible consequence.
- a hint concerning the prevention of the hazard

NOTICE!

Do not remove or damage any warning label.
Use only cleaning agent IPA, because aggressive solvents may destroy the labels.
Immediately substitute any unreadable warning label (can be ordered from SUSS MicroTec).
Warning labels serve for the safety of the user!

1.15 Emergency Off and Safety Interlocks

SUSS lamp houses and machinery (e.g. mask aligners) are equipped with safety related interlocks according to their inherent risks. Such interlocks may consist of door locks, door switch, flow monitoring device and EMO functions. These interlocks can switch off the CIC1200 Gen2 and / or control the CIC1200 Gen2 status using signal or power line connections to the CIC1200 Gen2. The EMO of the host machine shall switch off the power line to the CIC1200 Gen2 via contactor or safety relay.

A sample of a safety circuit is shown below. For further details refer to the manuals of the host machine or contact SUSS service.

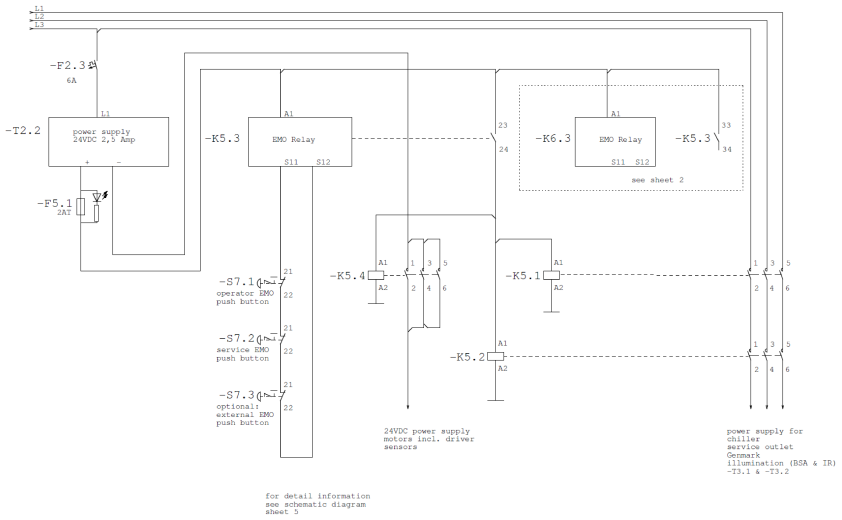


Fig. 1 - 1: Interlock Sample from MA200 Gen3

Opening the lamp house door will immediately open the door switch, effectively turning off the CIC power supply the same way as by activation of the EMO button. The EMO-relay K5.3 will switch off the CIC main power.

WARNING!

Never defeat safety interlocks or EMO between the CIC and the lamp house or machine!

2 Technical Specification CIC1200 Gen2

Operating Mode:	Single channel constant power Independent dual channel constant intensity remote control
Output Power:	LH200* or NFH: 200 W LH350*: 600 W LH1000/ LH1500*: 1200 W maximum continuous. (*LH= SUSS Lamp House)
Output Voltage:	382 V DC open circuit (max); regulated to lamp specific requirements
Output Power Regulation:	± 1% within specified mains input range
Mains Input:	200-240 V, 50/60 Hz; SEMI F47 L+N+PE or L1+L2+PE Max. power: 1500 W Exchangeable fuses in rear panel: 2x 10 A slow-blow, 5x20 mm.
Lamp Ignition:	Single pulse ignition with up to 20 kV puls. Active current limit during warm-up. Remote start unit with polarity switch.
Optical Sensor: **(for CI-mode) external**	Dual channel using silicon photodiodes with selected filters (option) according to machine configuration.
Optical Control: **(for CI-mode)**	Digital meter: 0-175 mW/cm2 front panel channel selected. Front panel level set and UV-probe adjustment.
Size: without remote start unit (located at LH)	Length: 540 mm [21,25“] Width: 260 mm [10,25“] Height: 152 mm [6,0“]
Weight: without remote start unit	21 kg (46 lbs)
Ambient Coniditions:	• Preferred application in clean room class 10.000 or better. • Ventilation grids must be free. • Environmental limits: indoor use only, Temperature range: +5°C to +40°C (storage and transport condition: -10° C to +50° C) Relative humidity: max. 80% non-condensing, up to 31° C, diminishing to 50% at 40° C • Altitude max. 2000 m

Approved Lamp Types (PN 100074148 only!)	Manufacturer	Type	Part Number (SUSS)	Usable with SUSS Lamp House (LH)	Notes
200 W Hg	Osram	HBO 200 W/DC	**G191806**	LH250, LH350, LH1000, LH1500	Cathode up
	Ushio	USH-250 S	**G169722**	LH NFH	Cathode up
350 W Hg	Osram	HBO 350 W/S	**G146049**	LH350, LH1000, LH1500	Cathode up (dUV-reduced)
	Ushio	USH-350 D	**G182538**	LH350, LH1000, LH1500	Cathode up
500 W Hg-Xe (Deep UV)	Ushio	UXM 501 MD	**G148979**	LH350, LH1000, LH1500	Anode up automatic selection in ignition box
1000 W Hg/DHL	Osram	1000 W/DHL	**100029742**	LH1000, LH1500	Cathode up
1000 W Hg	Osram	HBO 1000 W/D	**G148959**	LH1000, LH1500	Cathode up
	Ushio	USH-1000 KS	**G169776**	LH1000, LH1500	Cathode up

Other lamp types or lamp house configurations, e.g. for Near Field Holography (NFH), only by or with written consensus of SUSS MicroTec.

3 PROGRAM PARAMETERS

for CIC1200 Gen2 for the various types of exposure lamps.

Lamp Type [W]	P_{min} [W]	P_{nom} [W]	P_{max} [W]	$N_{2\ time}$ [s]
200 Hg	150	200	250	300
350 Hg	250	350	430	300
500 HgXe	350	500	600	180
1000 Hg/DHL	800	1000	1200	180
1000 Hg	800	1000	1200	180

Legend:

P_{min} [W]	Minimum lamp power to run the exposure lamp
P_{nom} [W]	Rated power of the exposure lamp
P_{max} [W]	Maximum power to run the exposure lamp
$N_{2\ time}$ [s]	If lamp cooling error becomes active (because of bad socket cooling or exhaust flow - i.e. when below the preset limits) this timer will be started. The lamp will be switched off after this time. The corresponding alarm message starts immediately and continues also after lamp has been switched off.



During the cool down period no function of the CIC1200 Gen2 is accessible.
A countdown starts and operation is blocked until zero is reached.

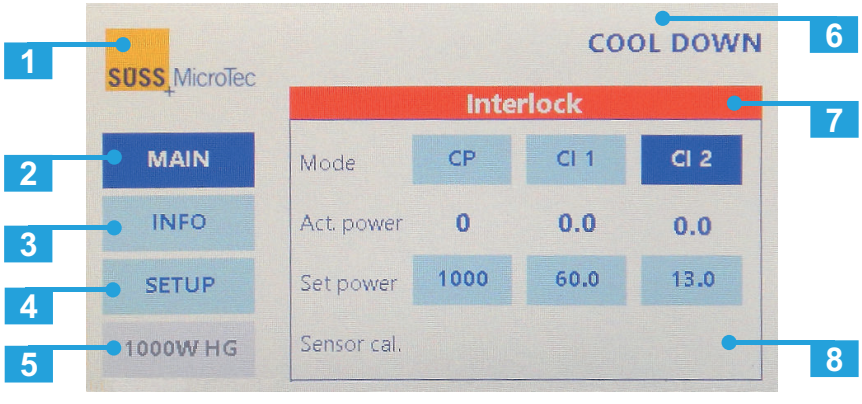
4 CONTROL ELEMENTS AND CONNECTIONS

4.1 CIC1200 Gen2 Front Panel



1	Lamp Power ON/OFF
2	Touch Display for Lamp Parameters
3	Status LEDs

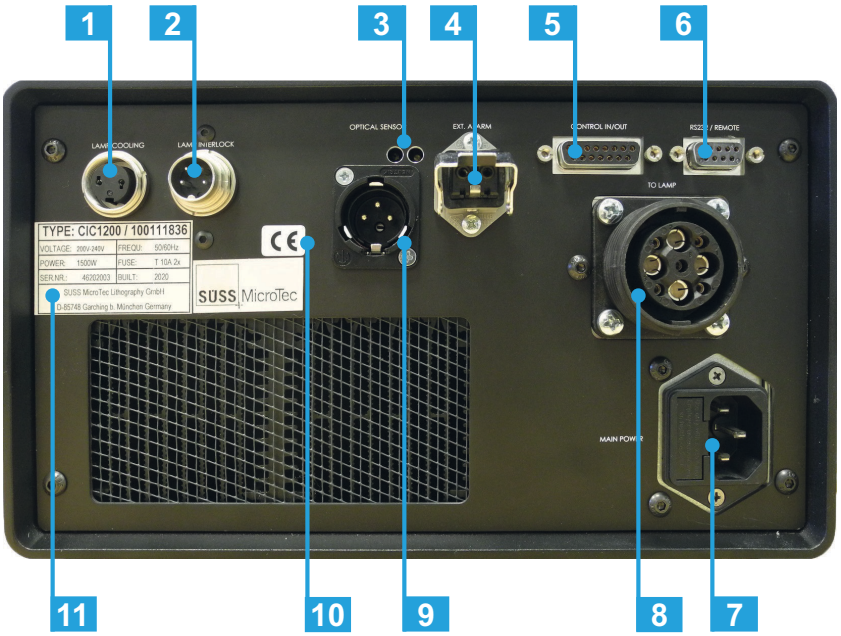
4.1.1 Touch Display



1	SUSS Logo - Home Button
2	Button: Main Menu
3	Button: Info
4	Button: Setup

5	Button Lamp
6	Current State Display
7	Status Bar
8	Parameter Display

4.2 CIC1200 Gen2 Rear Panel



1	Lamp Cooling Interlock
2	Lamp Interlock
3	Fine Adjustment of Sensor Input Signal
4	External Alarm
5	Control IN/OUT
6	RS232/Remote
7	Main Power with Fuses (T10A)
8	Connection to Lamp
9	Optical Sensor
10	CE Sign
11	Nameplate

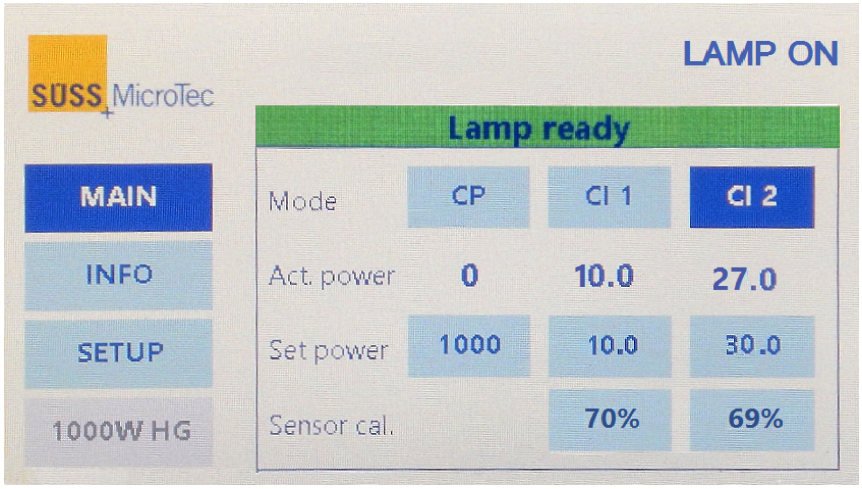
4.2.1 Nameplate

TYPE: CIC1200 / 100111836	
VOLTAGE: 200V-140V	FREQU: 50/60Hz
POWER: 1500W	FUSE: T 10A 2x
SER.NR: 12314500	BUILT: 2020
SUSS MicroTec Lithography GmbH D-85748 Garching b. München Germany	

- Product name/ part number
- Voltage
- Frequency
- Power
- Fuse requirements
- Serial number
- Year of construction
- Manufacturer's address

4.3 The Pages of the Touch Panel

4.3.1 MAIN Page



The MAIN Page shows all current settings and data of the lamp and the used mode of the power supply.

Two modes are available:

- Constant Power (CP)
- Constant Intensity (CI)

SUSS Logo:

The SUSS Logo in the upper left edge of the page serves as a "Return" button.

► Click it to switch back to the previously displayed page.

Current State Display:

The display in the right upper edge shows the information about the lamp state, e.g. the following states can be displayed:

- LAMP ON
- COOL DOWN
- ...

Status Bar:

The status bar shows the state of the CIC1200 Gen2, eg. the following states can be displayed:

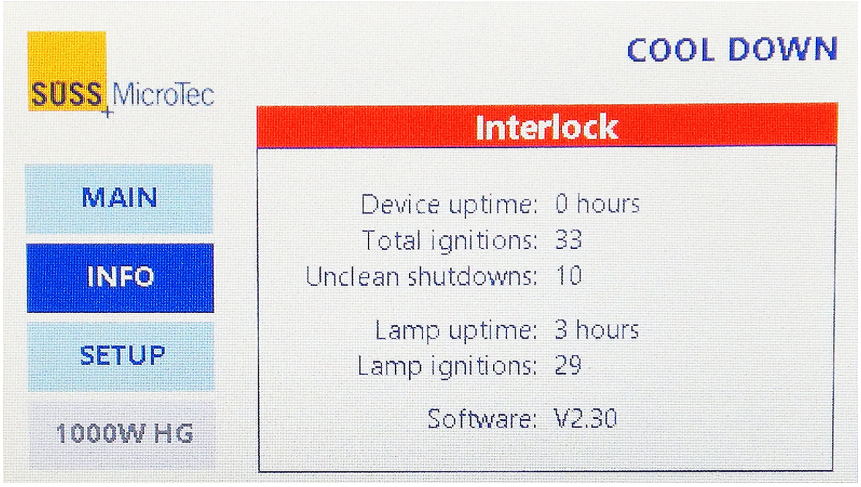
- Lamp Ready
- Interlock
- ...

Parameter Display:

The parameter display shows the chosen parameters for the running process of the CIC 1200 Gen2:

- Current mode
- Actual power
- Set power
- Sensor calibration

4.3.2 INFO Page



The display on the INFO page shows some general information concerning the lamp and the CIC1200 Gen2.

CIC1200 Gen2:

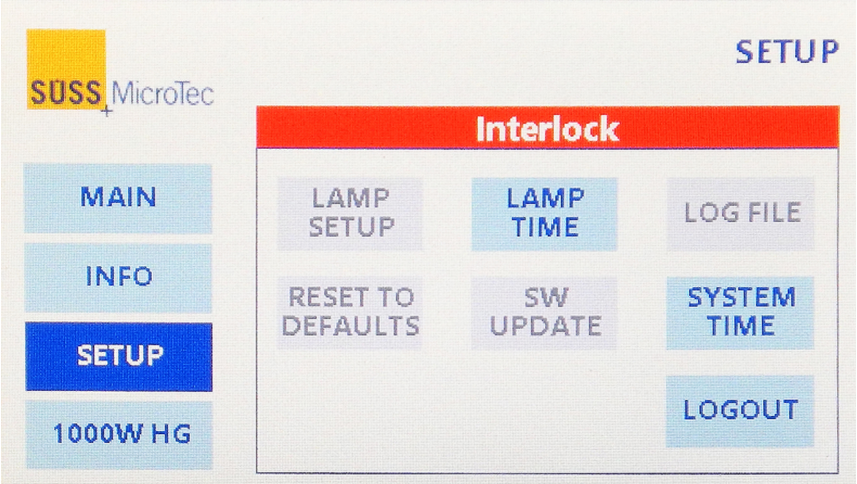
- Device uptime: total uptime of the CIC1200 Gen2
- Total ignitions: number of all attempted lamp ignitions (even if unsuccessful)
- Unclean shutdowns: "Unclean shutdowns" occur when the CIC1200 Gen2 is switched off while the lamp is on.

Lamp:

- Lamp uptime: total uptime of the lamp
- Lamp ignitions: number of ignitions of the lamp

- Software: Software Version of the CIC1200 Gen2

4.3.3 SETUP Page



The SETUP page gives access to several settings and service tasks.

Service Tasks:

The access for service tasks is restricted and password protected. Only service personnel from SUSS MicroTec is allowed to perform service tasks.

- Lamp Setup
- Reset to Defaults
- Software Update
- Log File

► Click the corresponding button to enter the sub-menu.

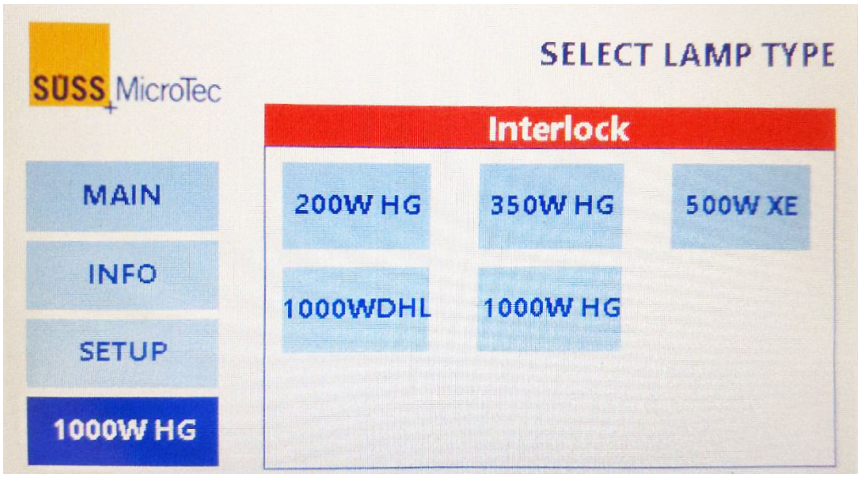
Common Settings:

Common settings are restricted and password protected.
The password for super users is: ***[1234]***

- Lamp Time: display and reset lamp time
- System Time: set system time and date.

- Lockout: button to quit the SETUP access.

4.3.4 LAMP TYPE Selection



The Parameter Display shows all available lamp types.

► Click the desired button to select the lamp type.

The current selected lamp type is displayed on the button for the LAMP TYPE selection.

The selection for the lamp type is password protected.
*The password for the super user is: **[1234]**.*

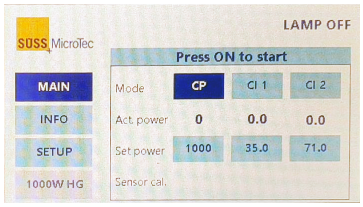
5 OPERATION OF THE CIC1200 Gen2

5.1 Switch ON the Lamp

As soon as the power supply is connected to the mains, it goes into stand-by mode.
The hardware buttons Power ON / OFF are used to switch the lamp on and off.

Interlock MA150e!
The lamp can only be turned on when the MA150e is turned off. Otherwise an interlock is active to prevent the lamp from igniting.

Starting Position:



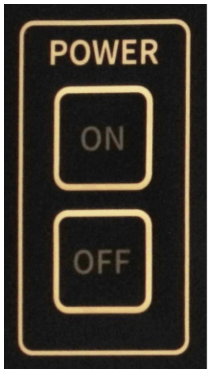
- **Only MA150e:** The mask aligner is switched off.
- The power supply is in stand-by mode.
- The current state is: LAMP OFF
- The status bar shows: "Press ON to start".

Modify the Lamp Parameters:

Before inition of the lamp you can modify the lamp parameters:

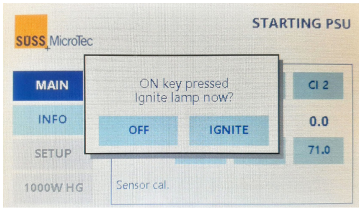
- Select/ change the lamp type.
- Modify the current for operation.
- Switch between constant power (CP) and constant intensity (CI).

Start the Lamp:



Press ***[POWER ON]*** at the front panel of the CIC1200 Gen2 to start the lamp.

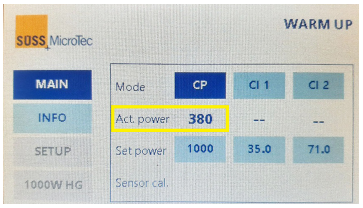
► A confirmation window at the touch panel prompts you to confirm the ignition of the lamp.



Click ***[IGNITE]*** to ignite the lamp.

► Ignition of the lamp is started.
The current state shows for a short time: IGNITION.

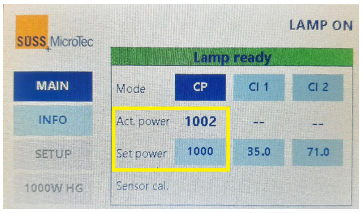
Warm Up of the Lamp:



The increase in the actual output *"Act. power"* up to the target output *"Set power"* of the lamp can be observed.

► The current state changes to: WARM UP

Lamp Ready:



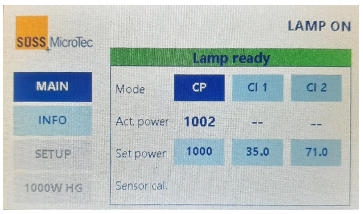
As soon as *"Act. Power"* and *"Set Power"* match, the current status shows: LAMP ON

► The status bar shows:" Lamp ready"

The Lamp is now ready for exposure.

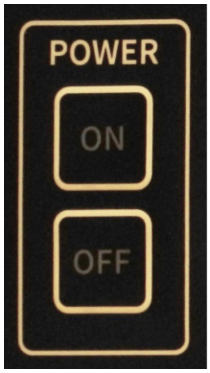
5.2 Switch OFF the Lamp

Starting Position:



- The mask aligner is running
- The current state is: LAMP ON
- The status bar shows: "Lamp ready".

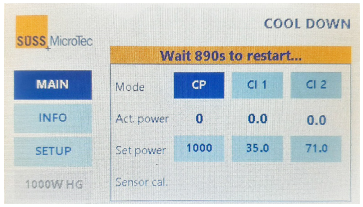
Switch off the Lamp:



Press ***[POWER OFF]*** at the front panel of the CIC1200 Gen2 to switch off the lamp.

► The lamp is immediately swiched off.

Display Status:



- The current state is: COOL DOWN
- The Act. power is "0"
- The status bar shows: Wait XXXs to restart...
- A countdown starts and operation is blocked until zero is reached.

5.3 Constant Power Mode (CP)

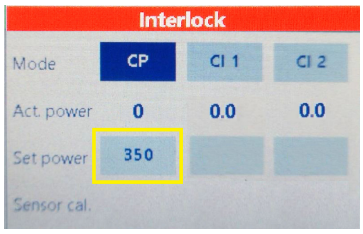
In *"Constant Power"* mode the exposure lamp is run with constant electric power.



- Click ***[MAIN]*** to display the MAIN page.
- Alternatively click the SUSS Logo to switch back to the previous page.

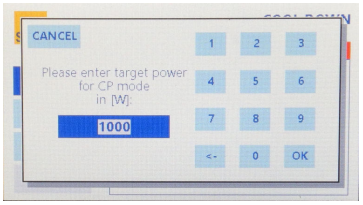


- If not yet selected, click ***[CP]*** to activate the constant power operation.

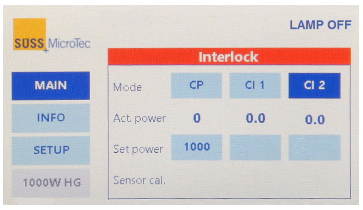


- Click the button of the current displayed power setting.

► A nummeric pad is displayed.



- Type in the desired power setting.
- Confirm with ***[OK]***



► The new power setting is displayed on the button.

5.4 Constant Intensity Mode (CI)

The *"Constant Intensity"* mode provides constant light intensity, regardless of the effects of lamp aging or fluctuations in power.

Two channels are available depending on the desired spectral range:

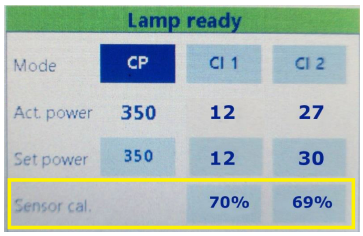
- CI1: for 365 nm
- CI2: for 405 nm

5.4.1 Adjustment of the Internal CI-Sensor

The internal CI-sensor value displayed at "Sensor cal" should always be between 50% and 95%.

To achieve this either:

- adjust to 70% at the nominal power of the lamp (eg. for lamp HBO 350 W/S: 350 W)
- or set the lamp to maximum power and adjust the sensor to 95%.



The actual power is continuosly displayed during exposure in the corresponding field of *"Sensor cal."*.

There are two adjustment options for the sensor:

Option 1:

Manual position setting of the internal sensor inside the mirror house:

- depending on the machine type, revision and optics there is a 2-channel light sensor installed near the light beam between the fly's eye and the front lens.

NOTICE!

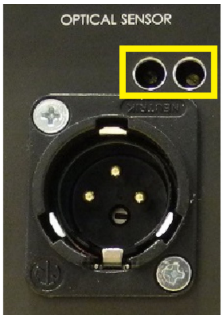
Adjustment of the Internal Light Sensor

The adjustment of the internal light sensor depends on the individual mask aligner and the used lamp house.

► The setting of the light sensor may only be carried out by trained personnel.

► Before setting, check the specific documentation for your device.

Option 2:



Fine adjustment of the sensor input signal:

- On the rear side of the CIC1200 Gen2 there are two openings for setting the signal for each sensor with potentiometer.



- Use a trimpot adjustment tool for setting.

5.4.2 Constant Intensity Operation

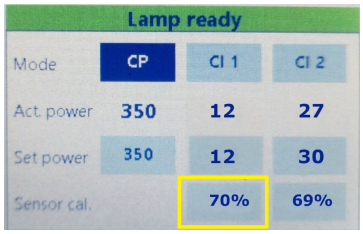
Calibrate the Internal Sensors

Required Tools:



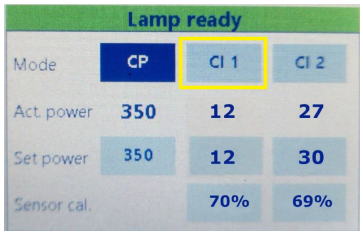
- External UV-Optometer
  (e.g. G207355 SUSS UV-OPTOMETER)
- Light measuring probe
  (e.g. G187080 LIGHT MEASURING PROBE 365/405NM)

External Measurement:



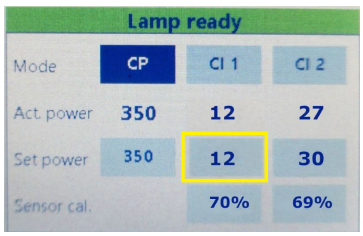
- Open the shutter to enable the measurement in the exposure area of the mask aligner.
- Measure the current UV intensity with the UV-Optometer (with the appropriate probe head for the desired wavelength) at 5 positions in the exposure area and calculate the average value.
- Touch the button for Sensor Calibration ("Sensor cal.) for CI 1.
- A numeric pad is displayed.
- Enter the average value and confirm with *[OK]*.

Work with the CI-Mode



1. Click one of the two available channels (matching to the desired wavelength):

- CI1: CI-channel 1 for 365 nm
- CI1: CI-channel 2 for 405 nm



2. Touch the corresponding button *"Set power"*.
A numeric pad is displayed.
Enter the needed intensity in [mW/cm²] and confirm with *[OK]*.

6 MAINTENANCE AND SERVICE

6.1 Maintenance of the CIC1200 Gen2

The CIC1200 Gen2 as a whole and also its sub-assemblies do not require user maintenance.

But following safety related activities are required during the use of the CIC1200 Gen2 with our mask aligners:

- Perform regular safety checks of the lamp house door interlock(s), as described in the user documentation of the respective mask aligner. Preferably do this safety check at every lamp exchange.
- With every lamp exchange, check the condition of the current connections in the lamp house and replace any darkened or oxidized component.
  Check also that the lamp wire is sufficiently distant to the housing (including closed door) that the high voltage ignition pulse can not spark over.
- Check also during lamp exchange, that all lamp cooling equipment is working properly:
  - lamp house exhaust flow,
  - cooling nozzle, supply tube and supply pressure.
- Reset the lamp life counter (see *“Common Settings:” on page 30*) when replacing the lamp by a new lamp.
- If lamp type is changed, change also the selection at the CIC1200 Gen2 lamp selection.



WARNING!

Risk of damage to the machine!

Another lamp type may require additional adaptation parts to fit to the lamp house geometry and the cooling requirements.

- Dispose off used lamps - pressurized and containing mercury - according to applicable local and company rules.
- After the warm-up period of the new lamp, check for correct cooling conditions (exhaust temperature and lamp socket temperature).
  For details see section "Lamp Cooling", or the installation manual of the respective mask aligner.
- When optics or the lamp type has been changed, a re-adjustment of the UV-measuring input could be required.



WARNING!

Risk for Personal Injury and Material Damage!

Prior to start lamp replacement, read and understand the related hazard safety warnings (see chapter *Chapter 1.13 “Safe Handling of UV-Lamps to Avoid Mechanical and Chemical Hazards” on page 20* and equivalent section in the mask aligner manual).

6.2 Error Messages and Other Notices

Standard messages:

Message	Reason
Press ON to start	
Press OFF to reset failure	
Lamp ready	
Wait Xs to restart...	

Warnings and notices:

Message	Reason
Warning: lamp is old	Actual voltage is less than minimum voltage
Warning: lamp burn out	Actual voltage is greater than maximum voltage
Warning: power deviation	Actual performance/intensity deviates from target performance/ intensity by more than 5%
Warning: sensor overflow	One of the sensors reports more than 90% light
Only allowed in STANDBY	Change lamp type while lamp is on

Error messages that lead to shutdown:

Message	Reason
Interlock	Interlock interrupted
Wire Interlock	Wire interlock interrupted
Machine Interlock	Machine interlock interrupted
N2 Interlock	N2 interlock interrupted
No igniton	Lamp does not ignite
Current deviation error	Deviation of actual current from target current by more than 50%
Current too low error	Actual current is less than ¼ of the maximum current (I_FIRE)
Current too high error	Actual current is more than 10% greater than max current (I_FIRE)
Power failure while lamp was ON	Shutdown of the device while the lamp is on (without prior OFF)
Internal device error	internal termination error in the logbook (unknown error number)

Other logbook entries:

Message	Reason
Log fle initalizaton	The logbook was reset
Lamp replaced	Lamp time reset
Lamp changed: %s	Change lamp type
%lu:%02lu %.1f A - %.1f V	Measured values before and after changing the lamp

Message	Reason
Time set: %s	Change system time
Internal error	Internal abort error in the logbook (unknown logbook entry type)

6.3 Installation and Service

6.3.1 Installation

The CIC is delivered in a special shipping box and may only be installed by an authorized SUSS technician.

It may only be integrated into SUSS devices or machines and may only be used with the specified lamp housings and lamps (see 2. Technical data CIC1200).

After intensive training by SUSS MicroTec, installation work can be carried out by experienced and qualified users.

However, never open, modify or change the CIC1200 Gen2 or the host computer with which it is used.

It must be ensured that the CIC1200 Gen2 itself is positioned in such a way that sufficient air cooling is guaranteed.
The air flow through the CIC1200 Gen2 must be allowed from the bottom to the rear.

6.3.2 Service and Technical Assistance

The CIC1200 Gen2 is not user serviceable and no internal parts can be repaired by the user.

If you experience difficulties with the CIC1200 Gen2 that cannot be resolved by setting the controls or replacing the lamp, contact your nearest SUSS MicroTec office (see www.suss.com).

Be prepared to provide following information:

- Your company name, address, telephone number and the name of the responsible individual whom SUSS may contact if further inquiry about the technical problem is necessary.
- Model number, serial number and software revision of the equipment.
- A list of associated equipment and description of the electrical connections.
- brief description of the problem.

When returning parts for service or repair to SUSS MicroTec Lithography ask in advance for your Return Material Authorization (RMA).
You will be provided with a tracking number during the repair cycle.

Whenever possible, use original packaging material (CIC1200 Gen2 special shipment box) or at least wrap it carefully with suited clean packaging material and an adequate box.
Also equip the container with shock indicators.

After the useful life time of the host machine or CIC1200 Gen2, the CIC1200 Gen2 may be disposed off as industrial waste and according local and legal requirements.

SÜSS MicroTec

USER MANUAL



Accessories

UV-Optometer

Radiation Measurement Device

Rev13 18-09

READ THIS MANUAL PRIOR TO PERFORMING ANY TASK!

User Manual

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This manual is a user documentation of SUSS MicroTec Lithography GmbH (in the following "manufacturer") and allows safe and efficient use of the UV-Optometer.

Prior to working on this product, the personnel must have thoroughly read and understood these instructions and, furthermore, know and observe officially recognized rules regarding occupational health and safety. The basic prerequisite for safe working is compliance with all the safety and handling instructions stated in this manual and the safety and installation manual of the tool.

Figures in this manual are for the fundamental understanding and can deviate from the actual design of the tool.

English is the original language of this manual.

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Service

Our customer service is pleased to provide further technical information.

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Email	service.aligner@suss.com
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1 WARNING and SAFETY PRECAUTIONS

1.1 Warnings



WARNING!

Risk of Eye Damage!

Invisible, high energy UV light may damage eyes or skin.

- ► Never use the machine without covers.
- ► When performing light uniformity adjustments always wear UV-protective glasses and cover your skin.
- ► Be especially careful with almost invisible UV radiation of UV300 and UV250.

Protective equipment: ■ Safety Goggles



UV-Safety Goggles
Safety goggles protect eyes from flying parts, splashing media and hazardous radiation.



CAUTION!

Sensitive Measurement Device!

- ► Do not touch the light window of the probe!
- ► Do not shake or bounce any component!
- ► Do not twist, bend or pull the cable!
- ► Do not store at extreme temperature, humidity, etc!



NOTICE!

Sensitive Measurement Device!

This instrument as well as its light measuring sensors are very sensitive measurement devices.
Protect these devices from detrimental environmental conditions, like dust, shock, vibration, humidity etc. - The specified measuring accuracy is only valid with adequate operating and storing conditions.
Detrimental effects can even permanently falsify the measurement values.
In case liquid should reach the interior of the instrument, risk of short-circuit exists!

1.2 Precautions

Do not open the housing (except the battery compartment for battery exchange). The instrument does not contain any parts which can be maintained by the user.
Service work must only be performed by qualified specialists.
After each repair a re-calibration at SUSS MicroTec Lithography is required.



- ► *Type labels (with serial numbers) are placed at the UV-Optometer and the probes.*
- ► *The UV-Optometer is equipped with two AA batteries.*
- ► *Use only suitable batteries for operation. SUSS recommends the use of alkaline batteries for best performance.*
- ► *If the UV-Optometer is operated in a housing take care of free air circulation to guarantee good temperature balance.*

Notes for the UV-Optometer Battery Care



WARNING!

Batteries may contain Acids and Toxins!

► Do not touch leaking liquids or salts.

► In case of body contact rinse immediately with sufficient water.

- The provided batteries must not be charged or reactivated otherwise. They must not be disassembled, thrown into fire or short-circuited.
- Take out used batteries immediately to prevent them from „bleeding“ which could cause damage to the Optometer. Also remove batteries in case of continuing disuse of the instrument.
- Always replace both batteries at once. Do not use different battery types or brands or batteries with different capacity.



CAUTION!

In case of return of an UV-Optometer **by airfreight** the batteries have to be removed from the UV-Optometer. (It is allowed to airfreight the batteries with isolated contacts separately packaged in the tool case. But it has to be declared in the shipping document (IATA A123)).



CAUTION!

Only use high quality, leak proof batteries.
SUSS MicroTec must not held liable for damage caused by leaking batteries in or outside of the instrument.



ENVIRONMENT!

Do not discard used batteries into domestic waste or environment.
Always dispose batteries separately and according to local regulations and prescribed measures!

2 Components of the UV-Optometer

2.1 Introduction

The UV-Optometer is a high-precision current measurement instrument, adapted to signal evaluation of optical radiation detectors.

The UV-Optometer (display unit) performs light measurement with a suitable sensor head (probe). Probes, suitable for this instrument can be universally combined with display units.
A limitation concerning sensor detection only exist with former versions of the UV-Optometer software (*Chapter 2.3.1 “Spectral Sensitivity” on page 11*).

Wavelength ranges resp. spectral sensitivity are only defined by the sensor head. The corresponding irradiance for this wavelength range is displayed at the UV-Optometer. The UV-Optometer shows the irradiance of two measuring channels simultaneously if the sensor is equipped for two channels (wavelength ranges, e.g. 365nm/ 405nm sensor).

Note that:

- every quantitative light energy measurement is only valid for the limited wavelength range of the used sensor type.
- the sensor never measures the whole light, but only a certain part of the light spectrum depending on the sensor characteristics.
- depending on the spectrum of the individual light source, measured light intensities within the same wavelength range can correlate very differently to each other.
- the UV-probes are calibrated for defined light sources which correspond to specific applications (high pressure mercury lamps, SUSS UV-LED lamps).

2.2 UV-Optometer Display Unit

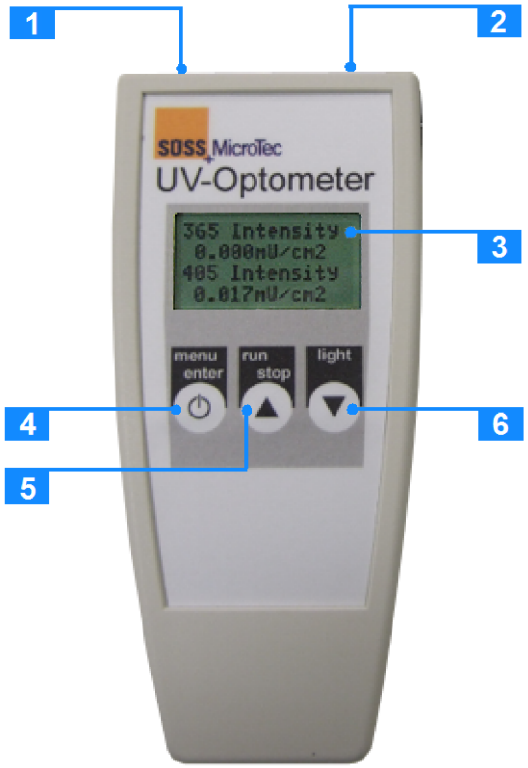


Fig. 2 - 1: UV-Optometer Display Unit

1	**UV-Probe - connector**
2	**RS232 interface**
3	**Display (4-line)**
4	**Multi-function key:**
	• ON
	• OFF (press for > 3 s) * see also 4.6
	• Menu - Change
	• Enter
5	**Multi-function key:**
	• Run/stop in operation mode "Dose Measurement"
	• Scroll in menu mode
6	**Multi-function key:**
	• Light on/off in operation mode (display background illum.)
	• Scroll in menu mode

Rear side (not shown): serial number, date of next calibration

CAUTION!

Risk of Damage!

► Do not apply pressure to the display. It can break.

► Do not press at the membrane keypad with sharp edges (e.g. finger nails).

2.3 UV-Probe



Fig. 2 - 2: UV-Probe

1	**Signal cable**
2	**Probe with diameter 38 mm**
3	**Measuring field with diffusing glass**
4	**Plug for connection to the UV-Optometer**
5	**Fixing screws to fix the plug to the connector of the UV-Optometer**

UV-probes are used to detect optical radiation and to transform it into an electrical signal. The UV-Optometer can be equipped with different probes, which can be calibrated for the spectral characteristics of the used mercury UV lamp:

- Probe 240 (PN.: 10005063) offers one channel to measure the narrowband range of 240nm.
- Probe 320 (PN.: G187081) offers one channel to measure the narrowband range of 320nm
- Probe 365/405 (PN.: G187080) offers the possibility to measure the intensity of two different wavelength ranges at the same time. One channel measures within the narrowband range of the 365nm line; the second channel measures within a broadband range of so called UV400 (365nm+405nm+436nm lines).
- UV-LED-Probe 365/405 (PN.: 100099317) offers the same possibility as Probe 365/405 but additionally the LED-spectra can be measured individually for each line (g-h-i).

Labels on the UV-Probes:

On the label at the back side of the probe following information is displayed:



Fig. 2 - 3: Labels

- Model number (e.g. MvL-D-0113-3)
- Measuring range (e.g. UV365/UV405)
- Serial number (e.g. SN4242)
- Number of the calibration certificate (e.g.1840714-WERK)
- Date of latest calibration (e.g. 2018-04)
- Possibly (after first recall) next recomended recalibration date (e.g. Recal.: 2019/04)

The color of the label lettering (red or black) displays whether the probe is suitable for measuring LED-light.

- RED:
  Probe is suitable for measuring individual UV-LED-lines.
  It either is a new UV-LED-probe with SW V.4.0 or it has been updated and calibrated to become a UV-LED-probe.
  Both need a UV-Optometer SW V.4.0 or higher at display unit.
- BLACK:
  The probe can be used for measuring broadband UV-LED-light but can not measure single UV-LED-lines (g-h-i). The calibration of this probe is made for mercury lamps.
  It can be used with SW <V.4.0 as well as with V.4.0 or higher (see also table 2.3.1)

NOTICE!
Probes with red label need a UV-Optometer with SW V4.0 or higher!

2.3.1 Spectral Sensitivity

Probe Part No.	**G187080 and 100099317**		**G187081**	**100005063**
Spectral function	UV365	UV405	UV320	UV240
Spectral sensitivity range [nm] (±5)	345-385	345-460	290-345	225-255
Display range with UV-Optometer [mW/cm²] *	0,01- 1.000	0,01- 1.000	0,01- 1.000	0,000001 - 200
Sensor type	GaP	GaP	SiC	Si
Required UV-Optometer SW version *(or higher)*	G187080: v.1.2 100099317 : v.4.0		v.1.2	v.1.9

*Upper limit may be higher for individual probes, but saturation of sensor is possible without warning

For exact spectral responsivity of individual probes: refer to the attachment, delivered with the first time calibration certificate of the probe.

Table 1: Spectral Sensitivity of Probe UV365-405

Detector: MvL-D-0113-3/ UV365/405 Example values:	
UV365 50%-level left [nm]:	349,2
UV365 50%-level right [nm]:	385,1
UV405 50%-level left [nm]:	350,7
UV405 50%-level right [nm]:	459,7

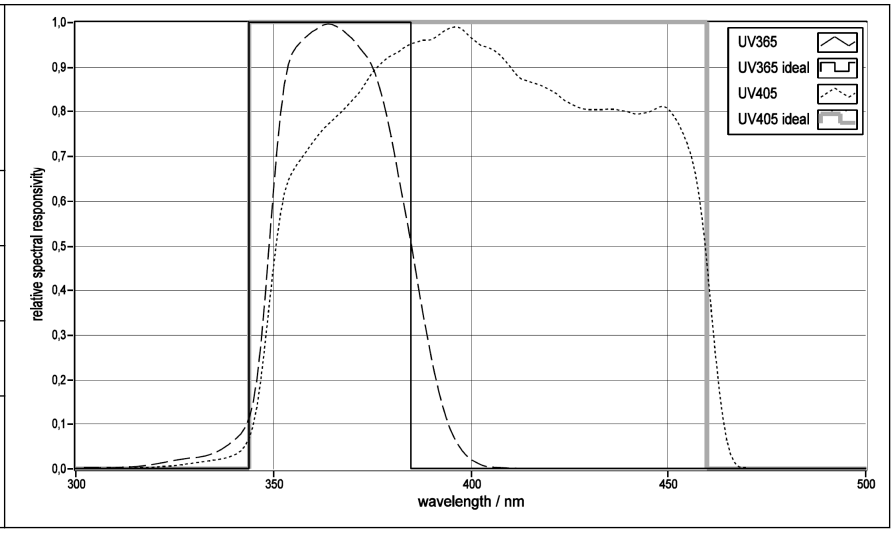


Table 2: Spectral Sensitivity of Probe UV320

Detector: MvL-D-0113-4/UV320 Example values:	
UV320 50%-level left [nm]:	282,6
UV320 50%-level right [nm]:	339,3

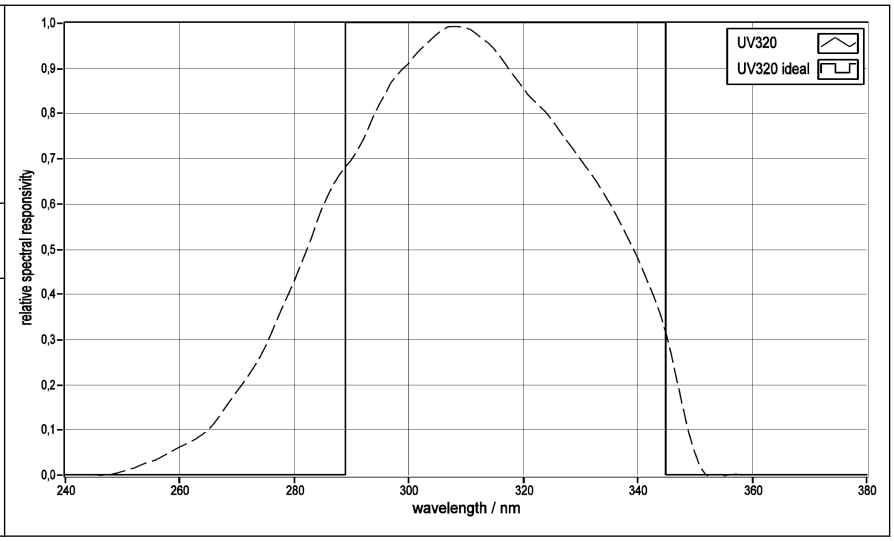
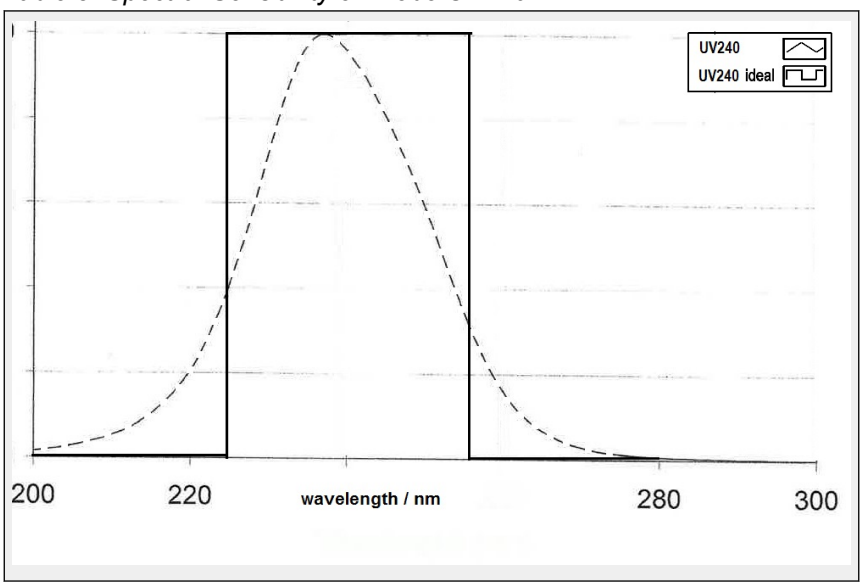


Table 3: Spectral Sensitivity of Probe UV240



2.3.2 Calibration Accuracy

Probe Part No.	G187080 and 100099317	G187081	100005063	Dim.
Spectral function	UV365+405	UV320	UV240	±%
Total accuracy	6	6	9	±%
Temperature drift	1	3	2	±%
Detoriation drift (100mW/cm² x 1000h)	3	3	5	±%
UV-Optometer	Total accuracy: ± 0,25% + 1digit			

2.3.3 Environmental Specifications

	Range	Dimension	Note
Temperature probes (spec.)	20 - 60	°C	Full accuracy
Extended temperature probes	10 - 70	°C	Reduced accuracy
Storage temperatur [probes + meter)	-20 ±60	°C	Store dry!
Humidity	<75	% rH	Non-condensing
	No shock!		
	Keep window clean and do not touch!		

NOTICE!

The measurement window is prone to mechanical damage.

► Always apply a protective cap on top of 240 nm probes, when not measuring.

NOTICE!

If the probe's internal temperature exceeds 70°C an overtemp warning is displayed. The probe should be removed instantly to avoid damage.

2.3.4 Mechanical Specifications

Dimensions: (probe)	diameter	38	[mm]
	height	17	[mm]
Measuring window:	diameter	5	[mm]
Cable	length	ca. 95	[cm]
Weight (approx.):	probe	64	[g]
	optometer (empty)	118	[g]
	optometer (incl. batteries)	162	[g]

2.3.5 Handling of the UV-Probe

To do measurement the probe has to be connected to the UV-Optometer. It is recommended to connect the plug to the socket of the UV-Optometer with the provided screws.

The measurand „Intensity“ describes the radiation power per unit of area (mW/cm²) within a defined spectral range (which is individual for each channel). Therefore the center of the sensor must be positioned onto the spot to be measured, with its measuring field directed to the light source.
For a reliable result it is necessary that the measuring field is completely lighted and that the light hits the probe perpendicularly.
Incidence inclination of up to 5° does not affect the measuring result as long as the lighting of the measurement field is symmetrical and uniform.



CAUTION!

Risk of Contamination!

Fingerprints, scratches or any kind of pollution and damage of the measuring field can lead to wrong measuring results.

► Do not touch the measuring field and keep it clean.

► Store it in a box if not in use.

The probe is a very sensitive measuring device. Improper handling can void calibration of the probe and requires its re-calibration.
While for the near-UV probes a slight contamination could be cleaned mostly without affecting the probe performance, the 240nm probe is specifically sensitive to any kind of contamination, because the wave-length-selective filter can be affected directly. Therefore put away the 240nm probe always with the appendant lid on top.



WARNING!

Risk of Damage!

Cable and connector must be handled with care. Never pull, twist or bend.



WARNING!

Risk of Eye Damage!

Handling optical instruments requires attention to related safety regulations.
Optical radiation can also contain hazardous, invisible radiation.
High intensive light can result in glare which can harm your eyes.
When optical radiation is used the corresponding regulation for operational safety must be followed.

It is recommended to perform the light measurement with a probe holder which is provided with the measuring tool case. It is precisely adapted to the dimensions of the probe and can be used with different long handles.
Using the probe holder a longer distance to the light source can be maintained and the positioning of the probe is much more easier.

Especially in combination with a (machine specific) light measurement plate all measuring positions can be reached exactly, quickly and reproducibly.

2.4 RS232 Interface

The UV-Optometer is equipped with a RS232 interface. Via this interface the operation mode can be controlled and measuring data can be read out. A special interface cable for the adaptation to the computer is necessary.

This special Y-cable feeds into the instrument also an external power supply (+5V) via the PS/2 connection of the computer. Remote mode requires this external supply.

NOTICE!

The RS232 connector on the UV-Optometer has the same layout as USB connectors. Operation with commercially available USB-cables is not possible and can damage the connected devices.

3 Preparation of the UV-Optometer

3.1 Power Supply

The UV-Optometer is used with two commercially available 1,5 V Mignon batteries (type AA). The instrument runs continuously for approx. 350 hours without back light. The end of the battery life time is indicated at the display with „Bat Low“.

It is recommended to exchange the batteries at the latest if the reading during initialization of the UV-Optometer displays: ***"Battery: 30%"***

To change the battery the cover of the battery box on the bottom side of the UV-Optometer has to be opened with the sliding lock. The polarity of the batteries must obeyed.

If the instrument is not used for a longer period the batteries should be removed to avoid damage of the UV-Optometer because of leakage of the batteries.

NOTICE!

Refer to the battery note in section 1.1.

3.2 Connecting the Probe

Basically measuring probes can be connected also when the UV-Optometer is already switched ON. But the displayed measuring mode can change due to the particular programming of the sensors.

It is recommended to connect the probe before switch-on the instrument and to mount the probe plug to the connector of the UV-Optometer with its two screws.

The individual calibration data for the probes are stored in the calibration data memory. The instrument identifies the connected probe and takes its calibration parameters into account.
(The measured current is displayed as radiation intensity/resp. dose corresponding to the calibration factor of the selected lamp.)

3.3 Installation in Fully Automatic Mode

With certain machine equipment the UV-Optometer can be used in fully automatic measuring mode. The connection with machine control and power supply is made by a corresponding Y-cable. In this case batteries are not necessary within the instrument.
The probe cables are especially adapted to this application.
The installation of the light measurement instrument is done at SUSS.

3.4 Display

The four-line display can be illuminated with a back light. It can be switched on and off with the key *[light]* * .

* Only in operation mode "Intensity" and "Dose". In all other modes the key is used differently.



Use of back light reduces the battery life time significantly.

4 Operation of the UV-Optometer

See also the condensed instructions (last page of this documentation) containing the diagram of the menu structure.

4.1 Starting the UV-Optometer

NOTICE!
Before starting connect the measuring probe!

Switch on the UV-Optometer by pushing the key *[ON]*.
The display screen shows for a short time:

SUSS MicroTec
UV-Optometer
V.4.0 *software version
Battery: nn% *battery state

Following for 2 seconds the probe info is displayed:

UV-Probe
2CH. 365/405 *Number of channels and their central wavelength
Serial No12345
Recal. 12/2020 *Expiration date of the calibration (not till second calibration)

If no expiration date is displayed you can probably find the date on your probe label.

If no probe is connected a prompting message to connect the probe appears.

If the expiration date of the calibration is exceeded, a warning message is displayed. Nevertheless this probe can be used for measurements.

After expired calibration date the probe shall be sent to SUSS MicroTec for re-calibration.
(See chapter ↬ Chapter 6 “Calibration” on page 28)

4.2 Selection of Measuring Method

4.2.1 Lamp Type Selection

After starting the UV-Optometer you are asked to select the type of the UV lamp to measure e.g.:

Select UV-Lamp
1000 W

With all 2-channel-probes the different light sources can be selected with the arrow-keys.

► Confirm the selected lamp with *[enter]*.

The LED-Probe (PN. 100099317) additionally offers the possibility to select single LED-lines for measurement.
This option may be used to control the light power of the LED-light sources in detail and if necessary to mix the desired spectrum on base of these measurements.



This option of single LED-line measurement is NOT suitable for a routine measurement of a mixed LED-spectrum. For this purpose the lamp type selection "1000 W" should be used.



From SW V4.0 or higher all parameters (incl. lamp type) are selected permanently until they are newly set.

4.2.2 Display of Selected Operation Mode

Right after confirmation of the lamp selection the equipment is in the state operation mode menu (FUNCTION).

The selected operation mode can be used instantly.
In operation mode "Intensity" for example the measurement for irradiance intensity is started immediately.



From SW V.4.0 or higher, it is set to the last used operation mode (intensity, dose or uniformity).
For version < SW V.4.0 it is set to "Intensity".

Change the Operation Mode

Alternatively you can switch from operation mode menu (FUNCTION) to main menu (MAIN).

► Press *[enter]* (< 3 sec!) .

In main menu a change of the operation mode is possible.

4.3 Main Menu (MAIN) - Selection of Operation Mode

The main menu is used to switch between the 3 operation modes and to pre-select specific tool parameters.



From SW V.4.0 or higher, the main menu displays the last used operation mode.
For version < SW V.4.0, it displays "Intensity".

The main menu can only be reached starting from the operation mode menu.

► Press *[enter]* for < 3 sec.

Following menu selection is available:

- **Intensity**
- **Dose**
- **Uniform./Mean**
- **Setup**

► Use the arrow keys to switch between the selection and confirm with *[enter]* (< 3 sec).

► Press the key *[enter]* to select the displayed mode and to reach the respective function from the main menu.

4.4 Setup Menu (SETUP)

After selection of **Setup** in the main menu and confirming with *[enter]* the sub-menu "Setup" is called.

Following menu selection is available:

- **Integration Time** *for intensity and uniformity
- **Dose Time** *for dose
- **Display Digit** *number of displayed digits
- **Select lamp** *jump to UV-lamp selection menu (only V.4.0 or higher)



From SW V.4.0 on, all parameters selected in "Setup" are saved permanently until they are newly set.
For version < SW V.4.0, after switch-on default values are set (as described below).

4.4.1 Integration Time

Here the measuring time for the irradiance „Intensity“ and "Uniformity" can be selected.

The UV-Optometer offers an selectable integration time of 200 ms, 500 ms and 1000 ms.

► Use the arrow key and confirm with *[enter]*.



After switch-on the UV-Optometer, the normal adjustment of 500 ms is selected automatically.

► *Software version 3: 500 ms*
► *Software version < 3: 200 ms*



With the use of 2-channel probes the time, needed for a measurement is twofold the selected integration time.

4.4.2 Dose Time

Here the dose time for the mode „Dose“ can be set.

The dose time can be adjusted with the arrow keys between 0 and 120 seconds. Upon completion of the selected time the dose measurement is stopped and the measured dose is displayed.

If a dose time of 0 is selected the measuring period is infinite. In this case the measurement has to be started and stopped manually within the mode „Dose“.

► Adjust the number of seconds with the arrow key and confirm with *[enter]*.



From SW V.4.0 or higher, after switch-on the UV-Optometer the last used dose time is pre-selected.

For UV-Optometers with SW < V4.0 the normal adjustment of 00 s (infinite) is pre-selected.

4.4.3 Display Digit

In this menu you can select between 4-digit or 5-digit display.

For standard measurement it is recommended using the 4-digit display.

The 5-digit display may be useful for very sensitive measurement, however that results in a relatively flickering display change.



Under special conditions (individual probe + actual value range) the number of displayed digits may be reduced by 1.

4.4.4 Select UV Lamp

This menu item enables an exit (!) for the selection of a different light source. It is available only from SW V.4.0 or higher.

It is useful for a detailed measurement of LED-lamps.

SW <V.4.0 does not offer the change of the light source during operation. You have to switch off and switch on again the UV-Optometer to change the light source.

4.5 Operation Mode Menu (FUNCTION)

4.5.1 Operation Mode: Intensity

In operation mode "Intensity" the irradiance in [mW/cm²] is measured and displayed. The integration time and therefore the refresh rate of the display is defined in setup "Integration".

For sensors with 2-measuring channels the measurement values are scanned in multiplex mode, measured simultaneously. The total integration time is doubled.

Example for a 365/405 probe (with Hg-lamp selected):

365 Intensity
- 0.00mW/cm²
405 Intensity
- 0.00mW/cm²

Measurement is performed continuously when in the intensity mode.

4.5.2 Operation Mode: Dose

In operation mode "Dose" the light energy is integrated over the measurement time.

If probes with 2 measurement channels are used (and a Hg-lamp ist selected) **one** channel for the dose measurement must be selected.

The dose measurement can only be performed for a single measurement channel.

Automatic dose measurement:

The integration is performed within a preselected time (1 to 120 seconds).

The adjustment is performed within the menu DOSE TIME.

► Press the key *[run]* to start the dose measurement .

The active dose measurement is displayed on the screen:

365 Dose
xx.xx mJ/cm² *mJ = mJoule
RUN *measurement is active
or:
STP *measurement is stopped

During running dose measurement the indication on the display is renewed every 5 seconds with a sample rate of 20 ms.

After completion of the predetermined dose time (1 - 120 seconds) or after pushing the „stop“-key the until then measured dose is displayed:

For example:

365 Dose
xx.xx mJ/cm²
STP

Manual dose measurement:

The measurement is controlled by the user with the *[run/stop]* key..

For this application in menu SETUP - DOSE TIME **time: 00s** has to be selected (if not just preselected).

► Press the key *[menu]* to exit the operation mode "Dose" in direction main menu.

For details see also ↬ *Chapter 8 “Application Notes for the UV-Optometer” on page 31*.

4.5.3 Operation Mode: Uniform./Mean

This mode supports the determination of the illumination uniformity and facilitates their logging.

With this operation mode up to 64 single intensity measurements can be stored. With these measurements at the end of this data collection (see below) , following values will be calculated:

Uniformity:	Uniformity of series of measurement in %
Mean.:	Average value of current series of measurements
Min.:	Minimum value with specification of the position
Max.:	Maximum value with specification of the position
The uniformity is calculated according to:	Uniformity [%] = ± 100 x (Max - Min) / (Max + Min)

In this operation mode the request to position the probe to measurement position 1 appears:

Position 01
Locate Probe

► Confirm the step with the right key *[arrow downwards]*.

The measured value is displayed for 3 seconds:

365Pos. 01
0.00mW/cm²
405 Pos. 01
0.00mW/cm²

Subsequently to the displayed value the request to locate the probe to the next position appears etc.

Up to 64 measured values can be stored in this way by pressing the right key.

► Push the middle key *[arrow upwards]* to terminate the data collection.

The information calculated from the measurements can be displayed with the arrow keys. If measurement is performed with two measurement channels the values for each channel are displayed subsequently.

► Press the key *[menu]* to exit the mode **Uniform./Mean**.

Switching off the device clears the calculated data.



For practical reasons it is recommended to select the measuring position sequence always in the same order because then the position of minimum and maximum value is always reproducible.

4.6 Switch-Off

► Press and hold the key *[off]* to switch off the UV-optometer.

On the display appears:

Turning off
UV Optometer
in 3 seconds

The key *[off]* has to be pushed for >3 seconds. The remaining time until switch-off is displayed.

NOTICE!

The key *[off]* is only active in operation mode. Pressing *[off]* for approx. 1s (sometimes twice) at any time, you can switch to operation mode. From here the device can be switched off (exception: active dose measurement).

The UV-Optometer has to be switched off also after long time measurements. An automatic switch-off ("auto-off") becomes active after approximately 1 hour.

5 Cleaning

General:

Cleaning of the probes may not be necessary as long as the probes are used under clean room conditions and without touching the measuring field with the skin.

In case of dust particles on the measuring field it is recommended to use CDA or Nitrogen blow for removal. In case of harder removable contamination use only lint free tissue soaked with DI water or IPA as liquid for cleaning (follow safety regulations for inflammable alcohol).

UV-Probe 240 nm:

The 240nm probe requires special care because of direct access to the delicate optical filter. Damaging the wavelength-selective filter would destroy the probe. Any contamination should be removed immediately and extremely carefully - remove fingerprints with Isopropanol (IPA) soaked tissue.

► Put away the 240nm probe with the appendant lid on top.

UV-Optometer Display Unit:

If required the UV-Optometer display unit can be cleaned accordingly with a slightly humidified tissue.

Disposal after Useful Lifetime:



ENVIRONMENT!

The UV-Optometer and its probes are electronic equipment, which have to be handled according to local regulations concerning electronic waste.

It is also recommended to send the parts back to SUSS MicroTec for recycling.

6 Calibration

Measuring Probes

The calibration of the measuring probes is performed at the certified calibration laboratory for optical radiation measurement of Gigahertz Optik company (acc. to ISO EN 17025, DAkkS/DKD Reg. No.: D-K-15047-01-00).

The handling of the calibration is done by SUSS MicroTec.
Each sending has to be scheduled in advance at SUSS to get a RMA-number. This number ensures the unique identification of the product until reshipment.

The calibration is documented within a calibration certificate. This certificate includes all information concerning the measurement probe as there are type name, serial number, channels, calibration factors for the intended lamp spectra to be measured, measurement units, deviation against the previous calibration as well as other data in conformance to international standards.

The individual spectral responsitivity of each probe is determined only during the first calibration. This spectral sensitivity specification delivered originally together with the probe is valid for the whole life time of the probe. Therefore the user shall archive the spectral sensitivity specification document with the valid calibration certificate.

The recommended re-calibration period for the probes is 1 year.

If you wish a longer calibration period you have to advise the desired period with the returning of the probe. Otherwise 1 year will be scheduled for the next calibration.
The new desired or recommended recalibration date will be displayed after recalibration on the UV-Optometer display (*Further information on page 19*).
If the probe is not yet recalibrated the recommended recalibration date can only be read on the probe (*Chapter 2.3 “UV-Probe” on page 10*).
Therefore in the UV-Optometer display you can read: Recal. 12/2099.

UV-Optometer Display Unit

For the UV-Optometer display unit a re-calibration is recommended after 4 years.
If a malfunction is suspected - e.g. because of mechanical or other damaging impact- it is strictly recommended to send the unit back to SUSS MicroTec immediately for inspection.



CAUTION!

In case of return of an UV-Optometer **by airfreight** the batteries have to be removed from the UV-Optometer.
(It is allowed to airfreight the batteries with isolated contacts separately packaged in the tool case. But it has to be declared in the shipping document (IATA A123)).

NOTICE!

Probes within fully automatic, machine-integrated light measurement systems are not intended for re-calibration.Their absolute readout can be verified with external, calibrated UV-Optometers.
If necessary a corresponding adjustment parameter can be programmed and stored to the respective machine control.

NOTICE!

The 2-channel probe 365/405 nm is programmed after calibration with a set of calibration factors applying for different typical lamps (= source spectra):

- ► Probe G187080 for mercury lamps only
- ► Probe 100099317 in addition for single line LED-lamps.
  Upgrade-calibration from G187080 to 100099317 is possible. *“Re-Calibration Services:” on page 30*

7 Accessories for the UV-Optometer

Accessories for UV-Optometer:

Part Number	Part Description
G187080	LIGHT MEASURING PROBE 365/405NM (calibrated for Hg-lamps only)
100099317	LIGHT MEASURING PROBE LED 365/405NM (requires SW V4.0 or higher)
G187081	LIGHT MEASURING PROBE 320NM
100005063	LIGHT MEASURING PROBE 240NM (SW-version 1.9 or higher)
G187079	UV-OPTOMETER
G167412	HOLDER for LIGHT MEASURING PROBE
100023837	DESKTOP HOLDER for UV-OPTOMETER
G207357	CASE AND INLAY FOR UV-OPTOMETER for up to 3 probes + holder (G167412)
G207355	OPTOMETER W/O SENSOR WITH CASE (G207357) case with UV-Optometer and both holders
G187082	ADAPTER CABLE UV-OPTOMETER-PC Y-cable, RS232 interface from UV-Optometer to PC
100059248	UV EYE PROTECTION GLASSES STANDARD
G207398	MANUAL UV-OPTOMETER ON CD
G207399	MANUAL UV-OPTOMETER_EN printed on cleanroom paper
	Light measurement plates for position-repeatable measurement of uniformity (machine specific for positioning instead of the mask holder)

Re-Calibration Services:

Part Number	Description
CAL-004	CALIBRATION of PROBE 365/405 (G187080)
CAL-005	CALIBRATION of PROBE 320
CAL-006	CALIBRATION of PROBE 240
CAL-007	CALIBRATION of UV-OPTOMETER
CAL-008	CALIBRATION of UV-LED PROBE 365/405 (100099317)
CAL-009	CONVERT CALIB. G187080 to 100099317
CAL-010	UPGRADE CALIB. UV-OPTOMETER SW V.4.x

8 Application Notes for the UV-Optometer

8.1 Understanding the Function "Dose" Measurement

Essential Definitions:

- Measurement quantities describe systematically the areic density (expressed by "/cm^2").
- **"Intensity"** (unit W/cm^2) means: irradiation power density = amount of radiant flux impinging on a unit surface area.
- **"Dose"** (unit J/cm^2) means: intensity integrated over the exposure time = amount of total radiation **energy** accumulated on a unit surface area – (1 J = 1 Ws).

Methods to use "Dose"

Method 1:

For adjustment respectively verification of the shutter control or rather the dose control of the uncalibrated lithography tool (aligner's exposure light timing) by a calibrated measurement device:

► The UV- Optometer must be used in manual Start/Stop-mode → SETUP DOSE TIME must be programmed as 00 (= infinite).

Sequence:

- Start "Dose" measurement (exposure light is still OFF).
- Exposure started and time controlled by the lithography tool.
- After exposure light is OFF again: Stop of "Dose" measurement.
- Read displayed "Dose" value.

Method 2:

UV-Optometer's internal time base is used – independently of the tool time – which implies that the exposure light must be continuously ON during the measurement.
A potential application may be to check the stability of the light source by repeated short time measurements when the light is permanently ON.

► Intended integration time must be pre-programmed in SETUP DOSE TIME (between 1 and 120 sec).

Sequence:

- Switch exposure light ON.
- Start "Dose" measurement.
- Wait until automatic stop by the UV-Optometer (light must be still ON).
- Read displayed "Dose" value.

NOTICE!

- ► Manual interruption of the automatic (internal time controlled) measurement is possible; but the displayed value should be disregarded because the time interval is „at least inaccurate“.
- ► When Dose measurement is running the accumulated dose value is updated every 5 seconds at the display.
- ► Dark current condition is represented by an extremely low or even negative value (dimension nJ or µJ).

8.2 How to use the UV-LED Probe efficiently

Introduction:

One of the benefits of UV-LED lamps over Hg-lamps is, that the spectrum of SUSS UV-LED lamps can be “tuned” according to individual requirements. This is in contrast to the “given” spectrum of mercury lamps, which can be modified only with absorbing filters.

The SUSS UV-LED lamps are composed of 3 single light sources (365nm + 405nm + 436nm) which altogether provide an UV spectrum comparable to the UV400 broadband spectrum which has been preferably used in mask aligner applications for decades.

But the output intensity of each UV-LED light source can be individually dimmed (bottom limit may depend on model) or could be switched off. Therefore every user has the opportunity:

- to optimize the lamp spectrum to his individual application, or/and
- to guarantee an extremely constant spectrum by compensating small spectral shifts caused by differences in long-term aging of the individual UV-LED light sources.

Requirements:

To use this opportunity it is required to measure precisely the light intensity from each individual UV-LED light source alone (both other UV-LED light sources are switched off).

Description:

The spectral responsivity of each individual SUSS UV probe is well known (it has been calibrated with initial probe calibration). Additionally SUSS UV probes can be calibrated in general for “any” specifically specified application UV spectrum. Therefore it was possible, to develop a modified 365/405nm probe by matching the calibration procedure of the probe also to the three single line spectra generated by the SUSS UV-LED lamps used in SUSS mask aligners.

The UV-LED probe (PN.:100099317) is programmed with additional calibration parameters for each of the UV-LED lines. This enables the probe to measure the UV intensity of the UV-LED light source absolutely line-by-line. To read the additional calibration parameters from the modified probe the UV-Optometer display unit requires SW-version V.4.0 or higher.

As a constraint it must be accepted that “absolute” UV intensity measurement of UV-LED light sources with “mixed” spectrum is not possible, because the spectrum may be differently mixed by the user or even for different applications.

SUSS recommends to select the “1000W-lamp” channel for routine measurements of mixed UV-LED-spectra.

If spectral stability shall be guaranteed over an extended period or for different equipment (i.e. the identical process running on interchangeable litho tools), use all 3 single UV-LED-channels to verify the exposure spectrum (measure always at the same position of the exposure area, preferably in the center).

For routine measurements use the 1000W lamp channel and compare this with the 3 single UV-LED measurements in regular intervals.

Plausibility Check:

The UV-Optometer software V.4.0 (or higher) includes a plausibility check by using of the two-channel measurement method:

- When a single UV-LED line has been selected as light source, it must be expected that both other sources are completely off.
- The UV-Optometer uses the second channel of the probe to verify that this assumption is fulfilled.
- If the intensity-check on the 2nd channel results in an unusual high value, the following warning will be displayed:

  “check spectrum”

  In this case the measured spectrum could be corrupted.

- When this warning is displayed check:
  - if the correct UV-LED light source has been selected
  - if both other UV-lines are completely switched off,
  - and if UV-stray light from any other sources may be present on the measurement field.

8.3 State Diagram of Menus (Condensed Instructions)

Menu Structure SUSS UV-Optometer (with 2-channel Probe 365+405nm)

(presented as hierarchical State-diagram with history-connectors)

start-up sequence displayed

switch **ON** UV-Optometer

UV-LAMP SELECTION MENU

Select UV-Lamp 1000 W | Select UV-Lamp 1500 W | Select UV-Lamp 5000 W | *Select UV-Lamp 365nm LED* | *Select UV-Lamp 405nm LED* | *Select UV-Lamp 435nm LED* | Select UV-Lamp Ampere (raw)

*// --- Version 4.x **and** connected LED-probe (Part # 100099317) only ----*

MAIN MENU (choose function)

Intensity | **Dose** | **Uniform./Mean** | **Setup**

Legend:
UV-Optometer Keys
menu enter | run stop | light

pressing key changes state as shown by transition (=arrow)

LED-source selected **or** 1-channel probe

2-channel probe **and** **NOT** LED

Select 365 Dose

Select 405 Dose

N:=01

SETUP MENU Integration

SETUP MENU Dose Time

SETUP MENU Display Digit

SETUP MENU select UV-lamp

(Version 4.x only)

SETUP MENU <escape>

INTEGRATION 200 ms — *V<3: default* | INTEGRATION 500 ms — *V=3.x: default* | INTEGRATION 1000 ms

DOSE TIME 00 s — *NOTE: (default) 0s=Start/Stop-mode* | DOSE TIME ... s — *use keys to in- or de-crement* | DOSE TIME 120 s — *max.time = 120s*

DISPLAY DIGIT 4 Digit — *default* | DISPLAY DIGIT 5 Digit | DISPLAY DIGIT <escape>

CONNECTOR-SYMBOLS:

- (S) SELECTOR – typically to select between Firmware Versions <4 ⇔ 4.x
- (H) HISTORY – remembering latest sub-state. (even after switch off/on)
- (L) cross-connector – just to avoid crossing transition arrows.

(*) **Note:** using calibration factor of selected UV-lamp

(**pressed shortly: <3 sec**)

INTENSITY 365 Intensity 405 Intensity

xxx nm **Dose** *(LED xxx Dose)* **STP**

xxx nm Dose *(LED xxx Dose)* **RUN**

Dose time expired

display updates every 5sec

measure +**display** N-value

t=3sec /: N:=N+1 (*N*<65)

Position N Locate Probe !

365 Calc. Uniformity% | 365 Calc. Mean | 365 Calc. Min. / Pos. | 365 Calc. Max. / Pos.

405 Calc. Max. / Pos. | 405 Calc. Min. / Pos. | 405 Calc. Mean. | 405 Calc. Uniformity%

Note: 2-channel probe with a Mercury-lamp selected is shown; but only upper line if 1-channel probe or LED-source selected

H *to function + state left before* (*as long as state data are still valid*)

pressed longer than 3 seconds

Switching **OFF** UV-Optometer

FUNCTIONS

SUSS MicroTec - First Line Contacts

	Service	Parts / Logistics	Technical Support
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Old Generation Tools SMT Reman Oberschleissheim - MA150RH/ML/CC - MA14/16/56/100 - MJB3, 21, 45, 55 - MA56, 25,26 - MA1006, RA120	**service.smtr@suss.com** Phone: +49 89 32007 - 567 Fax: +49 89 32007 - 555	**service.smtr@suss.com** Phone: +49 89 32007 - 551 Fax: +49 89 32007 - 555	**service.smtr@suss.com** Phone: +49 89 32007 - 550 Fax: +49 89 32007 - 555

Note: To ease procedures please always provide the equipment and serial number.

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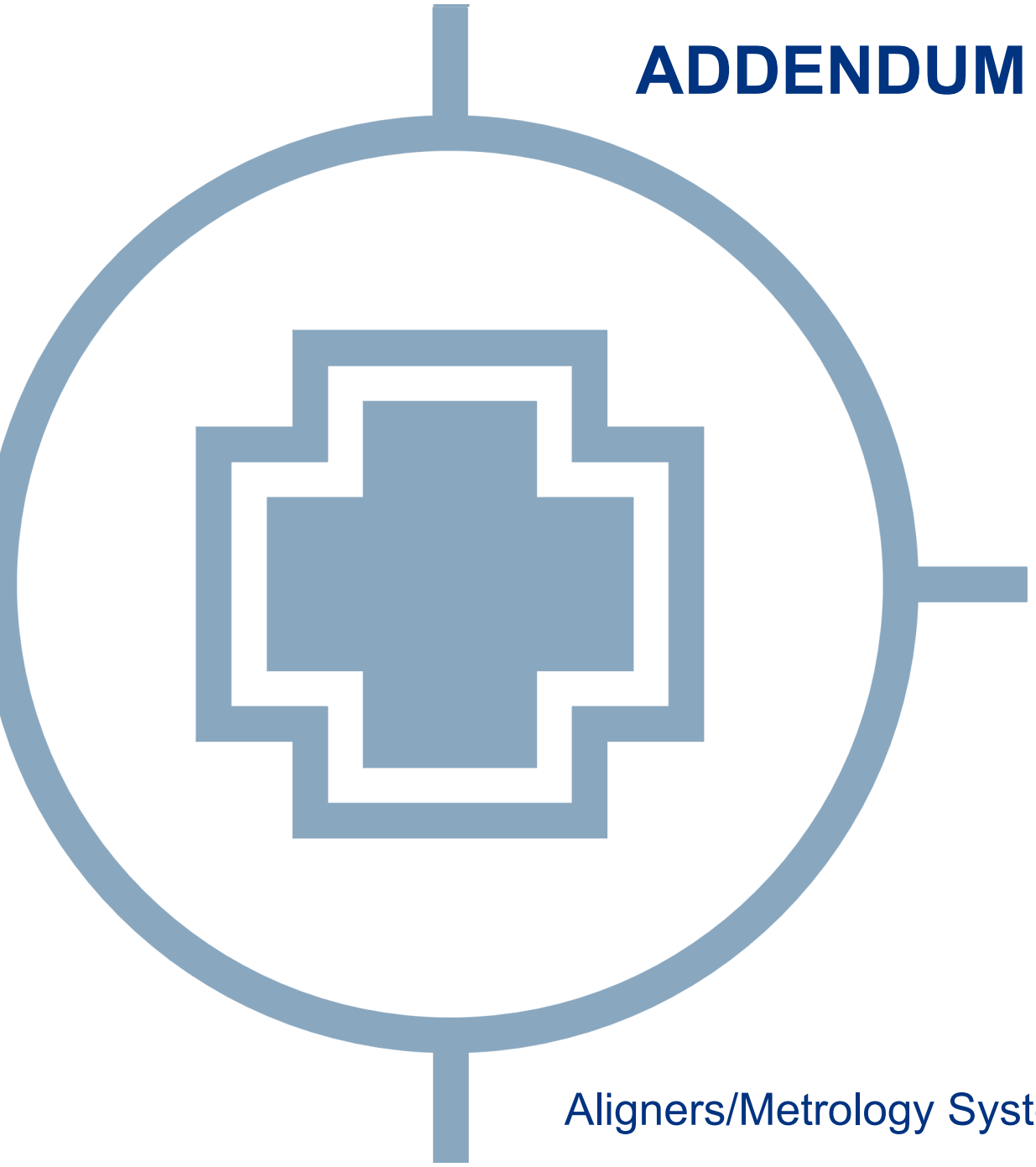
ADDENDUM



Aligners/Metrology Systems

AUTO ALIGNMENT

Cognex PatMax and VisionPro

Rev01/13-07

D40 10289064

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Cleanroom printed and electronic .pdf-format (CD-ROM).

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PREFACE

Automatic alignment is not easy at all. Besides getting along with TSA, BSA, Large Clear Field, DirectAlign and other abbreviations characterizing the machine configuration, you have to fight target appearance changes from wafer to wafer and a quite complex user interface of the pattern recognition with many parameters to be adjusted properly.

Delimitation

In this paper we explain how to get reliable automatic alignment in mask aligners. We do not discuss the accuracy of the alignment.
Fortunately a good model and good parameters will produce good reliability and accuracy. But the accuracy is determined by additional mechanisms such as run out (due to previous process steps, contact mode, exposure dose), mask and wafer contact due to debris on the chuck, edge bead or a low gap), focus axes calibration, mask print errors, Large Clear Field Mask Motion (LCMM) mode, microscope illumination and many more.

We will focus on the training and finding of targets, but not on the way how TSA or BSA works, what the MTS or DirectAlign do etc. This you find in the operator manual of your machine.

Also we will not discuss parameters that have not proven to be of importance for mask aligners.

Notes:

Not all functions discussed here are available on all SUSS machines.

The screens shown in this manual are mostly from the MA100/150e. But those in MA200Compact and MA300 are similar, in DSM8/200 and MA8 they may be slightly different but you will find the same functions elsewhere on the screen or in menus or dialogues.

PREFACE

1. INTRODUCTION

There are three main challenges to the creation of a good pattern recognition

- Variation of wafer targets
- Process variation affecting targets
- The particular alignment tool to be used

1.1. Target Appearance Changes from Wafer to Wafer

The most frequent and difficult problem is that the targets change their appearance from wafer to wafer (see Fig.1-1).

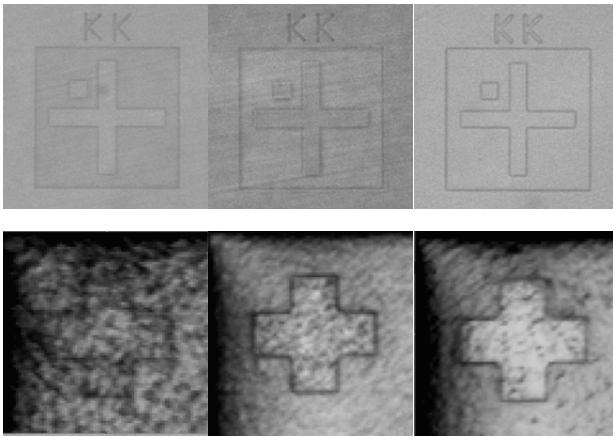


Fig.1-1: Appearance Changes from Wafer to Wafer

Sometimes these differences may be negligible, sometimes very special changes are required in order to make the pattern recognition program robust.

A logical consequence of wafer to wafer variation is that many times it is not sufficient to train the pattern recognition with just one wafer, because this one wafer is not representative of all wafers in production. After training the initial pattern further testing with many more wafers is often required to insure the pattern is optimized.

If you have little experience and help, this optimization period may last a long time. Experience is something you have to gather yourself, but this report will provide you many hints and suggestions towards improving your pattern recognition.

1.2. Target Appearance Changes from Process to Process

A second challenge is that there is no standard alignment target for all processes. A cross is not always a homogeneous area, its gray value is not always the same and an edge is not always a simple transition from dark to bright.

Consequently the model and parameters of the pattern recognition system cannot be simply transferred from one process level to the next. The parameters of a low contrast cross will be different from those of a cross with a double edge (see Fig.1-2).

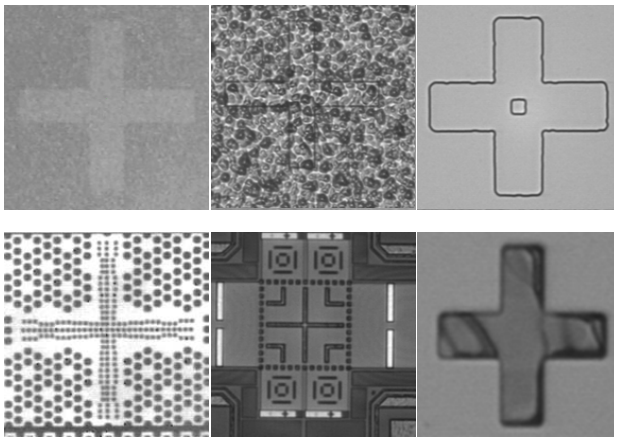


Fig.1-2: Appearance Changes from Process to Process

1.3. Pattern, Scene, Match

"Pattern Matching" is a common and powerful class of principles to find alignment targets. Its characteristic is a "pattern" or "model" which must be trained in the first step to finding the targets. The pattern is typically very similar to the structure to be found on the substrate (see Fig.1-3)

After a search by the system if the "match" between pattern and target is high, you will get a high score. High scores (> 95%) are in general typical for reliable and accurate alignment.

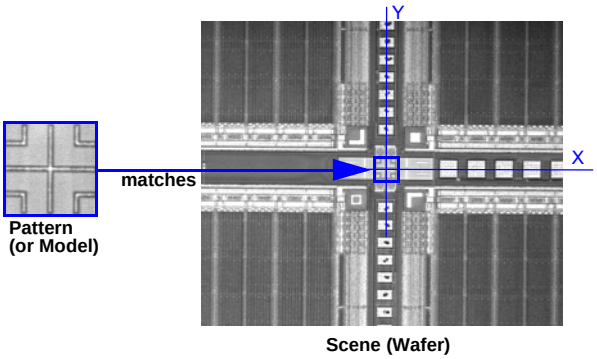


Fig.1-3: Matching Pattern to Wafer

1.4. Cognex PatMax

SUSS uses a pattern matching algorithm of Cognex Inc. called „PatMax". For throughput reasons it works with two models, one for the coarse search, the other for the fine search.

A pattern or target is defined as areas of pixels going from dark to light which will define boundaries. A continuous boundary between regions of dissimilar pixel values will define the edges of a pattern.

PatMax will use this edge information when searching for a target using two search modes, course and fine. Since the position information resides in the edges of the target, the pattern consists of many edge elements (see Fig.1-4) which have a sub-pixel position, a direction and a polarity. The length of the edge elements varies from 1 to 10 pixels and are often determined automatically by PatMax.

The coarse model's elements typically have a length between 2 and 4 while the fine model will have a length of 1. The length of these segments is called the "grain limit", so you have the parameters "coarse grain limit" and "fine grain limit". In the "frame window" of PatMax, the coarse model appears yellow, the fine model green.

Grain limits control which features are detected in an image by PatMax during the analysis of an image. To detect only large features in an image PatMax will use a larger granularity setting (course search). To detect smaller images in an image PatMax will use a smaller granularity setting (fine search). Granularity is expressed as a radius of interest, in pixels, within which features are to be detected.

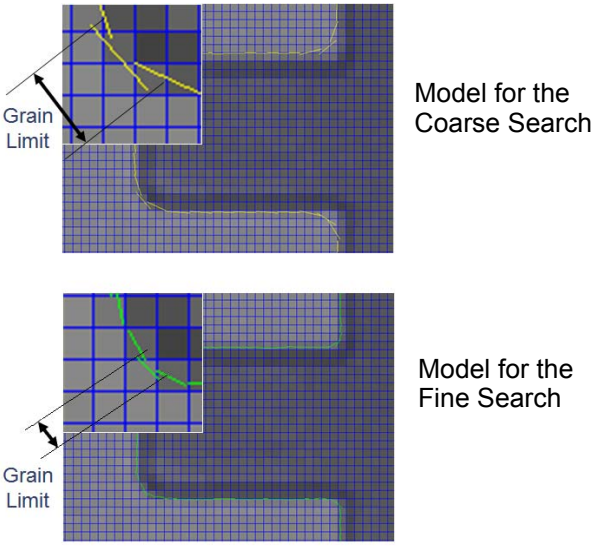


Fig.1-4: Coarse and Fine Search Pixel Information

PatMax always performs a coarse search first, which delivers some "instances", which are further filtered during the fine search. Finally the software will decide which target delivered the highest score during the fine search. If a target is not found in the coarse search, it cannot be found in the fine search. Since the coarse search results are invisible, you may sometimes be confused and should keep in mind, that the coarse search may have encountered a problem. This will be discussed in more detail later on.

Note:

When you search for a pattern match, the results are displayed in green, yellow and red, but at this time in the report the meaning of the color code is "good match", "acceptable match" and "no match".

The position and direction of the edge elements are calculated from the gray values of the neighboring pixels and have sub-pixel information. This sub pixel accuracy is further increased by averaging all the edge elements of the target, but only if the target is large enough which gives an accuracy of up to 0.025 pixels.

For example, a microscope with a 5x objective and a magnification of 1 pixel/µm such as in the MA200Compact, MA300 and DSM200 will provide a 25 nm resolution and is therefore sufficient for automatic alignment. The advantage of a low power objective is that you have a large field of view and a high depth of focus, which provides SUSS machines with good stability and reliability. The only trade-off is that the visual resolution will be relatively low and it is not so easy to “see” an inaccuracy of 0.5 to 1.0 µm or below.

Recommendations for target size and objective:

Target size, length and width	70 ... 130µm
Minimum width, height of image	50µm
MA300, MA200Comp, DSM200	Recommended objective 5x
MA100/150e	Recommended objective 5x (10x, if visual resolution is not sufficient

Table 1-1: Target/Objective Recommendations

1 INTRODUCTION

2. BASICS

2.1. Iterative Procedure

- **Train**
- **Test**
- **Analyze Failures**
- **Improve**

As mentioned earlier, the operator will **train the model** to the best of his knowledge. We are giving rules and tools, but the experience in understanding the proper target is only gained through experience.

The logical next step is **testing the targets**. The simplest test is trying to find them i.e. perform a “Test Search”. More in depth testing will be later on. While testing the targets the operator may modify **the search parameters** of PatMax parameters to improve the search results. The best test of course is the automatic alignment of many wafers i.e. the production runs – with the “AL-Check” still ON. The AL-Check parameter lets you pause the automatic alignment run after the alignment is completed just before exposure to visually assess the alignment accuracy.

Sometimes the machine will stop after a few wafers because a target is not found or the alignment is not acceptable. Now the reason for the **alignment errors needs to be analyzed.** A couple of tools and rules make that easier and will give hints **to improve the model and the parameters**. After that improvement the process restarts with testing many wafers.

Step	Tools
Train the Model	• Rules for creating a „Good Model“
	• Objective, illumination, magnification, aperture, filter, focus, contrast
	• Selection of the target, die and wafer used for pattern training
	• Model parameters
	• Further tools like masking, synthetic models, comparing coarse and fine model
Find the target Test the target Produce wafers	• Test search, test alignment
	• Production of many wafers with AL Check ON
	• Visually judging the match and the models, comparing coarse and fine model
	• Visually judging the alignment, overlay of images, changing the focus and zoom
	• „Mistake“ testing
	• Search parameters
	• (Test run with images from the image log)
Analysis of alignment errors	• Error message text
	• Use of AL-Editor and Vision-Pro to analyze what happened
	• Last image
	• Single step mode
Improve	• Modify model and/ or parameters

Table 2-1: Stepwise Improvement of Auto Alignment

There is no general rule how many wafers need to be processed until the align check option can be switched off or how many improvement loops are needed. Practical values range from 1 to 1000 wafers. That depends on the financial value of a badly exposed wafer, how long it takes to detect it, and can it be reworked.

2.2. Using PatMax Algorithm

Compared with alternative algorithms like CNL, PatQuick, Caliper or Blob, PatMax has the advantage that you get arithmetic (position, score) and graphic (edge elements) feedback. The graphic feedback consists of both models and the match or match code.

PatMax shows the quality of the match with green and yellow lines, red line represent missing edge elements.

In the example below (Table 2-2) we explain how the graphical feedback i.e. the match code in PatMax helps to analyze the reasons for a misalignment. In the second image you see the good match of the proper target, i.e. the PatMax edge fits the image well.

In image 3 you see a quite good match, too (ca. 70% score), and some missing edges (red lines). Most interesting is to compare image 2 and 3 now.
You find a yellow line (black arrow) indicating a good match, although the polarity was inverse compared to the model. The experienced user knows that the reason for that good match was the parameter “Ignore Polarity” which was set to ON. If it would have been OFF, then the algorithm would have displayed a red line and the score would have been lower.

ONLY Cognex PatMax gives graphical feedback

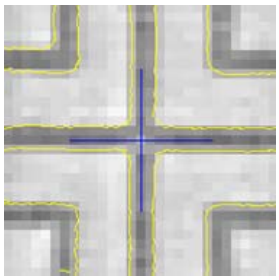
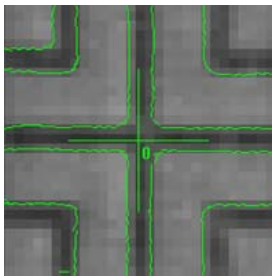
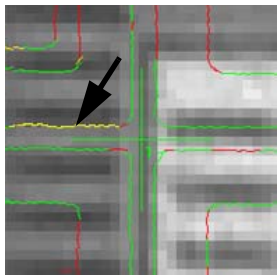
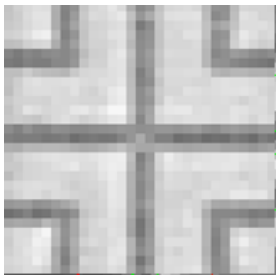
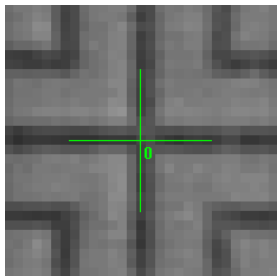
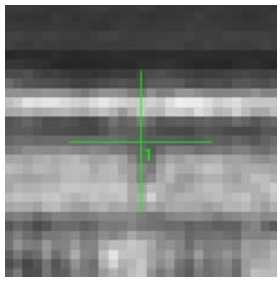
Algorithm	1 - Model	2 - Match Code - Proper Target	3 - Match Code - Mistake
PatMax			
CNL			

Table 2-2: Match Codes

2.3. Using the AL-Editor

One of the biggest improvements of the new software is the implementation of the graphical feedback in the AL-Editor.
Now most of the applications for auto alignment can be solved within the AL-Editor.
Only delicate targets which cannot be processed reliably should be treated with special VisionPro parameters.

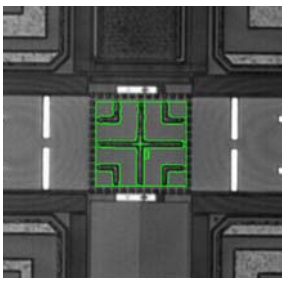
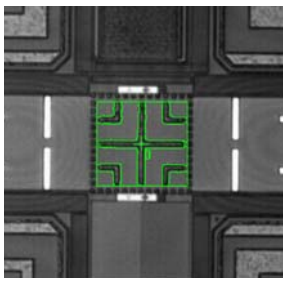
SUSS AL-Editor	Cognex VisionPro Editor
	

Fig.2-1: Same Graphical Feedback AL-Editor and VisionPro

2.3.1. Description of the AL-Editor

The AL-Editor is described and explained in the general machine documentation of the MA100/150e.

2.4. Using the VisionPro Editor

The so-called VisionPro editor is a user interface of Cognex that allows to display the graphical feedback of PatMax. This graphical feed back is now also visible within the SUSS AL-Editor. The VisionPro editor provides more parameter variations than the AL-Editor and is therefore necessary if the parameters within the AL-Editor are not sufficient to solve your alignment requirements.

You get access to the VisionPro Editor in the AL-Editor Mask or Wafer tab in the <Train> frame.

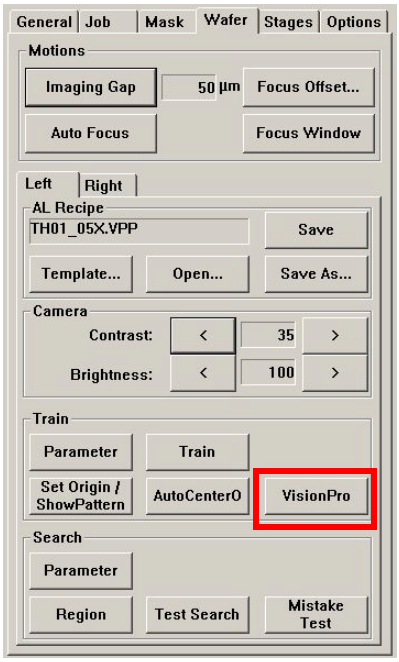


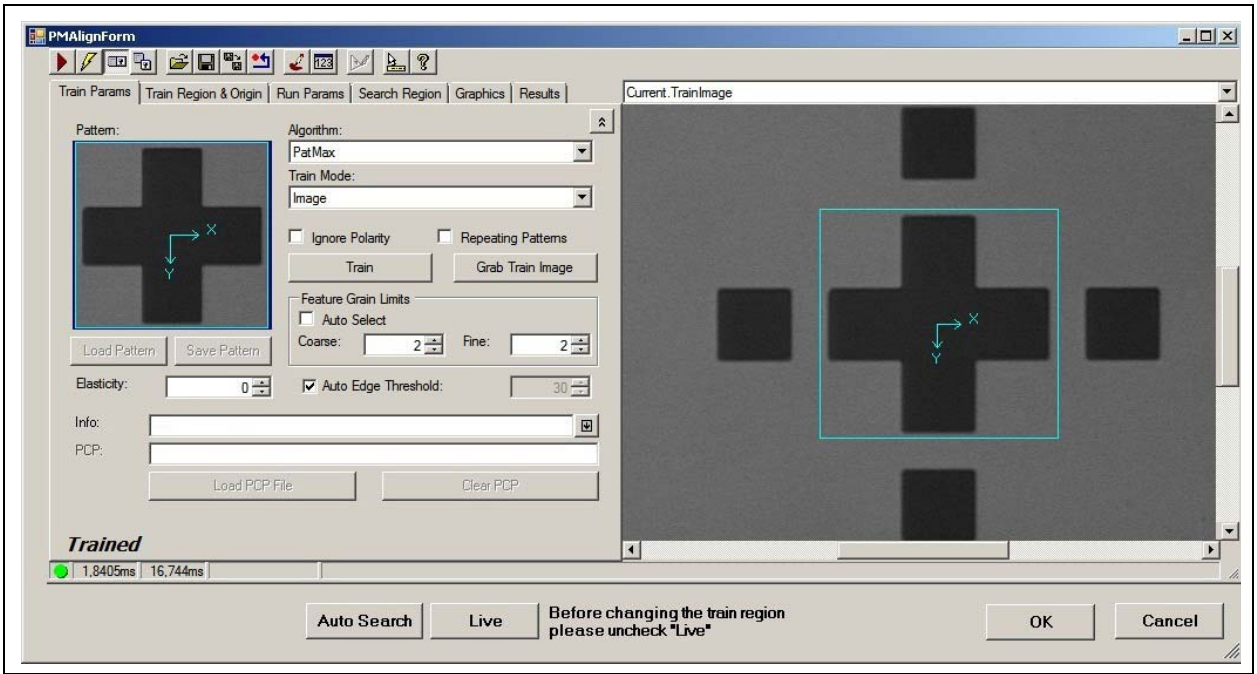
Fig.2-2: AL-Editor - Wafer Tab

Rule:

- **AL-Editor AND VisionPro Editor display the graphical feedback of PatMax.**
- **Use the AL-Editor for your standard applications.**
- **Use VisionPro only for delicate targets applications.**

2.4.1. Description of the VisionPro Editor

2.4.1.1 General



Control Buttons:



	Run the PMAlign tool. You must have a trained pattern, an input image, and specified run parameters. PMAlign searches for the trained pattern in the input image. You may constrain the pattern search to a search region within the input image.
	Toggles electric mode. When selected, the PMAlign tool runs automatically if certain parameters have changed. These parameters are indicated by electric bolt icons that appear when the tool is in electric mode.
	Opens the local tool display window, which can display the Current.InputImage, Current.TrainImage, or LastRun.InputImage buffer.
	Opens one or more floating tool display windows. You can display the Current.InputImage, Current.TrainImage, or LastRun.InputImage buffer. Unlike the local tool display, you can resize or move the position of the floating tool display window.
	Loads a VisionPro persistence (.vpp) file, which contains a set of saved properties for this vision tool object type. Loading a persistence file for another object type throws an error and the load is unsuccessful. For more information about VisionPro persistence features, see the topic Persistence in VisionPro.
	Saves the current properties of the underlying tool to a VisionPro persistence file. You have the option to save either the entire tool or the tool without its images or results.
	Saves the current properties of the underlying tool to a new VisionPro persistence file.

	Resets the underlying tool to a default state.
	Opens the Image Mask Editor for creating a mask to add to the training image.
	Opens a new, separate results window, allowing you to view run results without turning to the **Results** tab.
	Launches the Model Maker for editing shape models when you are using Synthetic PatMax.
	Enables or disables the display of tool tips for individual items in this edit control.
	Access the VisionPro online documentation.

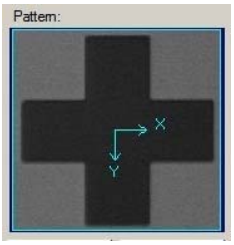
Auto Search	PMAlign is continuously acquiring new images and searches in them. The result is displayed in LastRun.InputImage and in Tab "Results".
Live ON/OFF	**Live OFF:** If you open PMAlign it uses/saves the actual camera image as "Current.InputImage". **Live ON:** PMAlign continuously acquires new camera images. Individual functions could be obstructed.

Image Buffers:

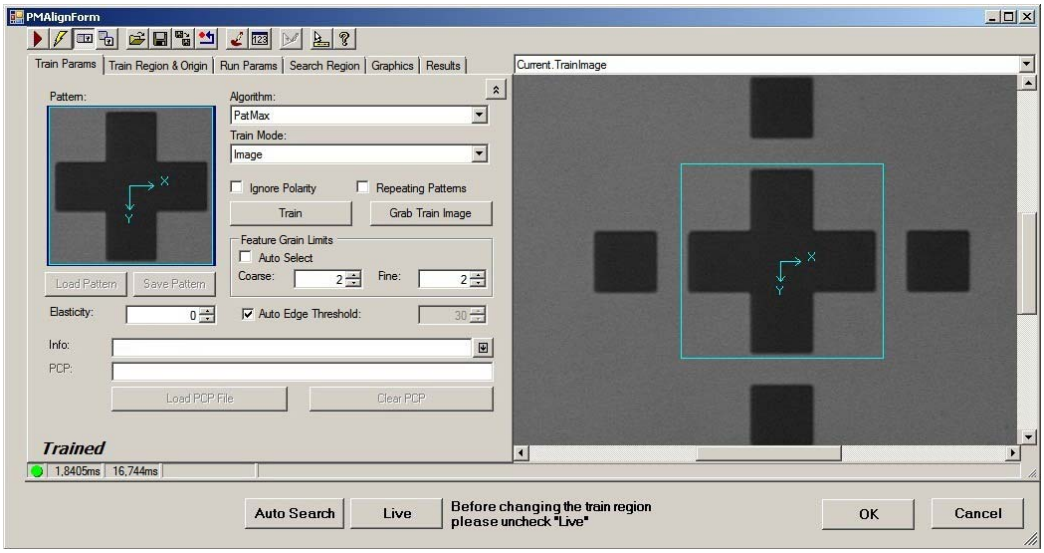


Current.InputImage	provides the input images to the PMAlign tool.
Current.TrainImage	contains the training image.
LastRun.InputImage	displays the last image on which the tool most recently ran. Use the Graphics tab to highlights the search area and the results of the search.

The PMAlign edit control has three image buffers. Two of the buffers use the underlying PMAlign tool's InputImage and TrainImage; the third buffer displays the last input image that the PMAlign tool ran on and the results of that search. All three buffers can be shown in both the local and floating tool display windows.
When you run the PMAlign tool, the tool searches the Current.InputImage for the pattern in the Current.TrainImage buffer, and stores the results of this search on the **Results** tab.

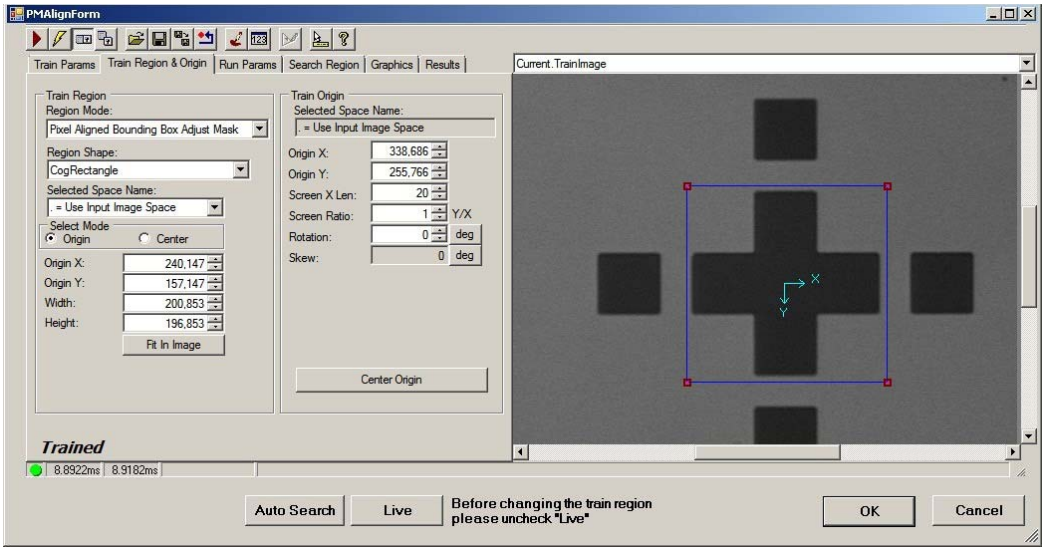
Pattern: 	Displays the trained pattern, created either from an image or from a collection of shape models. This is specified by the TrainRegion, which is highlighted by a blue border, within TrainImage. You can set the train region using the Train Region and Origin tab or by resizing its display in Current.TrainImage. The message text at the bottom of the tab indicates whether the PMAlign tool is trained.

2.4.1.2. Important Parameters in Train Params Tab



Use the Train Params tab to set training parameters and to train the search pattern.	
Chevron Button	 Opens a window with additional parameters.
Algorithm	Select the search algorithm to use for training. • We force you to run PatMax in the AL-Editor. If you want to use the other modes, you have to work in the Vision Pro Editor.
Train Mode	Choose whether the PMAlign pattern should be trained based on the pixel content of the training image or trained based on the shape models you create and modify with the Model Maker. • The AL editor forces you to use the "Image" setting.
Ignore Polarity	If enabled, pattern polarity is ignored. If disabled, only patterns with polarity matching the trained pattern will be found. You must allow the tool to ignore polarity if you are using a trained pattern made of shape models and any of the models have an undefined polarity.
Elasticity	Specifies the Elasticity property, which is the amount of variance, in pixels, allowed by the PMAlign tool. In general, you should specify a nonzero elasticity value if you expect inconsistent variation in patterns in run-time images.
Auto Edge Threshold	Disable the automatic value if you want to set a different threshold for the absolute minimum value of edge magnitude, below which the edge direction will be randomized.
Feature Grain Limits	If GrainLimitAutoSelect is not selected, then the GrainLimitCoarse and GrainLimitFine grain limits that you supply are used.

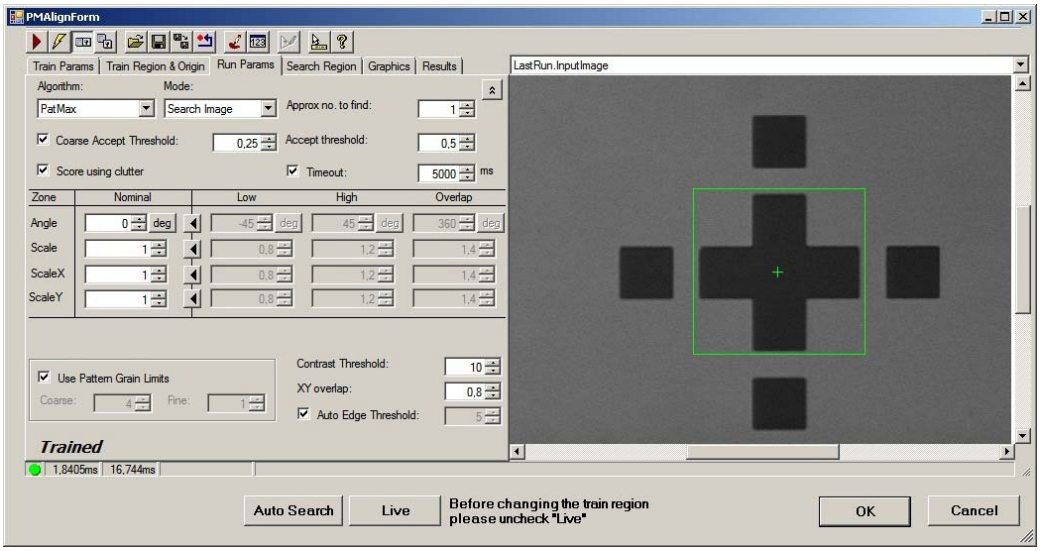
2.4.1.3. Important Parameters in Train Region & Origin



Use the **Train Region and Origin** tab to define the TrainRegion, which defines the area of theTrainImage buffer that becomes the trained pattern. You can also define the train region graphically in the Current.TrainImage buffer. It may be easier to first specify the training region graphically, then use this tab to fine tune the train region parameters. The PMAlign edit control updates the train region values so that the values on this tab always match the shape of the train region in the Current.TrainImage buffer.

Region Mode	Defines the bounding box for the region. **Pixel Aligned Bounding Box** encloses the defined region within a rectangle. This means that the portions of the image that are outside the defined region but within the bounding rectangle are included. **Pixel Aligned Bounding Box Adjust Mask** encloses the defined region within a rectangle, but masks out the image portions that are outside the region but inside the enclosing rectangle. The result is that the defined region is closer to what you specify. If you are training a pattern from a collection of shape models, you must use a Pixel Aligned Bounding Box, as a **Pixel Aligned Bounding Box Adjust Mask** region is not supported for shape training.
Region Shape	Select the shape of the input region. Selecting **None=Use entire image** means that the tool uses the entire input image. • The AL-Editor forces you to use the "CogRectangle" setting.
Select Mode	Available when **Region Shape** is **CogRectangle**. Selects the set of parameters that define the rectangle.
Center Origin	Sets the train region's origin at the center of the train region.

2.4.1.4. Important Parameters in Run Params Tab

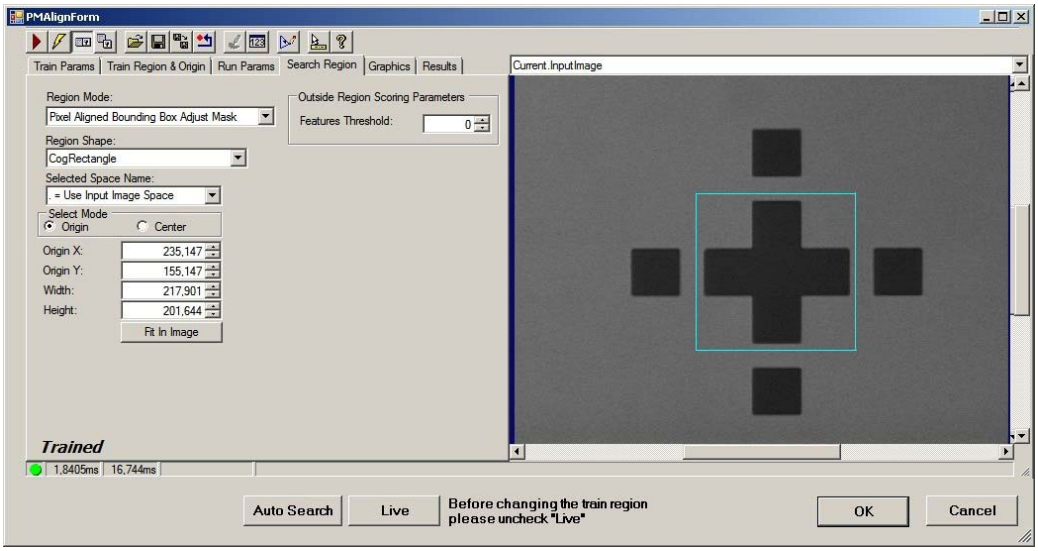


Use the Run Params tab to specify how to perform the pattern search. These parameters include the run algorithm to use, thresholds and limits, and the amount of rotating and scaling allowable during the pattern search.

Chevron Button	 Opens a window with additional parameters.
Algorithm:	Select the search algorithm to use for training. • When you train a target in the AL-Editor it automatically selects "PatMax".
Mode:	By default, the PMAlign tool uses **Search Image** mode to search the entire image for the coarse features that indicate the presence of the pattern it is trained to locate. • AL-Editor automatically sets "Search Image"
Coarse Accept Threshold:	The PMAlign tool uses a default Coarse Accept threshold to refine early search results based on the coarse features of the pattern. You can enable the **Coarse Accept threshold** and specify a different value, forcing the tool to consider more (lower value) or fewer (higher value) potential matches in each run-time image. The threshold value cannot exceed the current value for **Accept threshold**. The edit control will correct the value for **Accept threshold** automatically if you set a value for **Coarse Accept threshold** higher than **Accept threshold**.
Score using clutter:	If checked, then the PatMax algorithm considers extraneous or clutter features when computing the score of a pattern instance. Considering clutter features usually results in lower scores. Available for the PatMax algorithm only.
Approx no. to find:	Specifies the number of results to look for.
Accept threshold:	Specifies the acceptance threshold for the result score. Only results with scores greater than or equal to this value are accepted.

Timeout	If checked, then the timeout value limits the execution time of the PMAlign inspection.
Use Pattern Grain Limits	If checked, then the granularity limits determined by the training pattern are used. If not checked, then the GrainLimitCoarse and GrainLimitFine values specified are in effect. • We strictly recommend to enable "Use Pattern Grain Limits"
Contrast Threshold	Defines the minimum acceptable contrast for a pattern instance. Only pattern instances where the average difference in pixel values across all feature boundaries exceeds the contrast threshold are considered by PMAlign.
XY overlap:	Result candidates overlap in area if the percentage of area overlap is greater than XYOverlap. PMAlign discards the weaker pattern instance when two pattern instances overlap for all degrees of freedom as well as area by the specified overlap percentage.
Auto Edge Threshold	Disable the automatic value if you want to set a different threshold for the absolute minimum value of edge magnitude, below which the edge direction will be randomized.

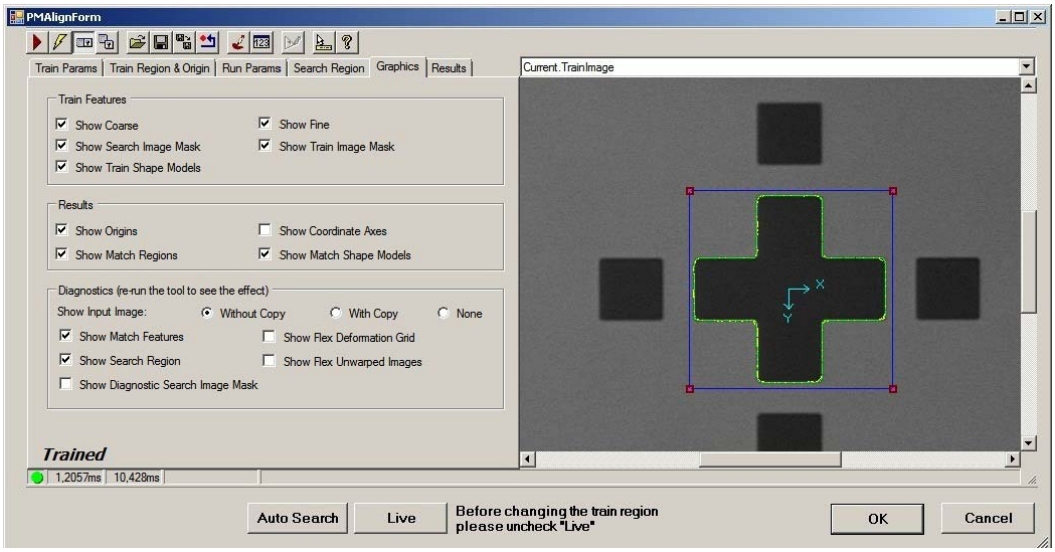
2.4.1.5. Important Parameters in Search Region



Use the Search Region tab to define the SearchRegionMode, the area of the InputImage buffer to which the pattern search is constrained. The search region appears with a blue border in the Current.InputImage, and you can graphically define the search region in this buffer. It may be easier to specify the search region graphically, then use this tab to fine tune the search region parameters. When you resize the search region in the InputImage, the values on this tab change; likewise, changing the parameter values causes the search region to alter its size and shape.

Region Mode	**Pixel Aligned Bounding Box Adjust Mask** encloses the defined region within a rectangle, but masks out the image portions that are outside the region but inside the enclosing rectangle. The result is that the defined region is closer to what you specify.
Region Shape	Select the shape of the input region. Selecting **None=Use entire image** means that the tool uses the entire input image. • The AL-Editor automatically sets "CogRectangle" when trained. • The default values are CogRectangle, Origin X = Origin Y = 5; Width = 630, Height = 470.
Select Mode	Available when **Region Shape** is **CogRectangle**. Selects the set of parameters that define the rectangle.

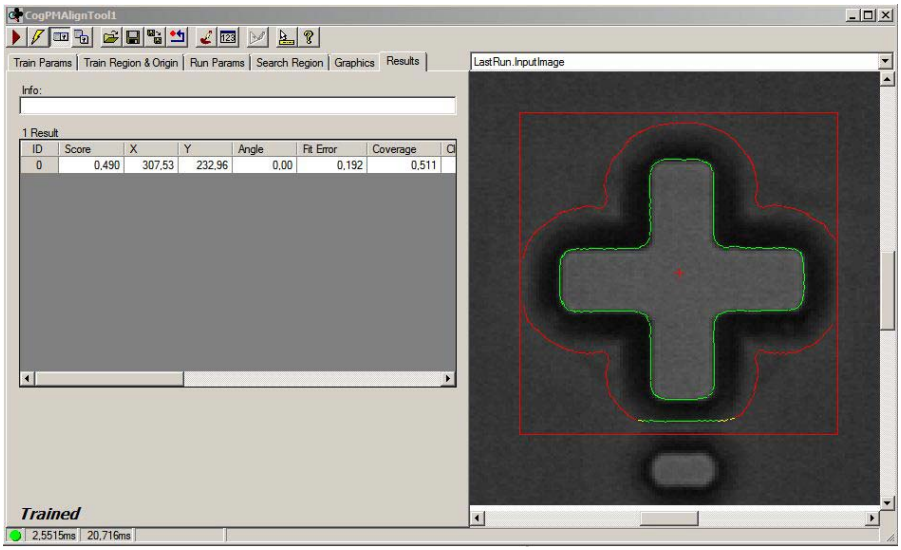
2.4.1.6. Options in Graphics Tab



Use the Graphics tab to choose the results graphics that are displayed in the LastRun.InputImage display.

Train Feature	You can show these features in the Current.TrainImage buffer, which contains the trained pattern: • Show features that were trained at the coarse granularity limit. Features are displayed in yellow. • Show features that were trained at the fine granularity limit. Features are displayed in green.
Results	You can show these features in the LastRun.InputImage buffer, which contains the image that the PMAlign tool last searched, and the results of that search. • Train pattern's origin • Train pattern's coordinate axes. • The match region. • The shape models of found features
Diagnostics	Displays the following features in the LastRun.InputImage buffer. • Show match features displays the found features that were used to match the trained pattern. Not all trained features may be present. For each matched feature, the color of the graphic indicates the quality of the match (red indicates poor matches, yellow fair matches, and green good matches). • Show search region displays the search region as defined in Current.InputImage buffer (or in the Search Region tab).

2.4.2. Display of the Results Tab



The **Results** tab displays the results of the most recent pattern searches. Use the slider control below the results grid to display the complete set of results.

Displays the following information for each result.

Score	for this result. The range is 0.0 to 1.0 with higher values indicating a closer match.
FitError	a measure of how closely the found pattern matches the features of the trained pattern, without regard to missing features. The range is zero (perfect fit) to infinity (poor fit). Used only for the PatMax algorithm.
Clutter	the number of extraneous features present in the result divided by the number of features in the trained pattern. Range from 0.0 to infinity. Used only for the PatMax algorithm.
Coverage	the percentage of the features in the trained pattern that are found in the search result. Range is 0.0 to 1.0. Used only for the PatMax algorithm.
MaxCoarseAcceptThresh-old	the maximum coarse accept threshold that would allow this result to be found.
X, Y	are the coordinates of the pattern's origin as measured in the selected space of the InputImage
Angle	is the rotation of pattern space as measured in the selected space of the InputImage.
Scale, ScaleX and ScaleY	are the scaling factors between pattern space and the selected space of the InputImage.

2.5. A „Good Model“

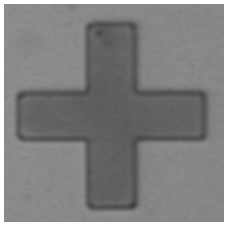
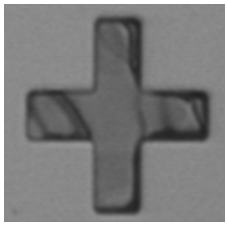
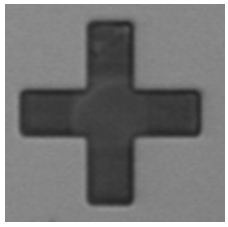
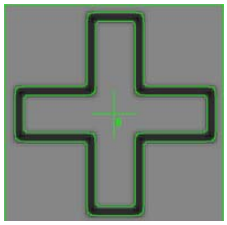
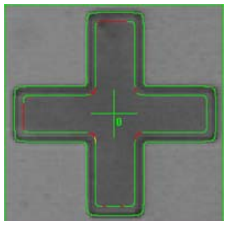
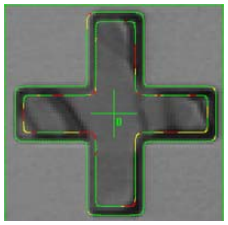
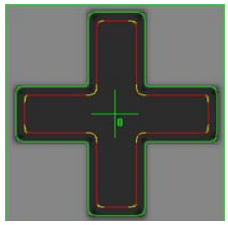
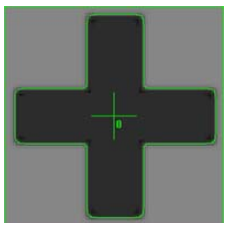
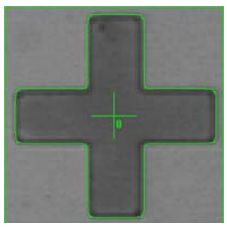
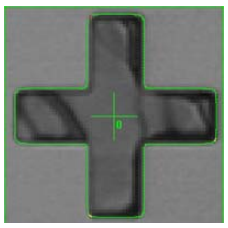
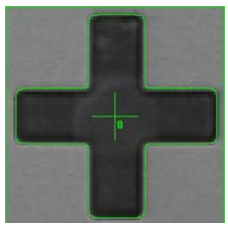
		Target 1	Target 2	Target 3
3 Wafers				
Model 1 (double edge)				
	Score:	92.3%	82.3%	53.6%
Model 2 (single edge)				
	Score:	100.0%	100.0%	100.0%

Table 2-3: Example 1 for a good model

Model 1 has a “double edge“, and produced a score from 53.6% to 92.3% while Model 2 has a “single edge” and always delivered a score of 100%. The reason for the higher score of model 2 is not that single edges are generally better but the edge of model 2 can be found in all wafers while the inner edges of model 1 can only be found partially in all 3 wafers. Model 2 has only those edge elements that are common to all wafers.

Conclusions:

- A model must have only those features common to all wafers. Such a model is referred to as a “good model”.
- Not every target is suited for training the model. You should select a target that looks like a good model, which is representative for all the other wafers, which is not damaged, occluded or smeared.
- Sometimes you may have to load another wafer in order to find a good target. But often you may only move the microscope to the next scribe line or choose the left instead of the right side.

The score values mentioned above are defined as the percentage of successfully found edge elements. Scores greater than 85-90% for a test search are desired.
In most cases it is sufficient to use the same model for both sides of the substrate. There is no need to train different models.
For MA200/MA300/DSM200:

- copy the model

For MA100/150:

- use the same name for left and right model

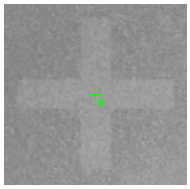
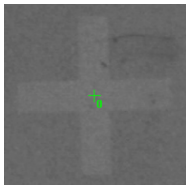
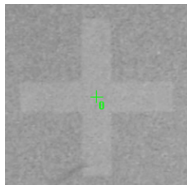
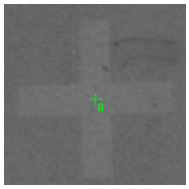
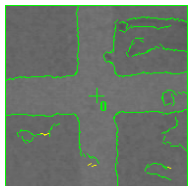
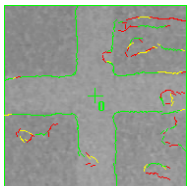
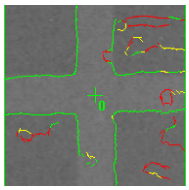
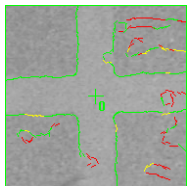
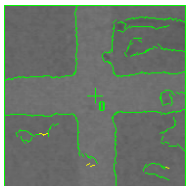
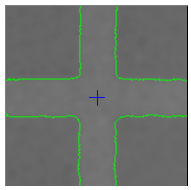
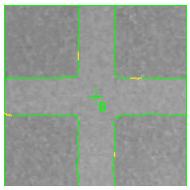
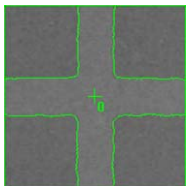
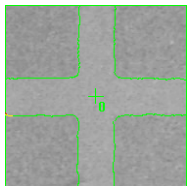
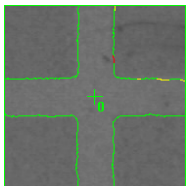
		Target 1	Target 2	Target 3	Target 4
4 Wafers					
Model 1 (Target 4)					
	Score:	66.4%	62.1%	67.6%	99.9%
Model 2 (Target 2, smoothed)					
	Score:	95.8%	100.0%	97.8%	94.2%

Table 2-4: Example 2 for a good model

Table 2-4 shows a similar situation as Table 2-3 but now Model 1 includes “random features” or “noise”. Target 4 was used to create the model, therefore it delivers a high score for wafer 4 but low scores for wafer 1 to 3 because the random features trained with target 4 are not found on the other targets. None of the 4 wafers can be used to create a good model because of the different random features.

Therefore the image used for training Target 2 could have been modified by defocusing the image before creating the model. The scores with this modified model are much higher and close to 100%. This model 2 “matches” all wafers much better than model 1.

The examples of table 2-3 and 2-4 show that “good” models will increase the search score on all wafers. Experience has proved that high scores correlate with higher reliability of the alignment process and improved alignment accuracy.

The concept of a “good model” is a very important aspect of pattern matching algorithms. The search parameters are less important. Alignment with a bad model may never be stable, even if you invest a lot of time in adjusting the search parameters. Alignment with a good model will make it easy to find the proper parameters, be reliable and work over a wide parameter window.

Rules for the “Good Model”:

- **It has only those edge elements that are common to all wafers,**
- **It includes only true, sharp edges without no noisy or double edges,**
- **It includes no random features or noise,**
- **It has edges which are long and steady (uninterrupted),**
- **It is unique and cannot be mistaken with some other feature in the field of view**

2.6. Objectives, Illumination, Background

The optics and particularly the illumination are the most simple and efficient means to achieve reliable alignment. Targets that are easily visible (good contrast, no annoying features) to the human eye will be trained easier and faster than targets which are fuzzy or distorted.

Low power objectives like Olympus 5x/0.15 as used on the SUSS tools are preferred because their high depth of focus makes the machine less sensitive to drift, vibration and operator errors while insuring that PatMax will still be sufficiently accurate to provide the best possible alignments.

For visual control of the alignment accuracy, a low power objective may allow to have both mask and wafer still in focus or close to it. A disadvantage is that the lateral resolution of the human eye is about 0.5 - 1.0 pixel, which may be insufficient if you require the very high alignment accuracy. The 2x zoom feature helps to improve control of the alignment. Also symmetric and suitably shaped targets with greater than 5µm difference between the edges of the mask and wafer target are required as well as experience with the PatMax process.

The color and bandwidth of the light source may also impact the appearance of the targets on the video monitor. By default MA150 tools are delivered with yellow Halogen illumination filters and all other machines with red LED illumination. It may be advisable to change the illumination filters in order to improve the image quality, see Fig.2-3.

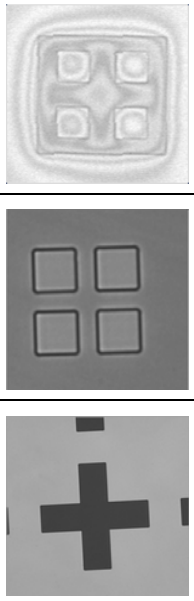
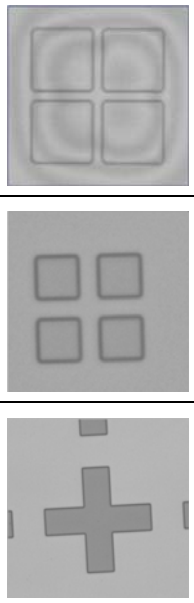
Monochrome (Red LED)	Broadband (Halogen Yellow Filter
	

Fig.2-3: Effect of Illumination Bandwidth

In Fig.2-3 the interference rings are less visible with broad band illumination: i.e. the bright lines around the black double edge vanish while the cross appears fully black and has no double edge using red LED light.

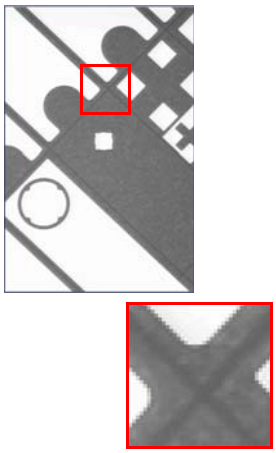
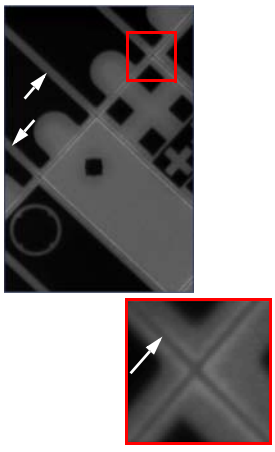
Incident (reflected) Light	Ring Light
Unpolished Sapphire	Shadow of the Mask
	

Fig.2-4: Incident Light versus Ring Light Illumination

In Fig.2-4 the contrast of the lines shown inside the black and white circles are modified by changing the illumination.
The image on left side uses incident illumination while the right side uses ring light. Ring illumination is mainly used for three dimensional features, in the example the lines were a few microns deep and manufactured by sewing or milling. And there is also another influence of the ring light visible. The mask shadow may cover the wafer line, if the chrome is too close to it, or if the gap it too high (see white arrows).

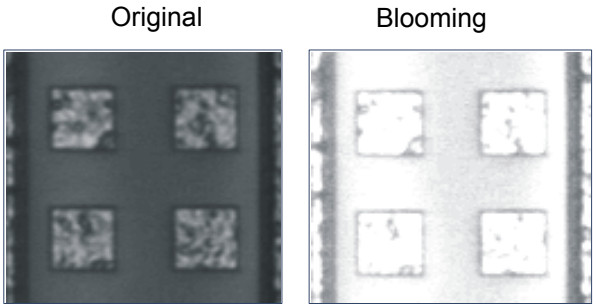


Fig.2-5: Saturation of Image

Yet another phenomenon is called "blooming" (saturation) of CMOS and CCD cameras.
If there is too much light then the normally dark pixels adjacent to bright areas become saturated.

Blooming has two impacts:
It can be used to reduce noise or random features inside the small squares (comparable to an eroding software filter), see Fig.2-5, left side original image, right side blooming.
But also the target can be modified, its size may change and the alignment accuracy be reduced.

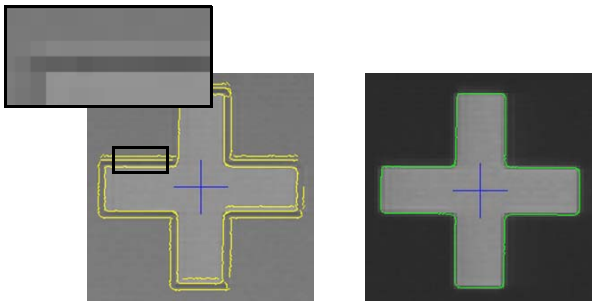


Fig.2-6: Training Mask Image Effect

In Fig.2-6 a mask target was trained with and without a wafer under it. The reflections on the wafer surface and the shadow of the mask cause apparent bright and dark lines which are not real but can be interpreted as true edges by PatMax and finally will cause alignment problems.
If you train the mask without the wafer, then the chuck will more or less absorb all light and you get a perfect contrast of the mask target and create a good model.

Training the mask without wafer is currently only available for MA100/150e and MA300.

Rules:

- **Avoid tedious parameter optimization and image improvement.**
- **Select the proper illumination and focus.**
- **Train mask without wafer if possible or set mask imaging gap to 5000 µm.**

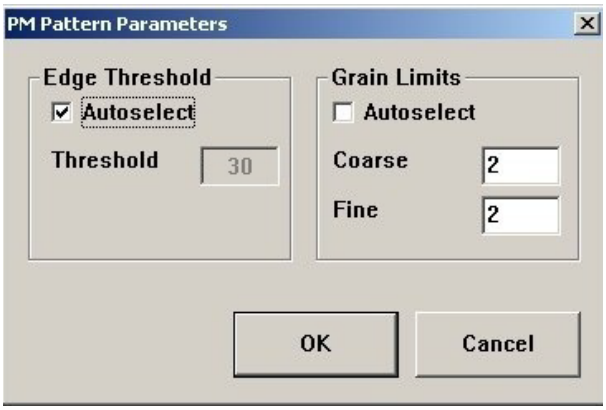
2.7. Setting the Default Parameters

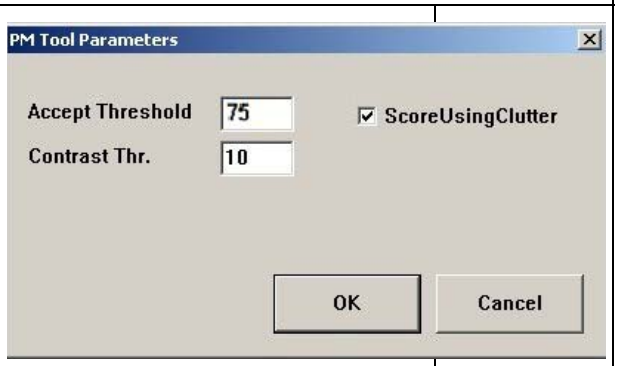
The first time you start training a model all PatMax parameters should be set to their recommended values using the AL-Editor or VisionPro panels. Please note that the parameters listed here are a general recommendation when starting a training session. Depending on your typical process it may be wise to use a parameter set which has been optimized specifically by you.

Note:

Use the button <Template...> in the AL-Editor to reset all parameters to their default values.

2.7.1. Default Parameters in AL-Editor



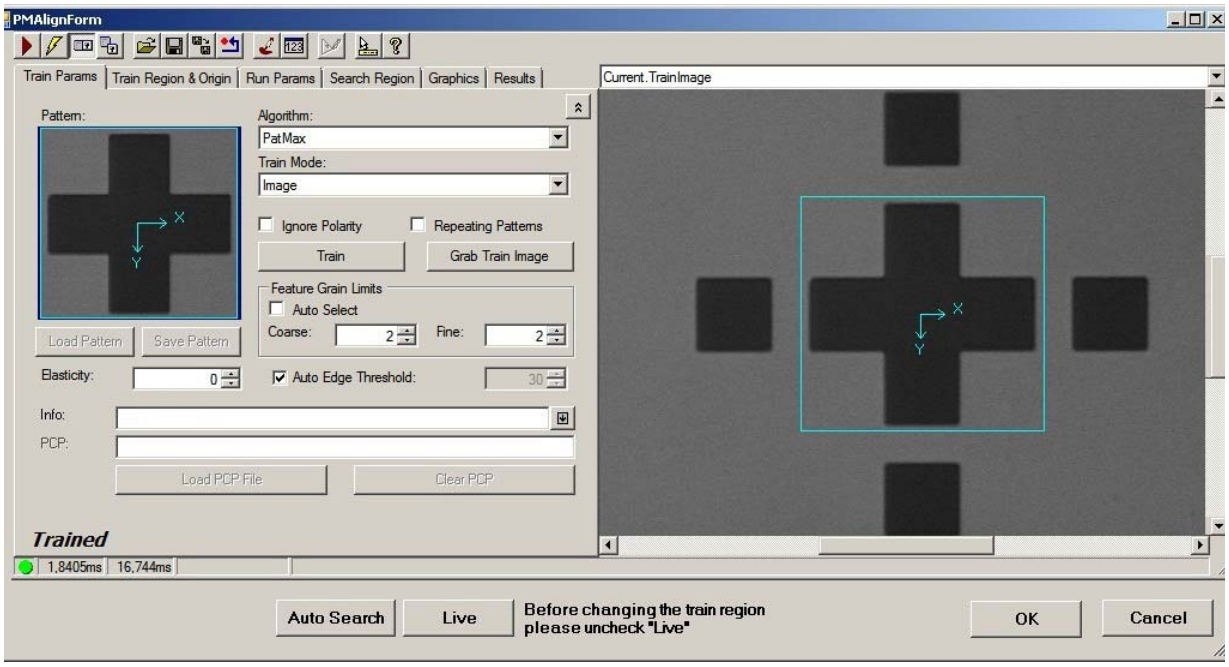


PM Pattern Parameters		PM Tool Parameters	
Edge Threshold		Accept Threshold	**75**
• Autoselect	**ON**	Contrast Thr.	**10**
• Threshold	**--**	ScoreUsingClutter	**ON**
Grain Limits			
• Autoselect	**OFF**		
• Coarse	**2**		
• Fine	**2**		

Table 2-5: Default Parameters in AL-Editor

2.7.2. Default Parameters in VisionPro Editor

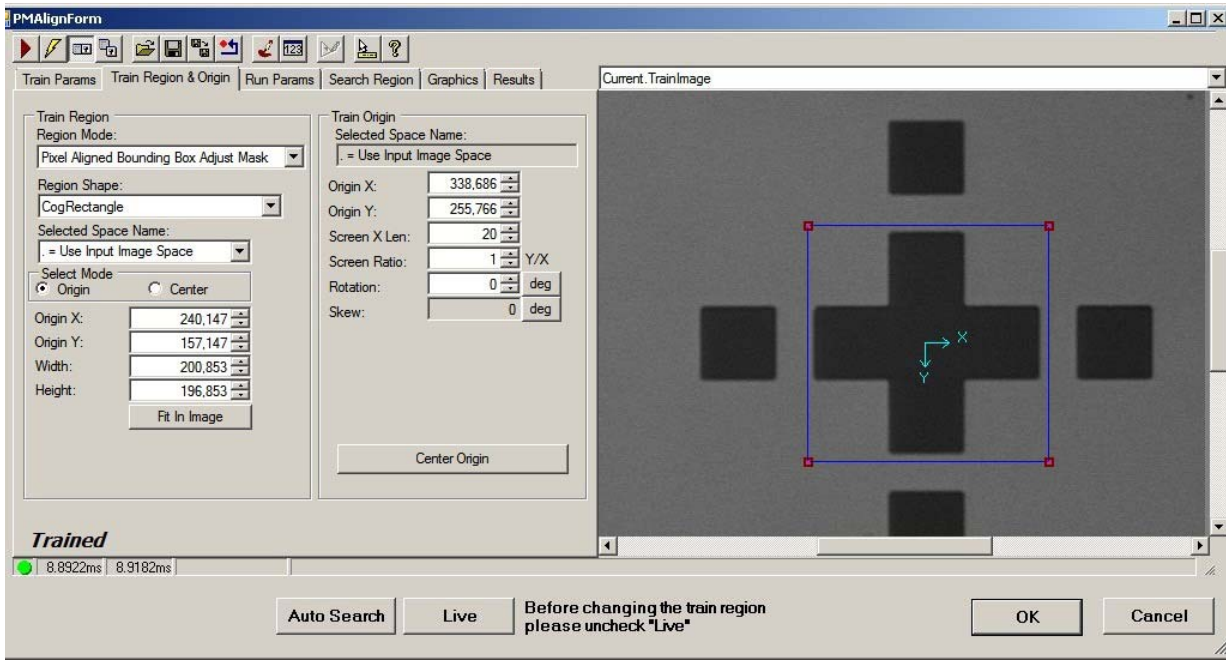
2.7.2.1 Train Params Tab



Algorithm:	**PatMax**	**Feature Grain Limits**	
Train Mode:	**Image**	• Auto Select	**OFF**
Ignore Polarity	**OFF**	• Coarse:	**2**
Repeating Patterns	**OFF**	• Fine:	**2**
Elasticity:	**0**		
Auto Edge Threshold	**ON**		

Table 2-6: Default Parameters in VisionPro Editor - Train Params

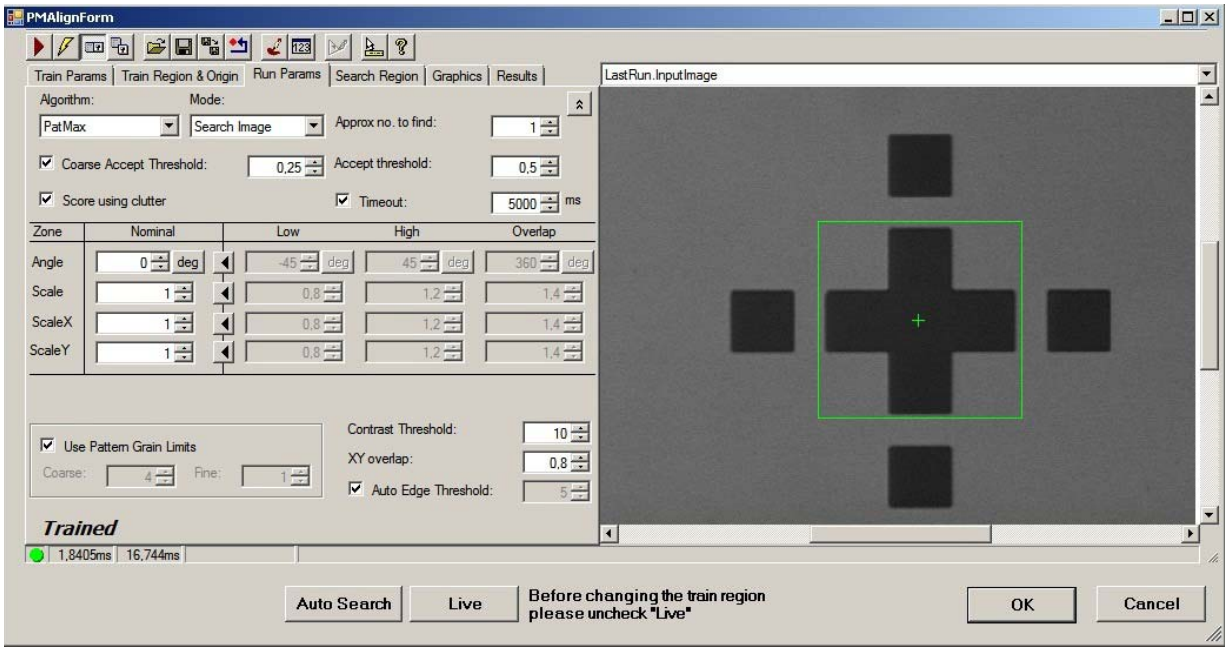
2.7.2.2. Train Region&Origin Tab



Train Region		**Train Origin**	
• Region Mode	**Pixel Aligned Bounding Box Adjust Mask**	• OriginX • OriginY • Screen X Len • Screen Ratio • Rotation	**Do not edit**
• Region Shape	**CogRectangle**		
• Selected Space Name	**= Use Input Image Space**		
• Select Mode	**Origin**		

Table 2-7: Default Parameters inVisionPro Editor - Train Region&Origin

2.7.2.3. Run Params Tab

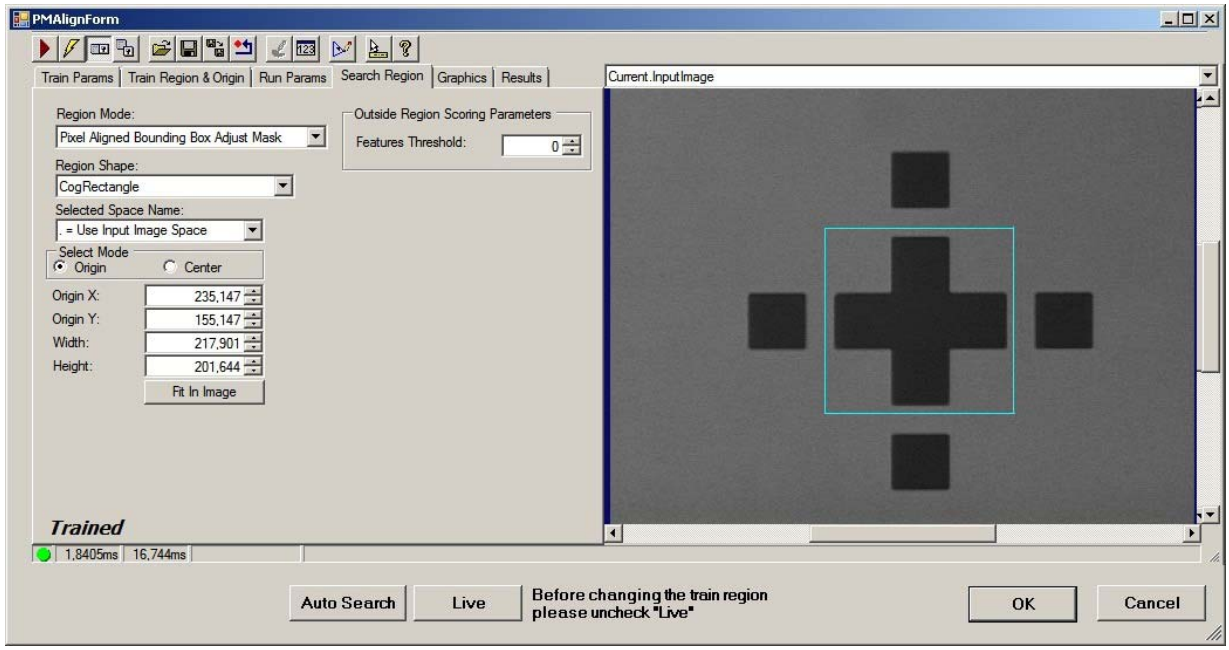


Algorithm:	**PatMax**	**Nominal*** **(Default: Arrows to the left)**	
Mode:	**Search Image**	• Angle	**0**
Coarse Accept Threshold:	**ON/ 0.25**	• Scale	**1**
Score using clutter:	**ON**	• Scale X	**1**
Approx no. to find:	**1**	• Scale Y	**1**
Accept threshold:	**0.75**		
Timeout	**ON/ 5000**	Contrast Threshold	**10**
Use Pattern Grain Limits	**ON**	XY overlap:	**0.8**
		Auto Edge Threshold	**ON**

Table 2-8: Default Parameters in VisionPro Editor - Run Params

* Nominal is valid and the corresponding fields for Angle/Scale/ScaleX/ScaleY can be edited if the arrows point to the left and the fields are white.

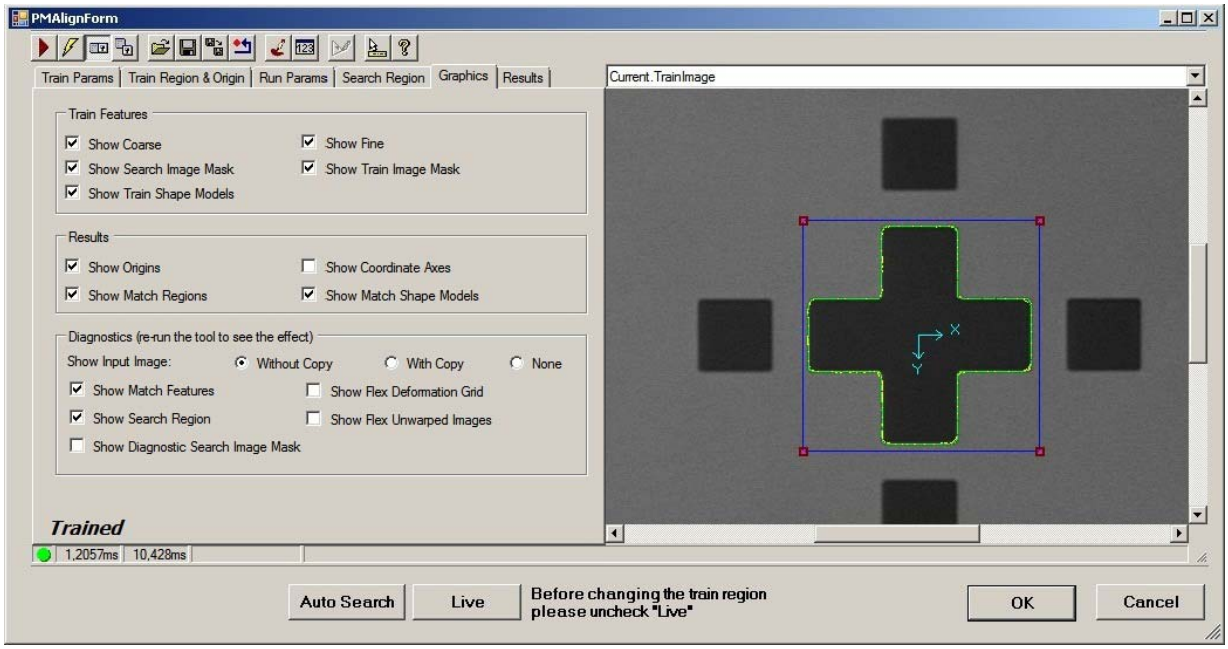
2.7.2.4. Search Region Tab



Region Mode:	**Pixel Aligned Bounding Box Adjust Mask**	**Outside Region Scoring Parameters**	
		• Features Threshold	**0**
Region Shape:	**CogRectangle**		
Selected Space Name:	**= Use Input Image Space**		
Select Mode	**Origin**		
• OriginX • OriginY • Width • Height	**Do not edit**		

Table 2-9: Default Parameters in VisionPro Editor - Search Regions

2.7.2.5. Graphics Tab



Train Features		**Results**	
• Show Coarse	**ON**	• Show Origins	**ON**
• Show Fine	**ON**	• Show Match Regions	**ON**
• Show Search Image Mask	**ON**	• Show Match Shape Models	**ON**
• Show Train Image Mask	**ON**		
• Show Train Shape Models	**ON**	**Diagnostics**	**ON**
		• Without Copy	**ON**
		• Show Match Features	**ON**
		• Show Search Region	**ON**

Table 2-10: Default Parameters in VisionPro Editor - Graphics

Rules:

- **Proper defaults help avoiding many problems.**
- **Since recipes are created by copying incorrect parameters propagate to other recipes.**
- **It is always worth defining your own specific default parameters set.**

2.8. Switching between AL-Editor and VisionPro

The pattern recognition can be trained in VisionPro as well as in the AL-Editor (see Operator Manual). Use the AL-Editor as your standard and switch to VisionPro only if your targets need special treatment that cannot be handled within the AL-Editor.

Switching from the AL-Editor to VisionPro:

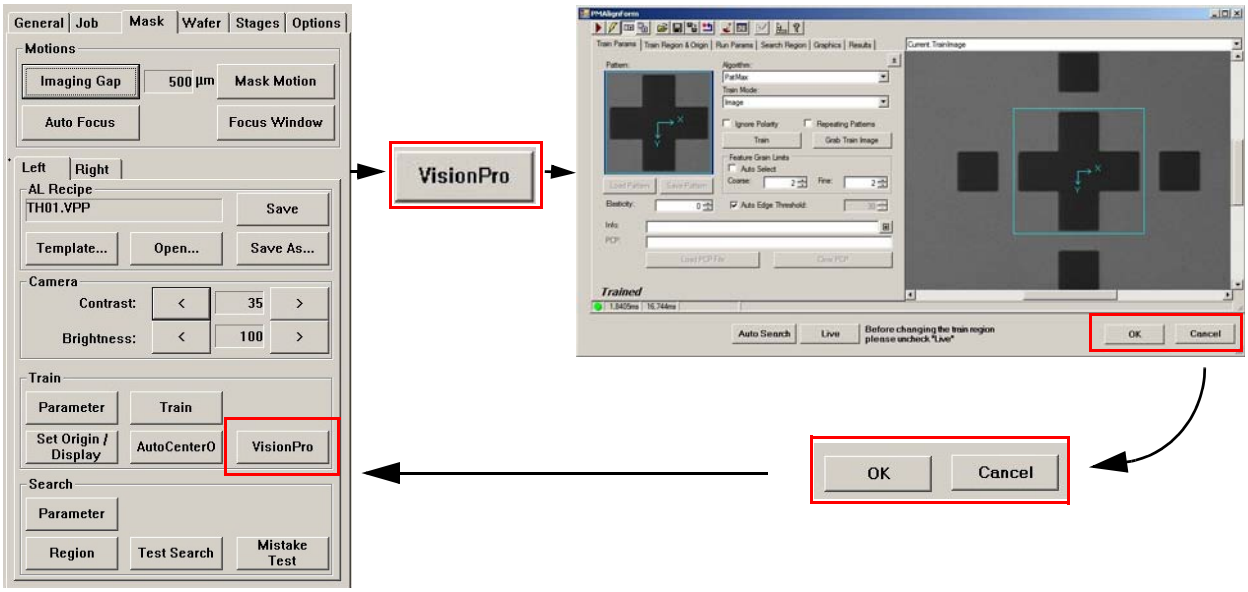


Fig.2-7: Switching between AL-Editor and VisionPro

- Press the button <VisionPro> in the AL-Editor Mask or Wafer Tab to open the VisionPro Editor.
- Press the button <OK> in the VisionPro Editor to save changes which you have made in the VisionPro Editor and to switch to the AL-Editor.
- Press the button <Cancel> in the VisionPro Editor to switch to the AL-Editor without saving any changes.

2.9. Setting the Algorithm

- In AL-Editor PatMax is used as the standard algorithm. It cannot be changed.
- You can set other algorithms in the VisionPro editor and use them as long as you do not switch back to the AL-Editor. (We do not have any experience with other algorithms than PatMax.)
- As soon as you try to train a new model in the AL-Editor, you are prompted to change your algorithm to PatMax.

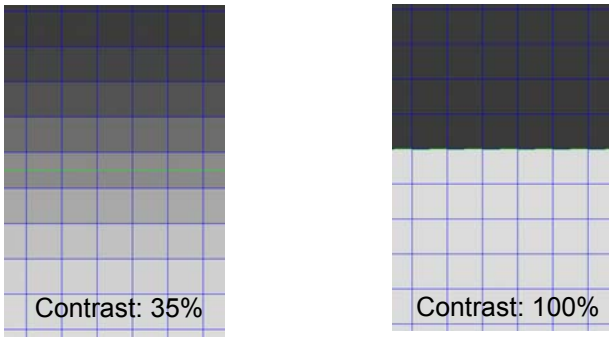
Rule:

We recommend to use PatMax as algorithm.

2.10. Setting Contrast and Brightness

- The default value of the **brightness is 100%** and should not be changed. (Exception: For some processes the MA100/150e requires different illumination levels for mask and wafer, which is not possible. That can to a limited degree be compensated with the brightness parameter).

- The default values of the **contrast is 35%** and should never be changed, too, because increasing the contrast reduces gray level information and the position accuracy is reduced. Fig.2-8 shows an example.



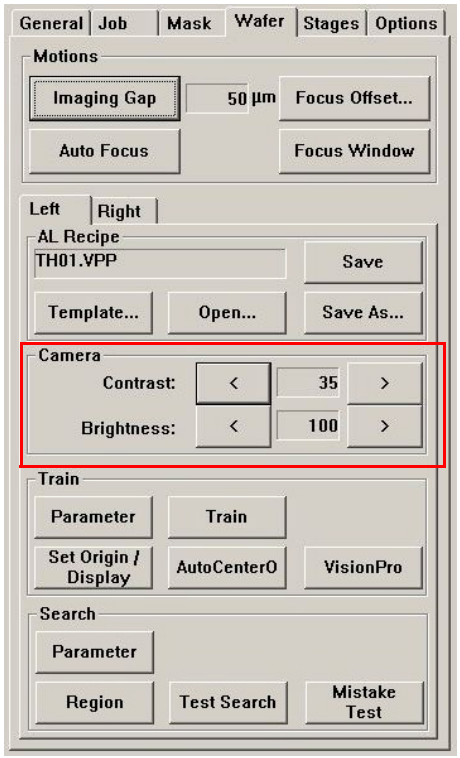


Fig.2-8: Setting Contrast and Brightness in AL-Editor

3. TRAINING A GOOD MODEL

3.1. Procedure

Training a pattern may be completed using the default AL-Editor or VisionPro. We recommend always using the AL-Editor (Table 3-1). You will get graphical feedback and have a choice of parameters for training.
Only if these parameters are not sufficient to solve your alignment requirements you may use the VisionPro Editor.

Typically you train "something" first and during the test and improvement loop you define step by step better models and parameters.

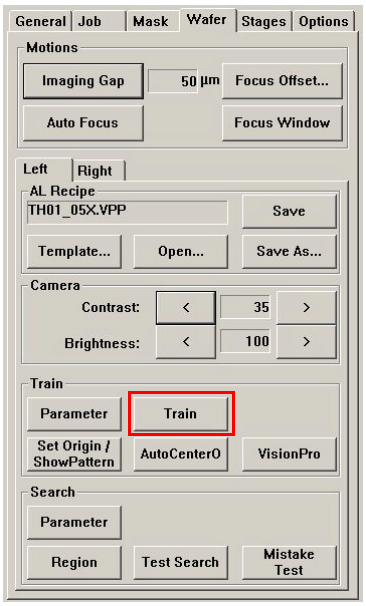
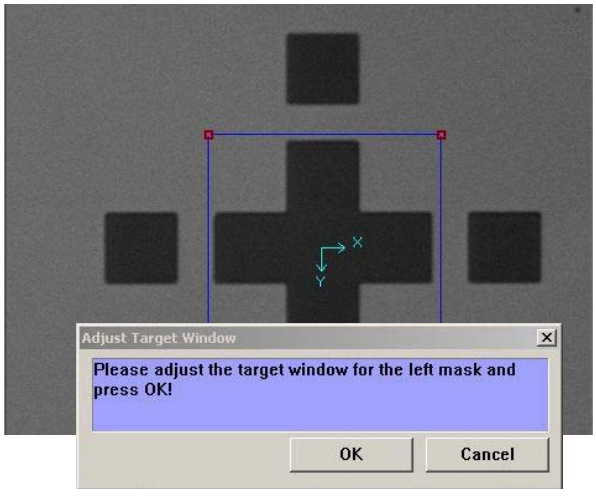
	• Training can be started in the AL-Editor. • Press <Train> in the Train frame of the Mask or Wafer Tab in the AL-Editor. **Note:** **When pressing <Train> , a new camera image is acquired and the image is stored as "Current.TrainImage" (= "Grab Train Image" Function of Vision Pro)**
	• A dialogue and a rubber band appear. • The rubber band marks the area where PatMax is supposed to define the patterns. • You can move and resize the rubber band. • Confirm the training with OK.

Table 3-1: Training a Pattern in the AL-Editor

3.2. Setting the Grain Limits

3.2.1. General

The "Grain Limits" influence the outcome of the model to a high degree and are therefore one or the most important parameters. As explained earlier, they represent the length of the "edge elements" of the fine and coarse model.
We recommend default settings of 2.0 for both. That seems to fit quite a lot of applications, but not all. The original Cognex default value is "Auto Select" and Cognex determines the values automatically following some secret rules. That works well for most masks, but not many wafer types.

Lower values of the grain limits increase the accuracy; therefore we recommend a value of 1.0 for the DSM200. Also thin lines and double edges are found more reliable if you have small values. Higher values of the grain limits filter noise and have an integrating effect, which is good for low contrast images.

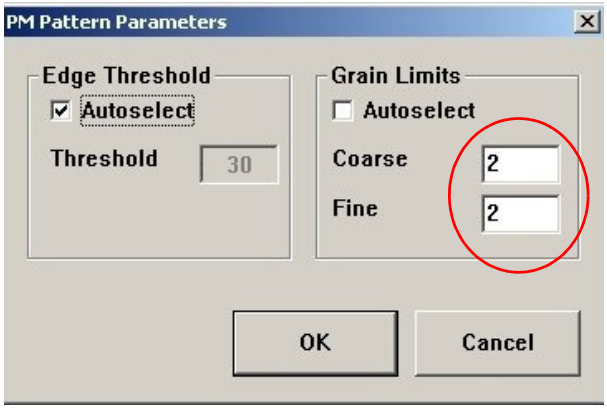
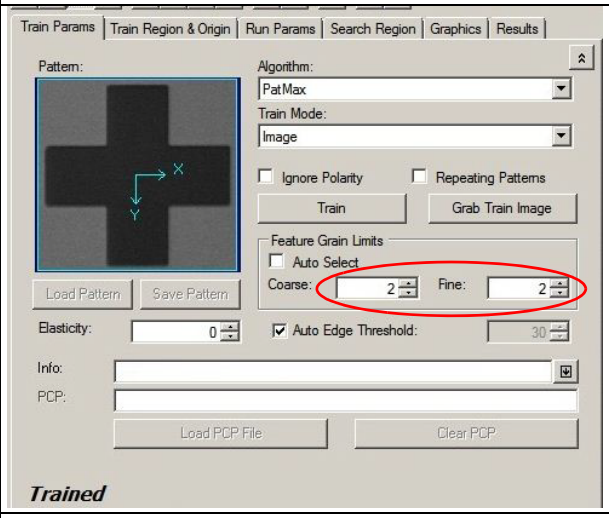
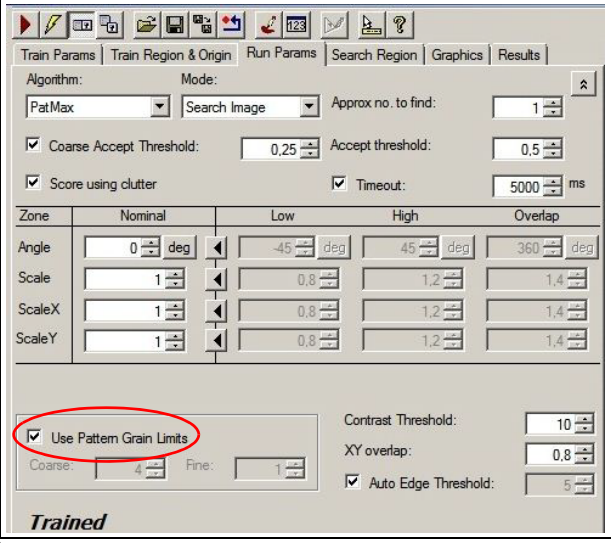
AL-Editor	VisionPro Editor
	
	

Table 3-2: Setting the Grain Limits in AL-Editor and VisionPro Editor

Note 1:

In VisionPro you find Grain Limits twice (see Table 3-2):

Do not change the values on RunParams page, insure that "Use Pattern Grain Limits" is ON and on the Train Params page insure "AutoSelect" is OFF. The values may be set to 2 and 2 initially.

Note 2:

A difficulty when training PatMax is that both grain limits impact what is defined as model. E.g. the coarse grain limits influences the fine pattern. That can make the training difficult, especially if you want to use the same coarse and fine grain limits. So sometimes you end up with synthetic models.

Rules:

AL-Editor/ VisionPro Grain Limits - Auto Select = OFF
AL-Editor/ VisionPro Grain Limits - Coarse = 2.0 (DSM200: 1.0)
AL-Editor/ VisionPro Grain Limits - Fine = 2.0 (DSM200: 1.0)
VisionPro Grain Limits - Use Pattern Grain Limits = ON

- **Larger values for low contrast, noisy and granular targets**
- **Small values for thin lines and double edges.**

3.2.2. Targets with Noise, Low Contrast or Grains

If the edge elements are short (low Grain Limit), small features like noise are declared as edges (see Model 1/ Table 3-3 below). Long edge elements (high Grain Limits) act like a filter and only (more or less) the desired edges are left (see Model 2).

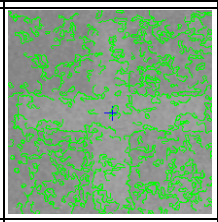
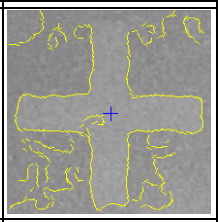
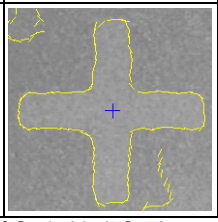
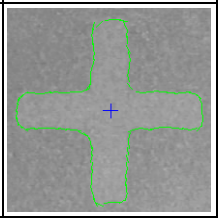
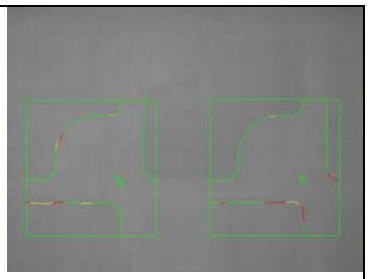
	Coarse Model	Fine Model
Model 1 Grain Limits: Automatic = 5.1 / 1.0		
Model 2 Grain Limits: Manual = 8.0 / 8.0		

Table 3-3: Effect of Grain Limit Setting

Another big advantage of high grain limits is that even targets with extremely low contrast are found. It seems that the grain limits act like an integration mechanism. In the example below values of 10.0 worked.

Successful Pattern Recognition with very different and low contrast models:



Grain Limits: Manual = 10.0/10.0

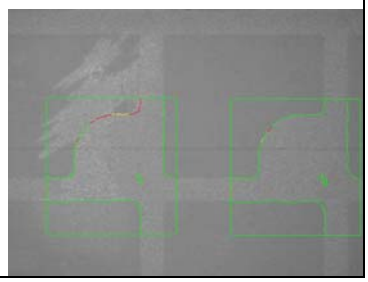


Fig.3-1: Optimized Grain Limits Setting

Rule:

High grain limits help, if images are noisy, have low contrast or a granular background.

Do not set the grain limits higher than necessary because it reduces the accuracy.

3.2.3. Targets with Thin Lines, Small Features, Double Edges

If a target consists of thin lines and Auto Select is ON, then PatMax will create a nice fitting fine model (with pattern limit 1.0) and a badly fitting coarse model (with a higher pattern limit). That coarse model can cause misalignment, see Fig.3-2. This misalignment can be accepted by the software, if the score is sufficient.

Note:

We generally recommend to have small, equal values for the grain limits like 2.0 / 2.0 or 1.0 / 1.0 if you have thin targets, small features or double edges. That makes both patterns match the target well and in an equal manner.

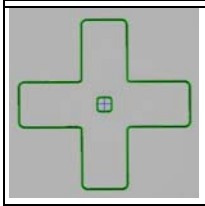
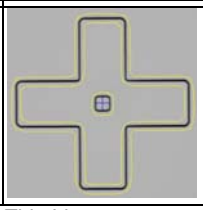
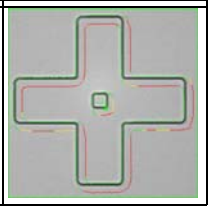
Fine Pattern	Coarse Pattern	Misalignment
		

Fig.3-2: Targets with Thin Lines

3.3. Defocusing - Impact of Focus

When training patterns, you will often get features in your model that you do not want.
There are at least 3 solutions to eliminate these features:

- Increase the Grain Limits
- Defocusing
- Masking

Defocusing should only be applied to the model, not to the image that is used for the search. If you use defocusing, be careful, do not defocus more than necessary. Defocusing may also be not well reproducible.

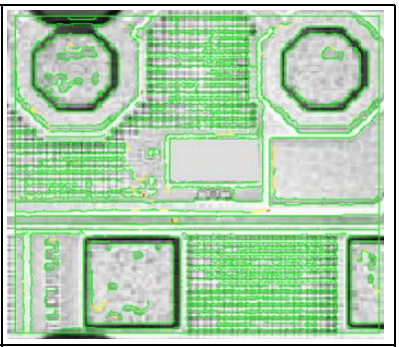
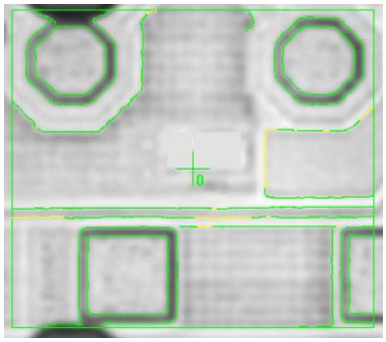
Normal Training	
Training after Defocusing	

Table 3-4: Defocusing

The advantage of defocusing depends very much on the appearance of the targets. The larger and simpler the target the better the positive effect of defocusing.

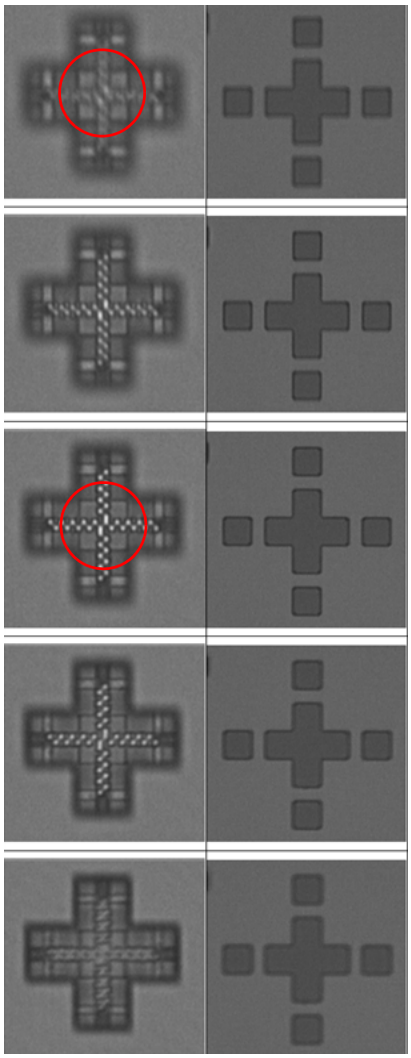
Defocusing [µm]	Small Pattern with many details	Large Pattern no small details
-40		
-20		
in Focus		
+20		
+40		

Table 3-5: Effects of Defocusing depending on Target Details

The left target (Table 3-5) shows small features. If you defocus, the details disappear and the score of the pattern recognition will drop considerably.
The right target shows a large, simple shape and the reliability of pattern recognition will still be high even with large defocusing. That means simple shapes increase the depth of focus.

Rule:

The targets should be large and have a simple shape (cross, square, circle) and have no small details or features.

3.4. Masking

An efficient method to remove unwelcome features from a model is the partial coverage of the image with a mask during training. The parts of the image that are covered with the mask will not be trained, see examples in Table 3-8. Masking is a powerful tool to remove those features from an image that you do not want to be part of your model.

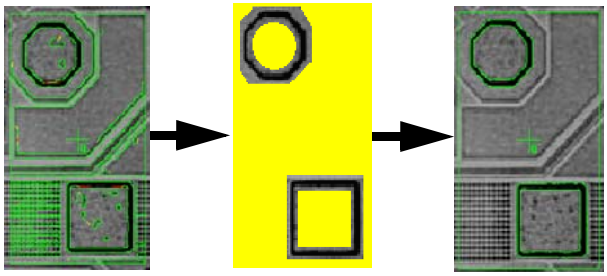


Fig.3-3: Masking Unwanted Features (1)

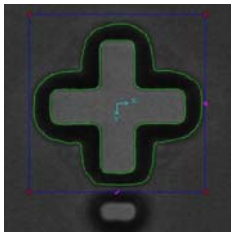
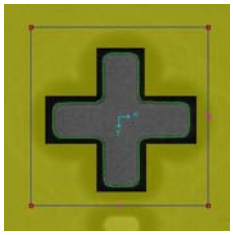
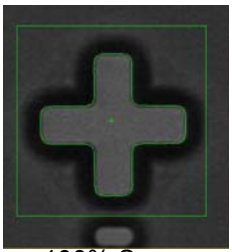
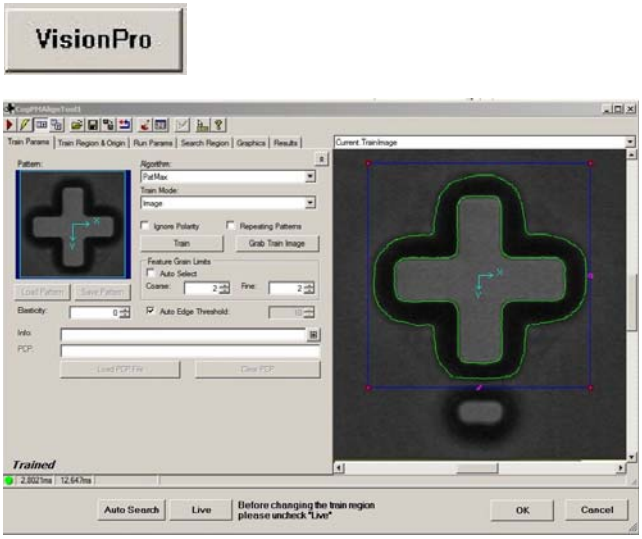
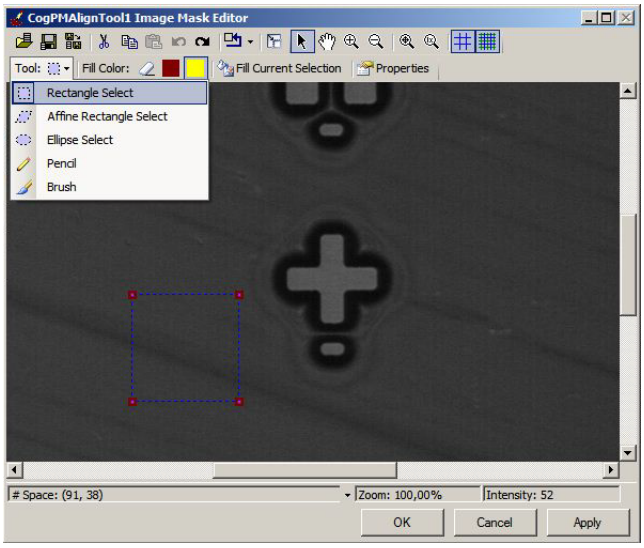
	Model Training	Subsequent Wafers
No Masking		 Low Score
Masking		 100% Score

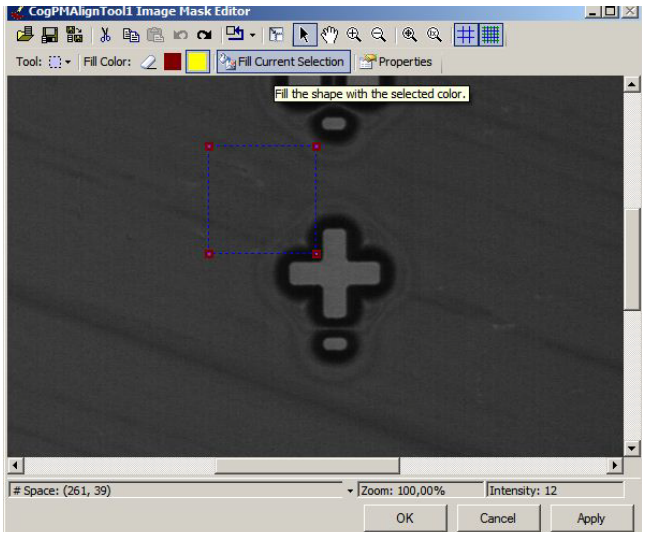
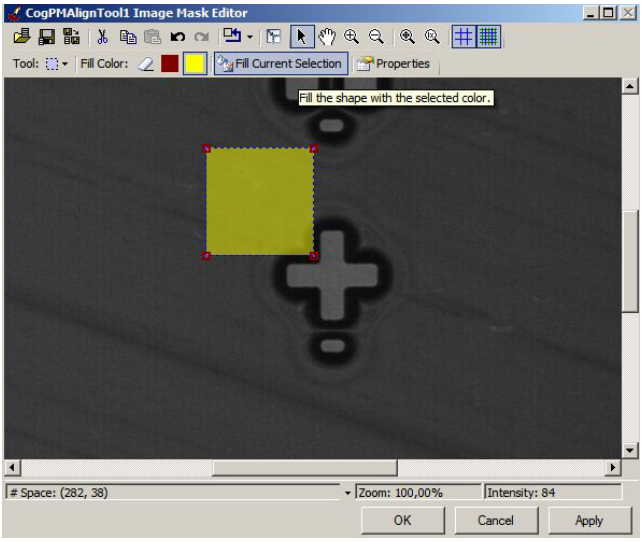
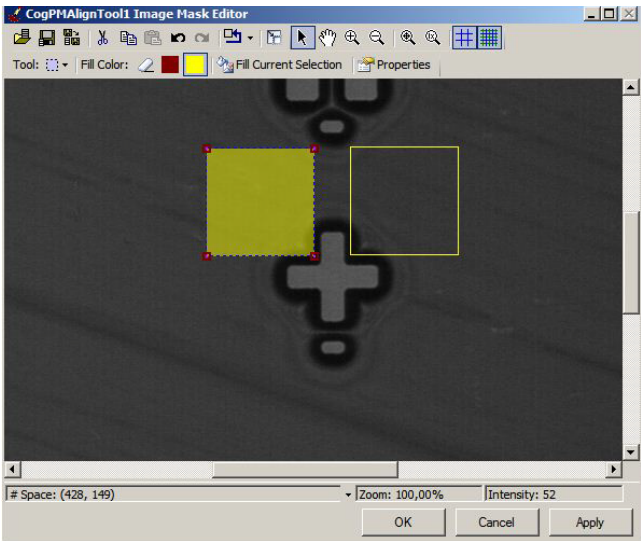
Table 3-6: Masking Unwanted Features (2)

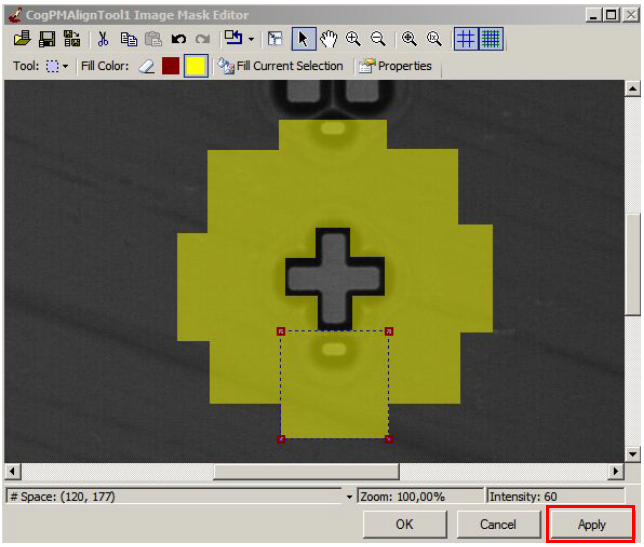
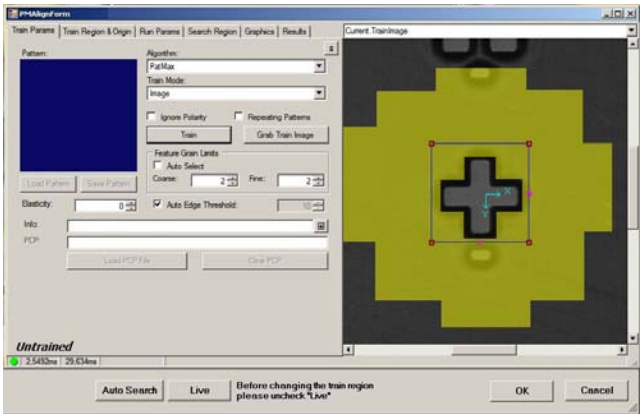
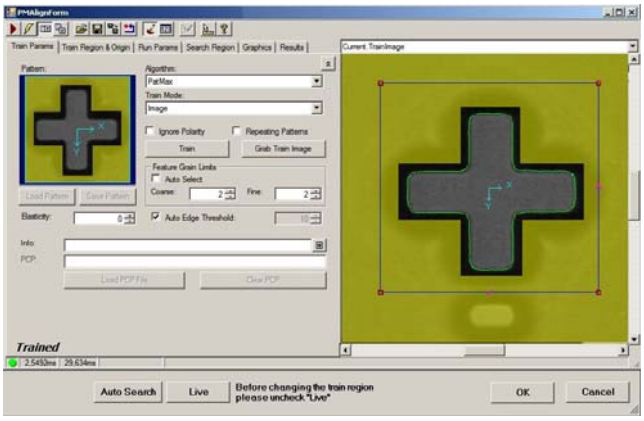
3.4.1. Correct Mask Option

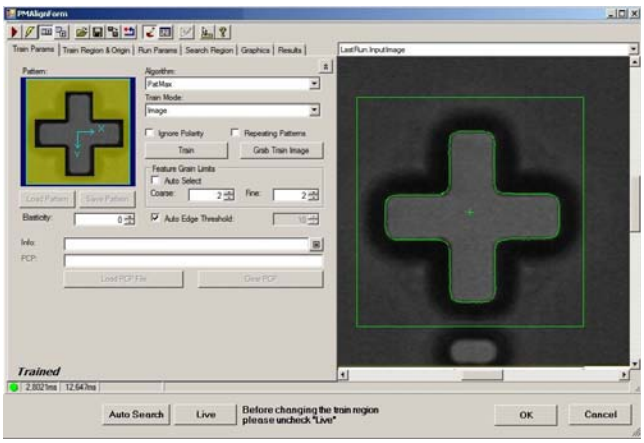
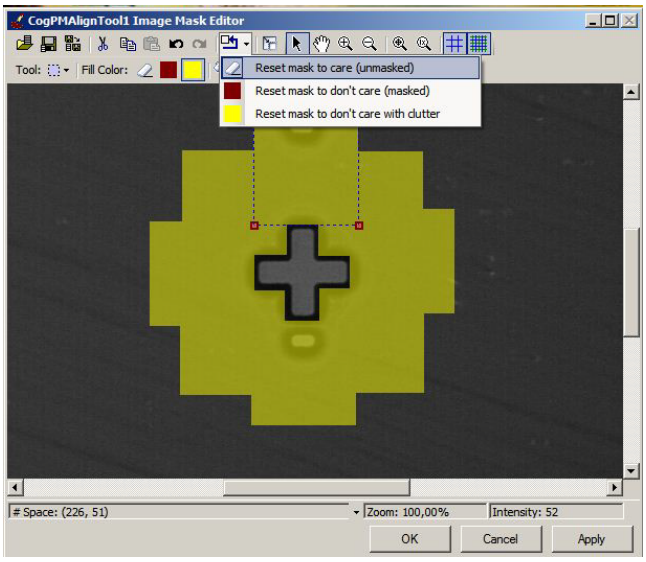
- If the mask is not removed after training, you may get errors, if you use the same recipe again. It depends on the size and position of the training rubber band. We recommend removing the mask after use.

3.4.2. Masking Steps

	• Press <VisionPro> to open the VisionPro Editor • Train the target, search the target as usual
	• Press  to open the Image Mask Editor. • In the Tool selection select <Rectangle Select> • A rubber band appears which represents the mask area and which can be expanded according to your requirements.

	• Drop and drag the mask rubber band to the desired position according to your require-ments. • Select the yellow filling color and press <Fill Current Selection>
	• The rectangle is filled and represents now a part of the masking.
	• Drag and drop the rubber band to the next desired masking area. • Press <Fill Current Selection>

	• Proceed until the surrounding of your target is masked. • Then press <Apply> • Close the Image Mask Editor with <OK>.
	• The masked „Current TrainImage“ appears in the window of the VisionPro Editor.
	• Retrain the target with the applied mask. **Note:** **Don't change the size or position of your train image (by pressing the "Grab Train Image") because your mask will not fit to your target any more and miss alignment will be the result.**

	• Run the next wafer to test the alignment. • If alignment is ok return to the AL-Editor.
	• If you want to remove the mask from your Current TrainImage open the Image Mask Editor and press the tool <Reset mask to care (unmasked). • Press <OK> to remove the mask and to leave the Image Mask Editor.

3.5. Alternate Models

Another powerful method of defining a model is to use a mask image that is the same size, shape and polarity of your wafer image.
It is a simple procedure to load a blank wafer and a mask with the desired image on the tool, set the focus for the mask the same as for the wafer, set the gap to some value that will provide a good image.
Now you simply create the wafer model, save it and proceed to test, adjust it using the proper mask and device level wafer to be aligned.
In some instances such as when the wafer image is distorted by fringes due to the resist you may improve the alignment by training the model on a wafer without resist.

3.6. Synthetic Models

Synthetic training is required if you have no wafer that lets you create a good model and if none of the above methods helped.
Synthetic training is usually "the last means" because it requires a well trained and experienced user.
Synthetic training requires designing a wafer image in a manner that lets you create a good model. In Table 3-7 you see that there is a cross in the scene but it is mixed with heavy grains. The synthetic image was design so that the cross was still present but the grains were removed and the lines were homogeneous.

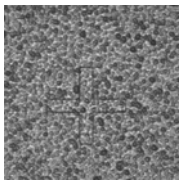
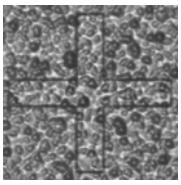
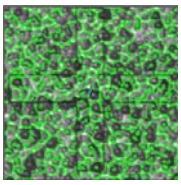
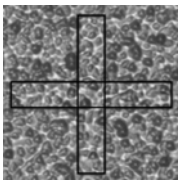
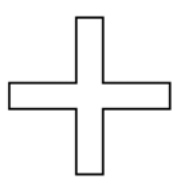
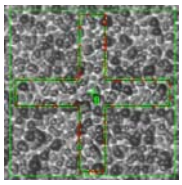
1-Original Scene	2-Zoom	3-Normal Model	4-Paint Over	5-Train Paint Over	6 Model fits Scene well
					

Table 3-7: Preparation of Synthetic Pattern

In principle synthetic training is easy:

- Create a pixel image of the scene. You can for example make a screen shot, load it into a pixel editor, cut it to size, and save it to the hard disk.
- Paint a good image over the pixel image. This is easier if your pixel editor can create a second layer. Then you fill the environment so that the granular or noisy background becomes invisible.
- Save the modified image, import it into PatMax, and train the model.
- Switch from image to the camera and test.

But often this is not sufficient and the image of a model must be improved over several iterations:

- You may have to adjust the line width.
- You may work only with the "inner" or "outer" edge.
- You may find size differences between model and scene. Those can be adjusted using the "Zone ScaleX" and "Zone ScaleY" parameters in the RunParams Tab (Chapter 4.6).
  Hint: Use the flexible Zones to find out the size difference and enter that as fixed value for the nominal Zone. Do this for X-axis then for Y-axis.
- In some cases you may smooth the image in order to get round corners or a non-whole number line width (e.g. 1.5 pixels).
- Crosses should be trained without the ends of the arms. This makes it easier to adjust the size (Zone).

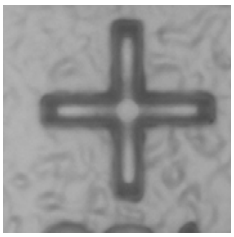
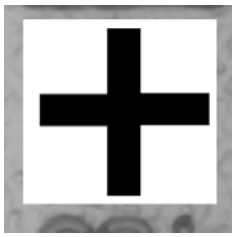
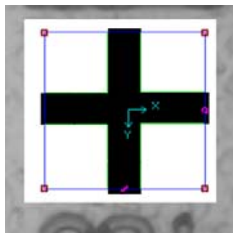
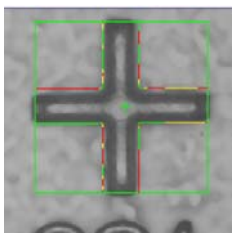
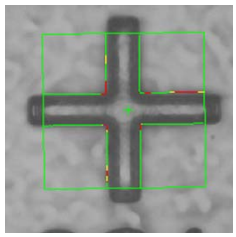
Wafer	Synthetic Image	Training	Search (Scale=100%) Score = 48%	Search (Scale=86%) Score = 81%
				

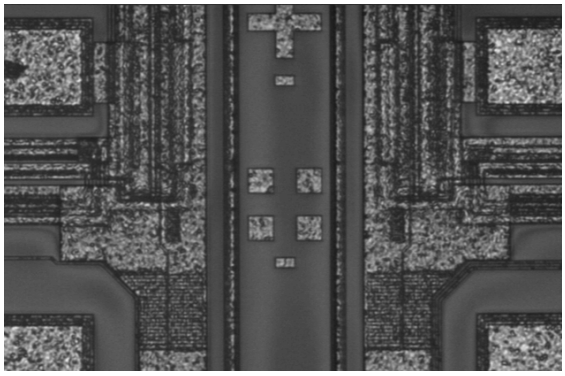
Table 3-8: Optimizing the Search with a Synthetic Cross

Rule:

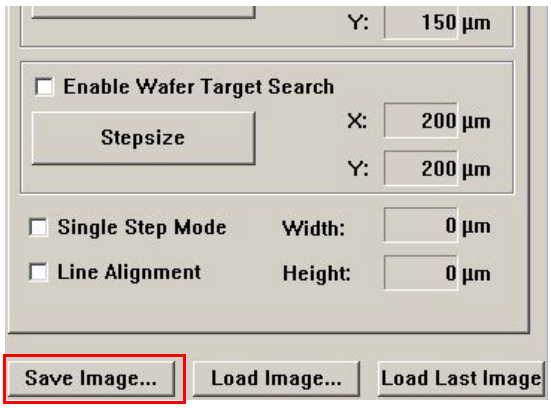
You need synthetic training if you have bad targets and all previously mentioned methods to create a good pattern failed.

A synthetic image is the „last means“ to get a good model.

3.6.1. Operation Sequence



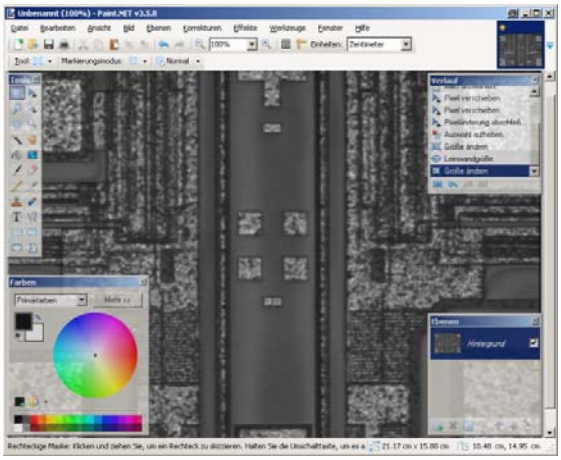
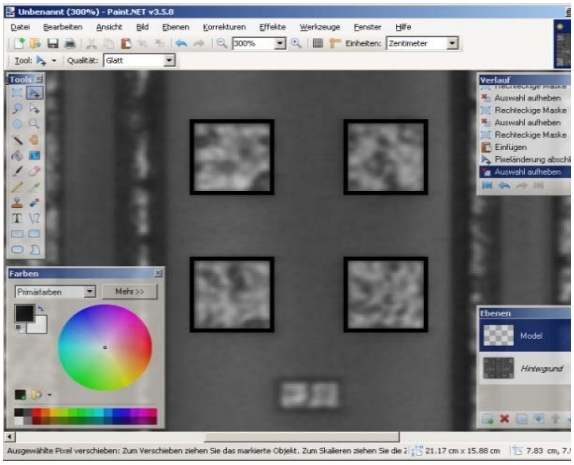
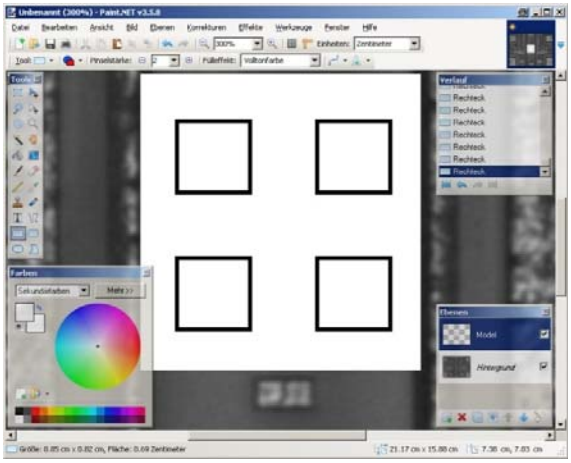
- Make a screen shot of the scene with the target.
- Paste the screen shot into a pixel editor (Microsoft Paint, Paint.NET, Corel PhotoPaint, Gimp...)
- Cut it to 640 x 480 pixels.
- Save it.

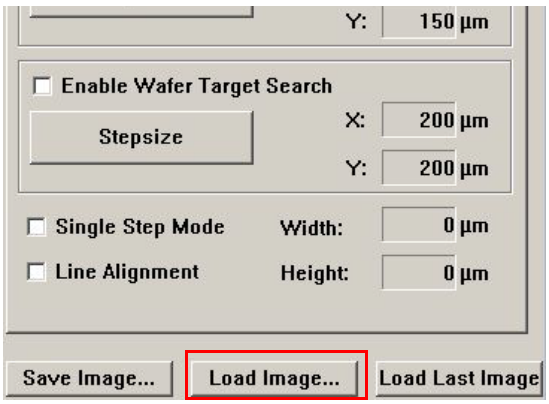
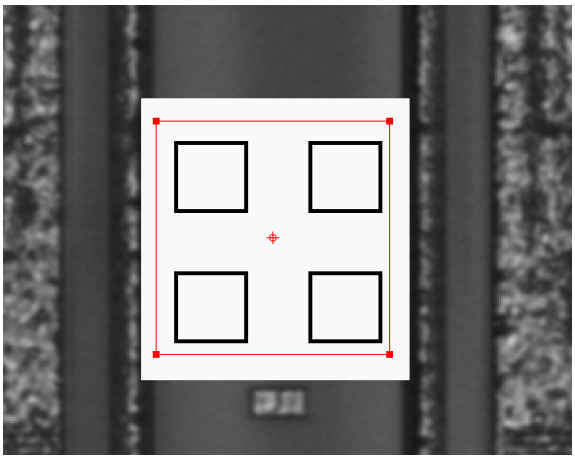
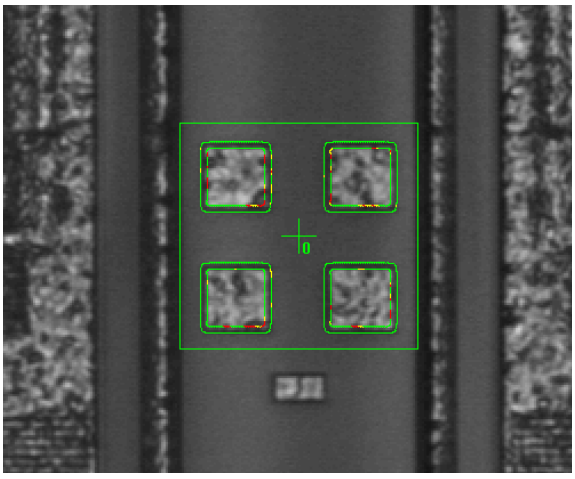


Alternatively:

The new AL-Editor offers a "Save Image …" function.

- Press the button <Save Image...> and save it.

	• Open this image with your pixel editor.
	• Zoom if necessary. • Paint the model over the image - if possible in a second layer.
	• Fill the background. • Make sure that you do not change the edge polarity. • You may remove the original image. • Save the new image with a new file name. • The format should be *.bmp, 256 color bitmap • Size is typically 302 kB at 480x640 pixels • Close the pixel editor.

<table>
<tr>
<td>
</td>
<td>• Go to the AL Editor.
• Press <Load Image...>.
• Load the synthetic image.</td>
</tr>
<tr>
<td></td>
<td>• Train the model as usual using the synthetic image.
• Press <Test Search> in AL-Editor.</td>
</tr>
<tr>
<td></td>
<td>Depending on the quality of the created synthetic image you will get a high score.</td>
</tr>
</table>

3.7. Uniqueness of Targets

3.7.1. Multiple Confusable Targets

Equal or very similar targets can be mistaken with each other.

There are three methods to avoid it:
- Combining several features into one model that is unique.
- Reduce the area of interest ("search window").
- Use the parameter „Score Using Clutter“, i.e. features that should not be there are taken into account when calculating the score.

3.7.1.1 Combining Features

Uniqueness is created by respecting the relative position of the multiple features in one model.
Uniqueness can be measured by doing the so-called "Mistake Test>.

The mistake test can be simply performed in the AL-Editor:

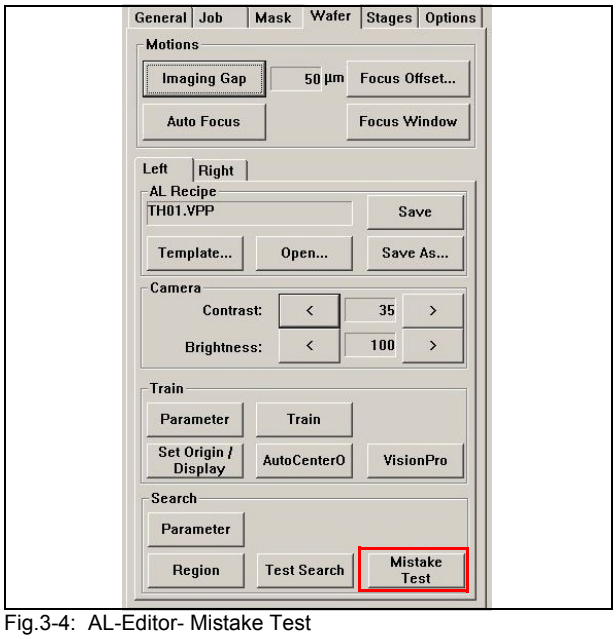


Fig.3-4: AL-Editor- Mistake Test

- Press the button <Mistake Test>.
- The program performs an automatic test search with following parameters:
  - Coarse Accept Threshold = 0
  - Fine Accept Threshold = 0
  - Approx no. to find = 2

PatMax displays the two instances with the highest score and lists their scores (see Fig.3-5).

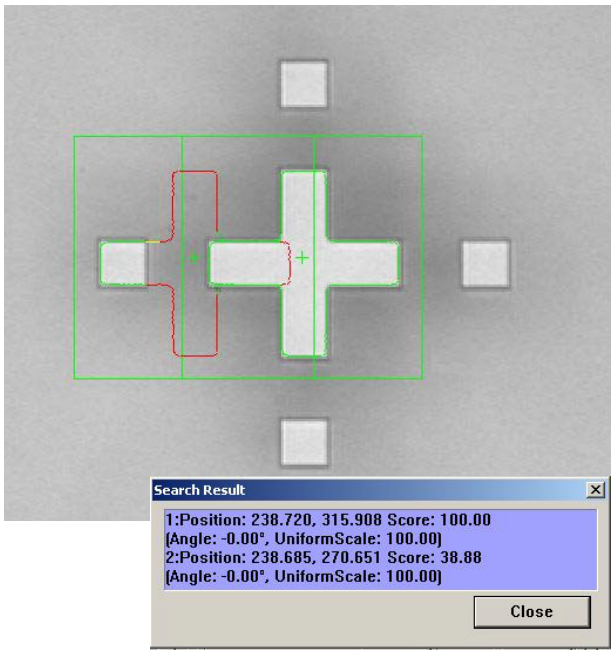


Fig.3-5: Mistake Test in AL-Editor

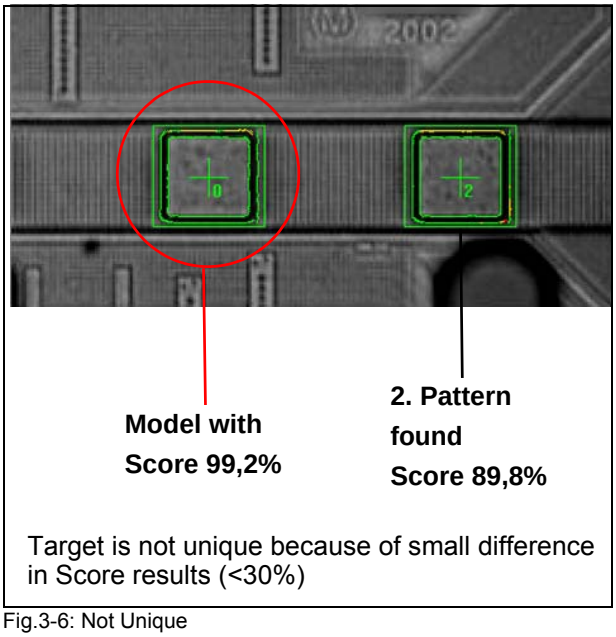


Fig.3-6: Not Unique

A match can be considered unique if its score is much higher than that of the other instance. The difference in score should be at least 30%. If the difference is small, then there is a risk that PatMax finds another instance i.e. the wrong feature on the next wafer.

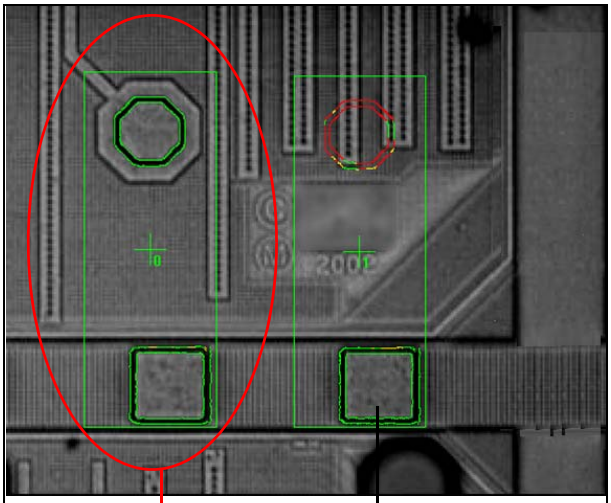


Fig.3-7: Unique

By combining multiple features in one pattern you get more edge information and more accuracy and you avoid mistakes.

3.7.1.2 Reduction of Area of Interest/ Use of „Score Using Clutter“

The next example (Fig.3-8) shows methods 2 and 3. The challenge was to find position 0 but not position 1-5. - The mask appears dark because ring light was used.

The reduced area of interest AOI (search area) blocks instances 3 to 5.

Note:

AOI should not become too small when searching wafers: The next wafer's position may be different depending on the prealignment accuracy and first exposure error.

Instances 1 and 2 are avoided by using the parameter "Score Using Clutter". The table in the image shows that PatMax can mistake the instances 0 and 1 if Score Using Clutter is OFF. Both instances match perfectly with the pattern and deliver 100% score. If Score Using Clutter is ON, then PatMax will take features into account that were not present during training; the blue arrow points to such a feature.

Now instance 1 gets a lower score of 66%, because the unexpected feature counts negatively.

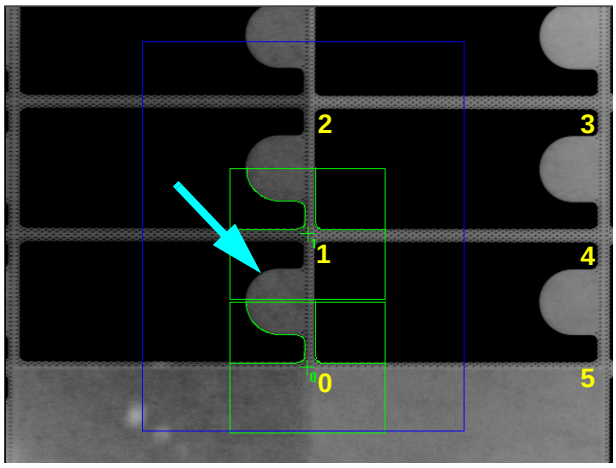


Fig.3-8: Defining Uniqueness

Score	Score Using Clutter OFF	Score Using Clutter ON
Position 1	100%	66%
Position 0	100%	100%

Fig.3-9: Uniqueness with ScoreUsingClutter

Rules:

The uniqueness of a target and model is measured with the Mistake Test.

The criterion is the difference in score which should be at least 30%.

There are three methods to increase the uniqueness:

- **Combining multiple features into a unique one**
- **Reducing the area of interest AOI (also called "search window")**
- **Score Using Clutter = ON**

3.7.2. Avoiding Mistakes with other Features

In Fig.3-10 we trained a "bad" model on some wafer. Then the next wafer was loaded and a mistake happened.
The score between model and scene was higher in the region close to the lower right corner where you find some "high frequency ripple" than that of the proper target.
The reason is that the match between bad model and bad target was low and that high frequency features have a high score with almost everything. The remedy was a good model, which was created synthetically.

This is another good example for using the mistake test.

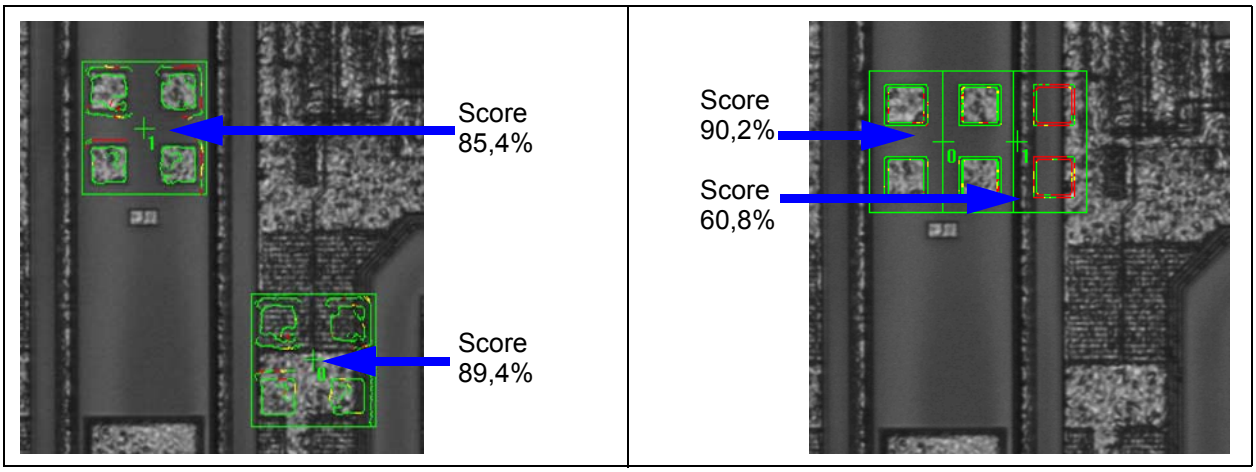


Fig.3-10: Creating Uniqueness

3.8. An Example of Finding the Wrong Image

For unknown reasons a wafer was loaded shifted or rotated into the machine.
Therefore the target was not in the field of view.

Normally the wafer target search (WTS) routine should have started in order to bring the target into the window.

But PatMax found a match with 70.4% score with some other feature in the field of view. That was above the Accept Threshold of 70% and the machine aligned the mask to that position.

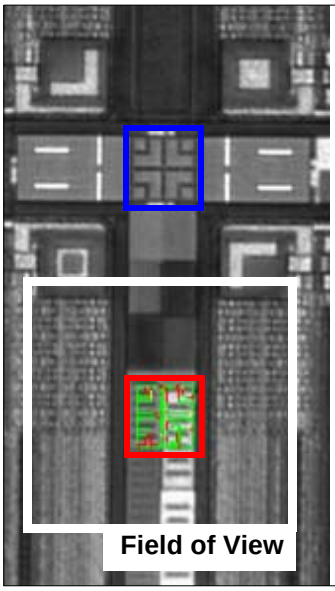
The enlarged details explain the first reason: Edges with an inverted polarity were scored positively (shown green or yellow) because the Parameter "IgnorePolarity" was ON.

A second reason was that those features of the wrong target that were not present in the model were not scored negatively because Score Using Clutter was OFF.

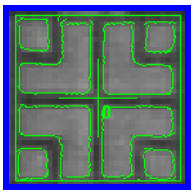
Finally the parameter "Elasticity" increased the score of the wrong feature.
The table in Fig.3-11 shows how the selection of the parameter influences the "uniqueness" and could have avoided the misalignment.

Note

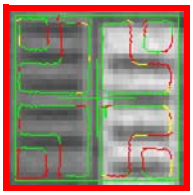
By enabling the "Stop at excess runout" parameter in the AL-Editor the machine would probably have stopped, too.



Trained Pattern



Mistaken Feature



Parameters	Trained Pattern	Mistaken Feature
Elasticity = 2 IgnorePolarity=ON ScoreUsingClutter=Off	100%	70,4%
Elasticity = 2 IgnorePolarity=ON **ScoreUsingClutter=ON**	99.8%	52,0%
Elasticity = 2 **IgnorePolarity=Off** ScoreUsingClutter=Off	99,8%	42,5%
Elasticity = 0 IgnorePolarity=Off ScoreUsingClutter=ON	99,8%	37,5%

Fig.3-11: Influence of different Parameters on the Score Result of the Mistaken Feature

Rules:

Always run a mistake test - unless no other feature is close to the target. The Accept threshold must be set high enough so that mistakes are avoided - even if the machine stops from time to time.

Always enter the Default values. Be careful when changing the parameters, especially those for the Degrees of Freedom and elasticity. Always switch Ignore Polarity OFF.

Score Using Clutter must always be ON except for noisy or granular images, DirectAlign, Enhanced AutoAL and Masking.

Enable the "Stop at Excess Runout" function in the AL-Editor.

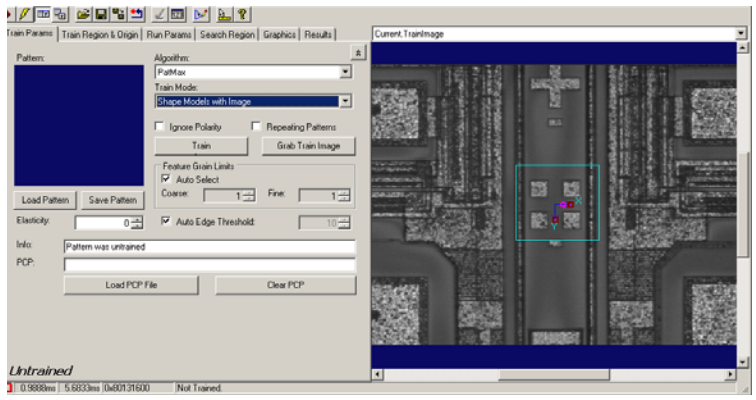
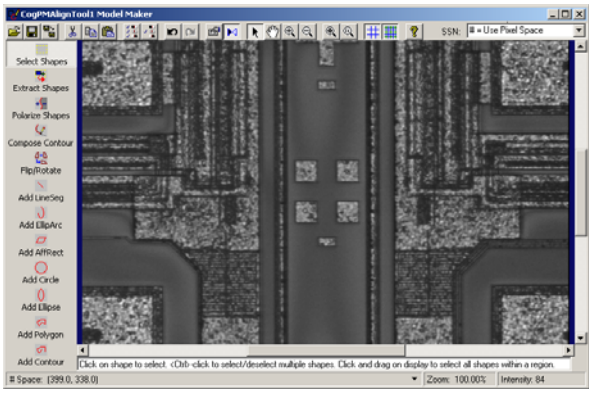
3.9. Creating Patterns with Model Maker (Shape Extraction)

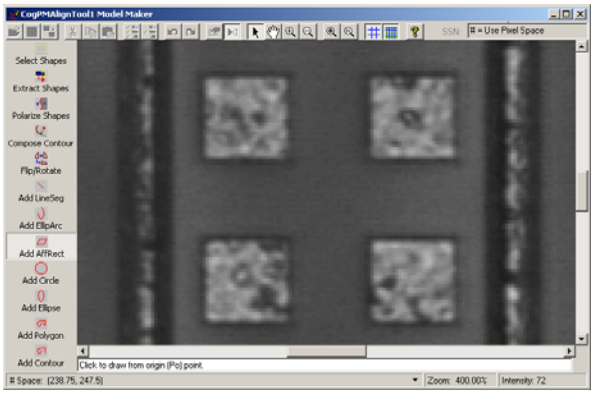
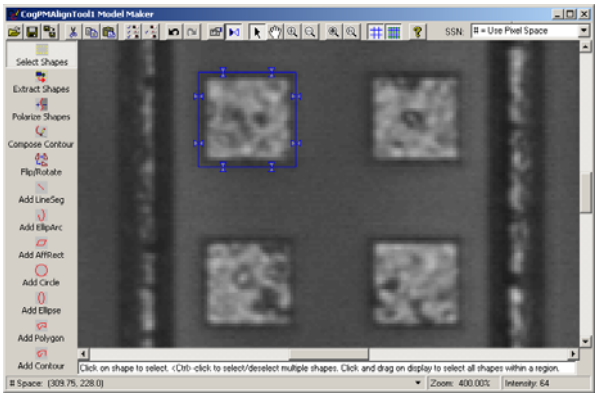
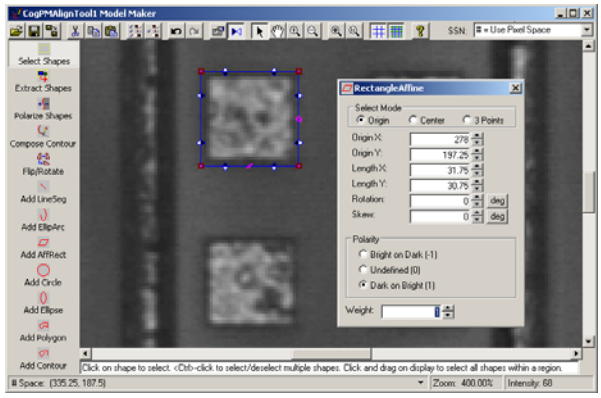
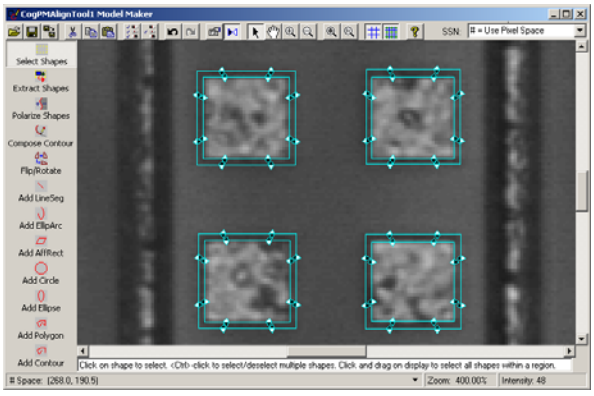
Shape Extraction is a mechanism that automatically creates VisionPro shapes based on the contours of an image. Model Maker includes a shape extraction tool that you can use to create shape model for PatMax.

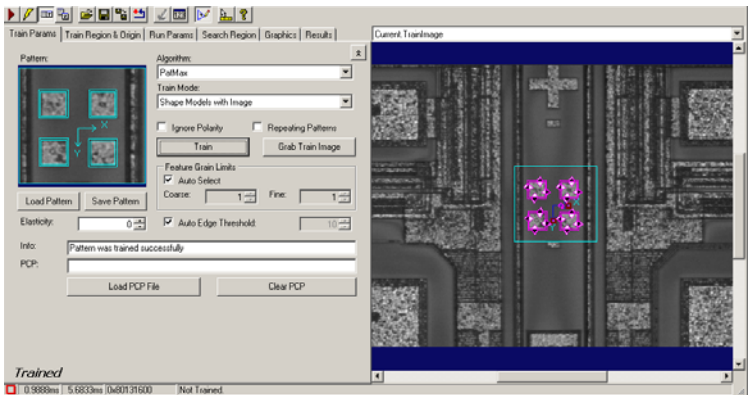
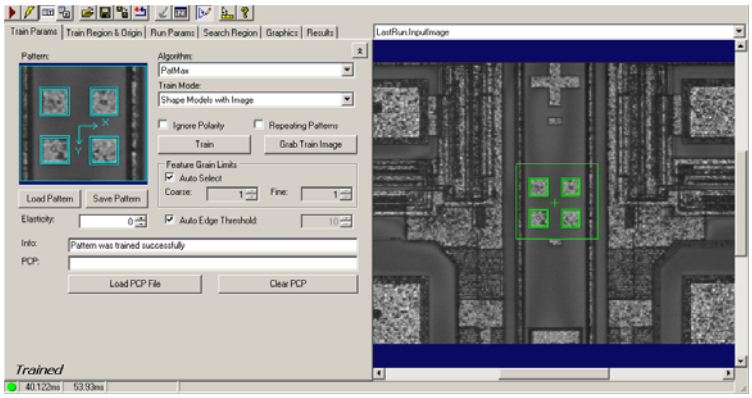
The model maker is a tool within the VisionPro Editor. It can be opened using the tool icon  .

You must have a training image and an appropriate training mode for the Model Maker button to be active.

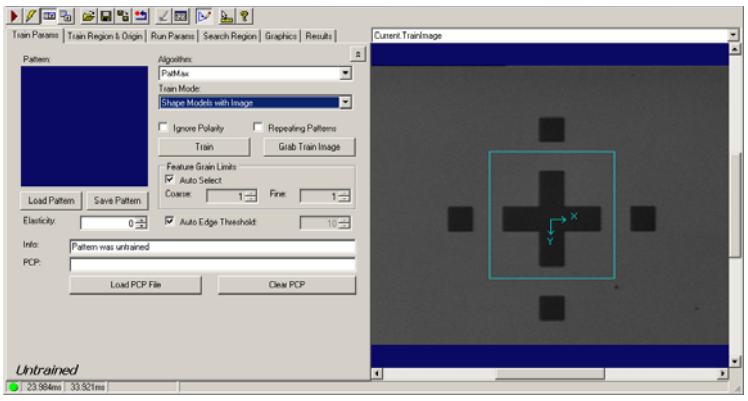
3.9.1. Method 1 - Pattern Creation

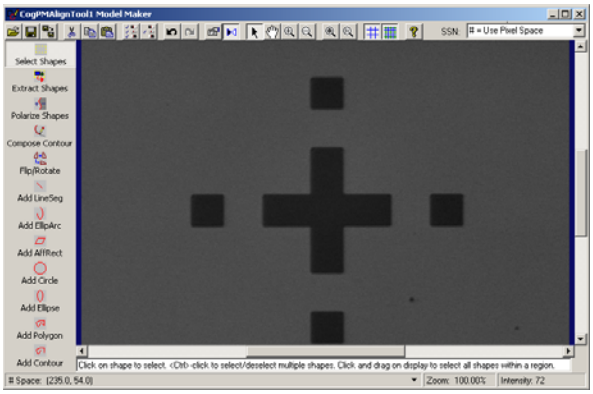
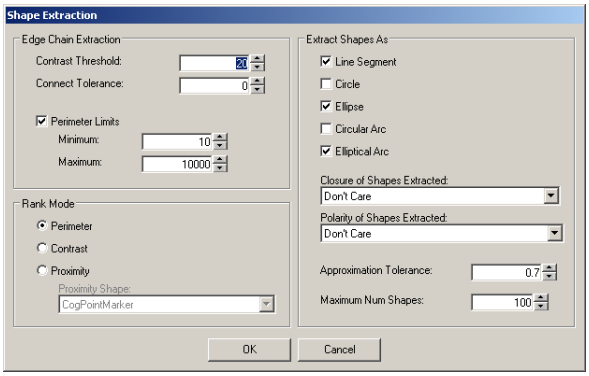
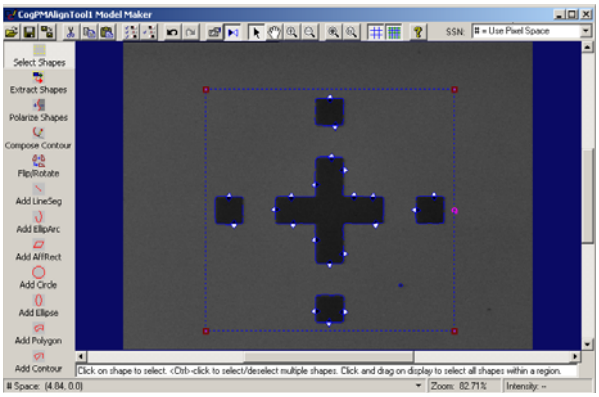
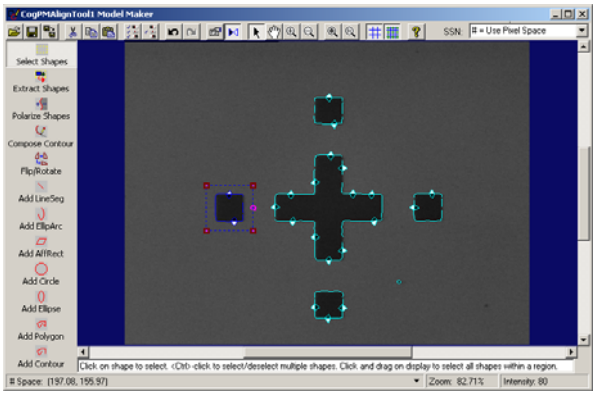
	• Load Wafer • Press <Grab Train Image> • Select "Current.TrainImage" • Select Train Mode • Shape Models with Image" • Start the Model Maker
	

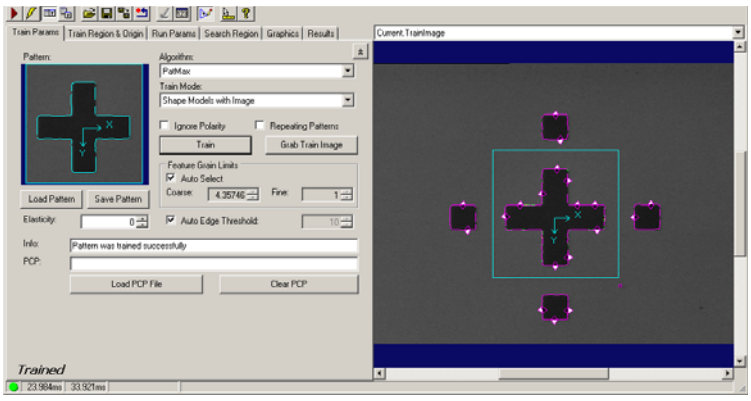
	• Zoom (right mouse button - context menu) • Press <Add AffRect>
	• Draw a rectangle **Note:** **There are many tools to edit the shapes according to your needs.**
	• Double click on the line • The polarity dialogue opens • Select the polarity
	• Add more rectangles (or other shapes) to complete the model

	• Change to the PMAlign Tab. • Press <Train>
	• Select "LastRun.InputImage" • Start the target search  • Return to the AL-Editor

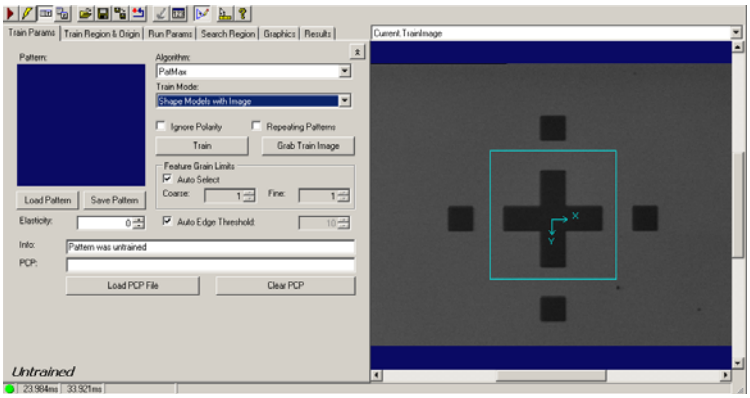
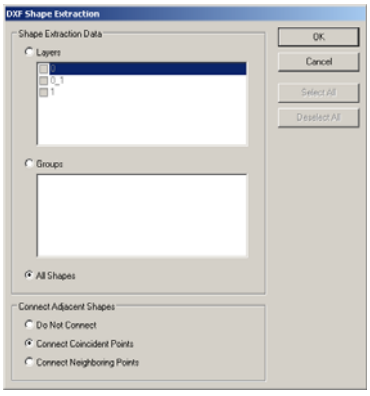
3.9.2. Method 2 - Pattern Extraction

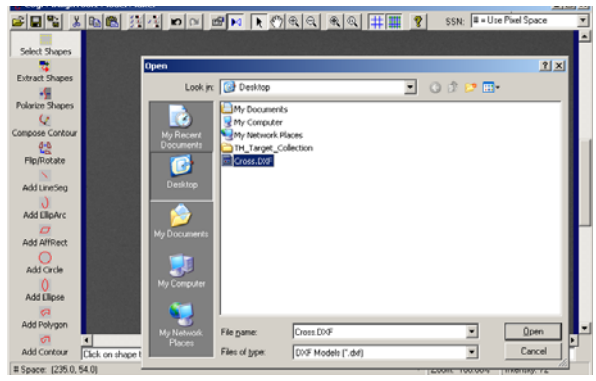
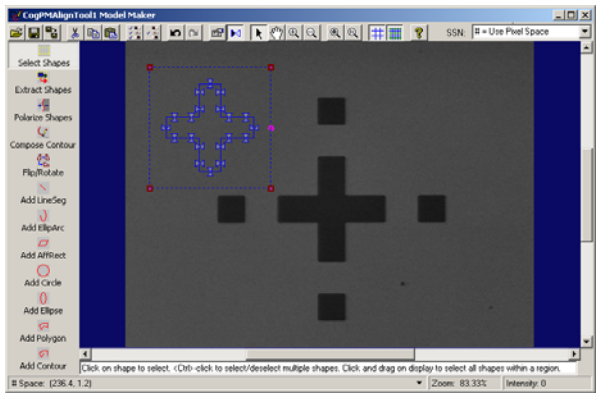
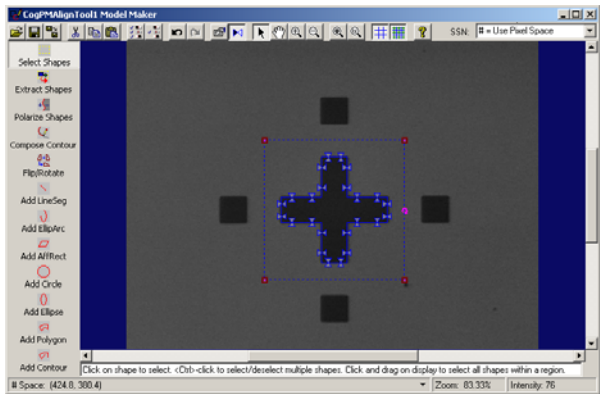
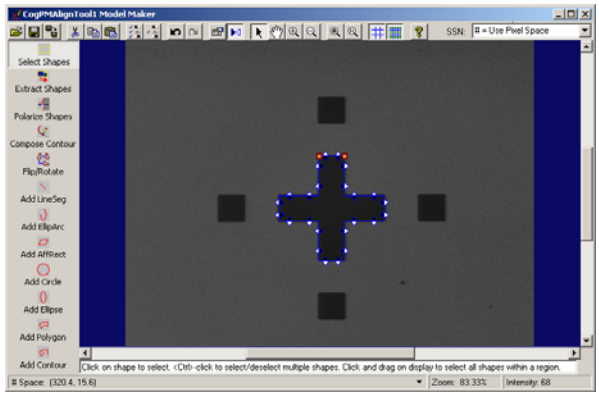
	• Load Wafer • Press <Grab Train Image> • Select "Current.TrainImage" • Select Train Mode • Shape Models with Image" • Start the Model Maker

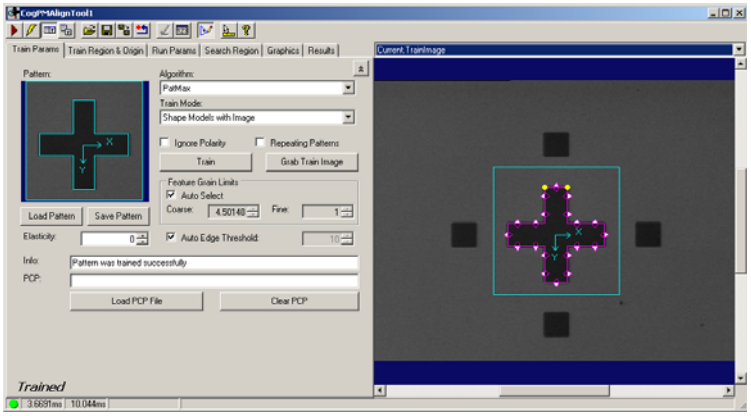
	• Press <Extract Shapes> • Zoom (right mouse button - context menu)
	• Press <OK>
	• The Model Maker proposes shapes now.
	• You can modify or delete them and add new shapes according to your needs.

	• Go to the PMAlign window • Press <Train> • Select "LastRun.InputImage" • Start the target search • Return to the AL Editor

3.9.3. Method 3 - Load CAD Data

	• Load Wafer • Press <Grab Train Image> • Select "Current.TrainImage" • Select Train Mode • Shape "Models with Image" • Start the Model Maker
	• Press Open  • Load the CAD model

	• Confirm the dialogue
	• The CAD shape is displayed
	• Select it, move it, make its size fit to the real image
	• Add polarities by double clicking on the lines and working with the dialogue that pops up.



- Go to the PMAlign window
- Press <Train”>
- Select “LastRun.InputImage”

- Start the target search 
- Return to the AL Editor

4. TARGET SEARCH

- Start the search with the default parameters.
- Do not run a full automatic alignment but start with a test search.
- You may have to decrease the „Accept threshold“ values initially if you do not find anything.
- Depending on the results of a Mistake Test you may have to further adjust the Accept Thresholds or even modify the model.
- The parameter "Score Using Clutter" must be set according to the criteria mentioned in 4.4.
- In most cases it is not necessary to modify the other search parameters.

4.1. Setting the Accept Thresholds

4.1.1. Machine Configuration

- We recommend using the AL-Editor for setting the thresholds.
- If a threshold is changed in AL-Editor, it has to be confirmed with <OK> **and** saved with <Save>. Then it is automatically assigned to VisionPro Editor.
- If a threshold is changed in VisionPro editor it has to be confirmed with <OK>. Then it is automatically assigned to AL-Editor.

Threshold	AL-Editor	VisionPro
Coarse Accept Threshold	• not available	• Accessible in Run Params Tab • Should be set to ON • Value 0.25 We recommend to set this threshold to the above settings by default. There is no need to change it.

Accept Threshold	• Accessible in PM Tool Parameters
	• Should be set to 0.75 by default
	
	• If necessary it may be customized for delicate targets.
	  • It should be high enough to reliably avoid mistakes
	  • It should be lower than the worst score of the proper target of all wafers
		• Accessible in Run Params Tab
		• Should be set to 0.75 by default

Table 4-1: Setting the Thresholds

4.1.2. Mistake Testing

- The Accept Threshold should be so high that mistakes can be reliably avoided. It must be above the highest score ever reached with a mistaken feature. That requires mistake tests on multiple wafers.
- The Accept Threshold must be so low that it is lower than the worst score of the proper targets of all wafers.

The mistake test can be performed in AL-Editor by pressing the button <Mistake Test>.

- Following parameters are set automatically:
  - Approx no. to find = 2
  - Coarse Accept Threshold =
    Accept threshold = 0

A test run is done automatically showing 2 instances as result. The data of the targets found is displayed in the Search Result window.

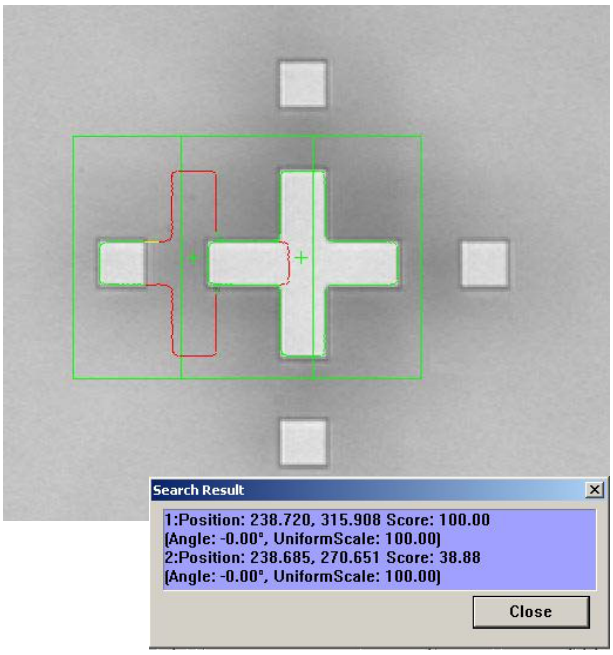


Fig.4-1: Mistake Test in AL-Editor

In Table 4-2 an Accept Threshold of 70 … 75% is feasible. This is a normal and typical situation.

Wafer	Score of Proper Target	Score of Mistaken Feature
1	100	40,2
2	99,3	44,3
3	78,1	66,0
4	85,0	54,1
5	84,4	39,6
6	98,3	56,0
7	90,1	49,6
8	81,1	41,2
Minimum	78,1	
Maximum		66,0

Table 4-2: Example of Mistake Test Results

But sometimes it is not possible because the lowest score of the proper target is smaller than the highest score of a mistaken feature. There are four solutions possible:

- Improve the model by adding additional features; adjust the search parameters (Score Using Clutter).
- If it is 100% sure that the proper target is always in the field of view, you can reduce the Accept Threshold as long as the target delivers always a higher score than any mistaken feature.
- If the target can be outside of the field of view, you must set the Accept Threshold so high that mistakes cannot happen. You have to accept that the machine stops from time to time. - This setting is a MUST, if WTS (wafer target search) in enabled.
- In many cases you can use the **Stop on Excess Runout** (see operator manual) as an additional safety feature. Depending on where a feature is mistaken, this method may be reliable enough.

Rules:

- **Always select the machine setting: 2nd Threshold = ON (Some machines do not have that)**
- **Search Threshold = 25% (always)**
- **Acceptance Threshold = 75% (typical)**
- **Properly setting the Accept Threshold requires tests with multiple wafers**
- **Accept < lowest score of the proper targets**
- **Accept > highest score of any mistaken feature**

4.2. Contrast Threshold

This is the threshold of the contrast that each edge elements has to pass. The contrast is the difference of the brightness of the pixels close to the edge measured in increments.

- It can be set in AL-Editor in PM Tool Parameters.
- It can be set in VisionPro Editor in Run Params Tab.

Contrast:

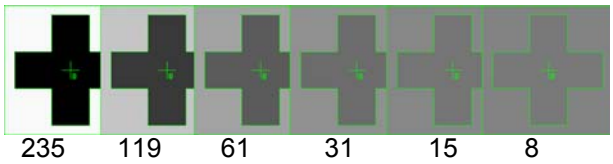


Fig.4-2: Contrast Examples

In general the default value of 10 has proven to be working well. Only when you have images with a very low contrast, you may set it to 2 or 1.

Rule:

- **Contrast Threshold = 10 (= Default)**
- **Very low contrast image: Contrast Threshold = 1**

4.3. Edge Threshold

The PMAlign tool uses a default edge threshold value to detect the edges within the patterns you are trying to train and locate in your images. In patterns where the contrast between pattern features can be low, the PMAlign tool can fail to train or locate them as it executes. If necessary you can disable the default value and specify your own minimum grey value between edges.

- It can be set in AL-Editor in PM Pattern Parameters.
- It can be set in VisionPro Editor in Run Params Tab.

If set to „Autoselect“ a fixed algorithm is used depending on the used grain limits and the image. You can influence the visability of edges within the model by changing the edge threshold (see Table 4-3).

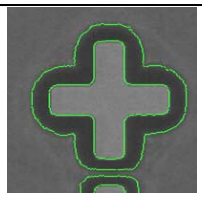
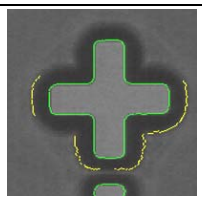
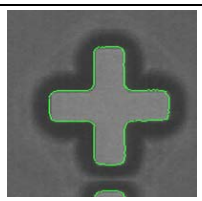
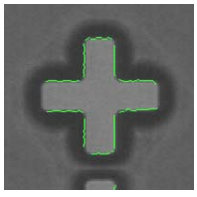
Edge Threshold	Model
Auto	
20	
30	
55	

Table 4-3: Influence of Edge Threshold

Rule: Auto Edge Threshold = ON

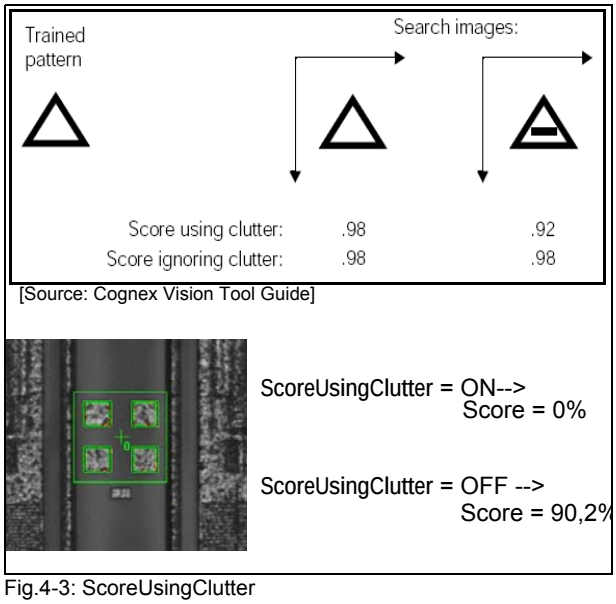
4.4. Score Using Clutter

The Score reflects the quality of the match between model and target. Roughly, one can divide the number of well matching (appearing in green or yellow) elements by the total number of edge elements.
A high score is a perfect match.

The Clutter (mess, noise, chaos, confusion, disorder, disturbance, muddle) is defined by Cognex in the Vision Tool Guide as:

- Features of an object that are present in the search image but not in the training image: extraneous features

The clutter can be taken into account when scoring (ScoreUsingClutter ON) or not (ScoreUsingClutter OFF):



[Source: Cognex Vision Tool Guide]

Fig.4-3: ScoreUsingClutter

- It can be set in AL-Editor in PM Tool Parameters.
- It can be set in VisionPro Editor in Run Params Tab.

Rules:

- **Score Using Clutter = ON (default)**
- **Score Using Clutter = OFF (noisy images, low contrast, granular target or background, masking, DirectAlign, Enhanced AutoAL)**

4.5. Degrees of Freedom (DOF)

For each of the possible degrees of freedom other than location you must either specify a nominal value, or a range of acceptable values. PatMax only searches within the combination of nominal and ranges that you specify.
In general, you should enable a degree of freedom and specify a zone if you expect patterns to vary in the degree of freedom or if you need to measure the degree of freedom.

- The degrees of freedom can be set only in VisionPro Editor Run Params Tab.

- The DOF are set to fixed values if the arrows point in direction left (Nominal).
  The default settings are 0-1-1-1.

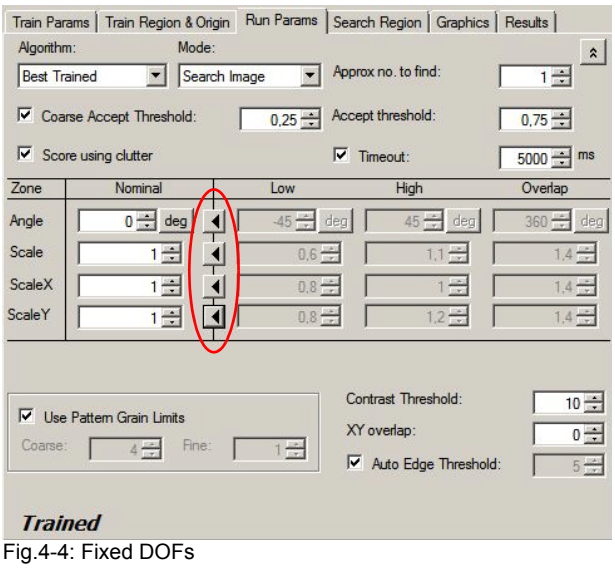
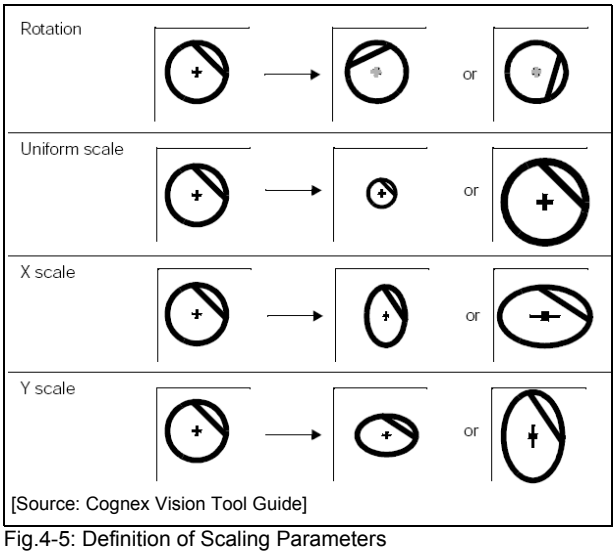


Fig.4-4: Fixed DOFs

Mathematically a Degree of Freedom (DOF) is a linear transformation, practically you can enlarge or shrink or rotate the model. Also you can make the model flexible so that it adjusts itself automatically to the target. You can set limits to this flexibility (but they do not work accurately).
The transformation parameters are magnification (1x=100x) and decimal degrees, you can combine X and Y (uniform scale) or separate X and Y (X scale, Y scale)

.



[Source: Cognex Vision Tool Guide]

Fig.4-5: Definition of Scaling Parameters

- The setting of flexible DOF is done if the arrows point in direction right (Low, High, Overlap)
- Do not change Overlap.

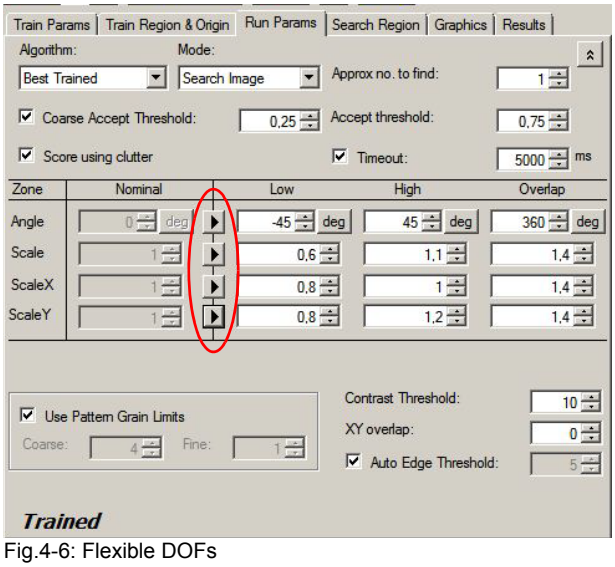
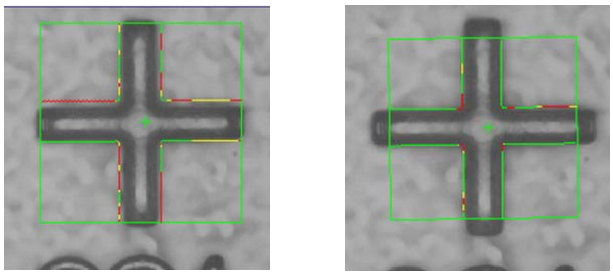


Fig.4-6: Flexible DOFs

Fixed DOF values are usually no problem. Often you use flexible values to determine the transformation value and then you enter those as fixed, nominal values. An example is below, where the synthetic image did not fit well (score 48%), the flexible DOF mode was used to determine the scale (86%) and then, this scale was fixed as nominal value, and score was acceptable (81%).



Uniform Scale =100%
Score = 48%

Uniform Scale =86%
Score = 81%

Fig.4-7: Changing the Uniform Scale Parameter

Flexible DOF cannot be recommended and is normally not needed. It increases the risk of mistakes (Fig.4-8). The time for calculating the match increase dramatically.
Fig.4-8 shows how flexible DOF can cause a mistake. We set the DOF to be flexible within a large range. Once the large cross was no more completely in the field of view, PatMax found a match and mistake as shown.

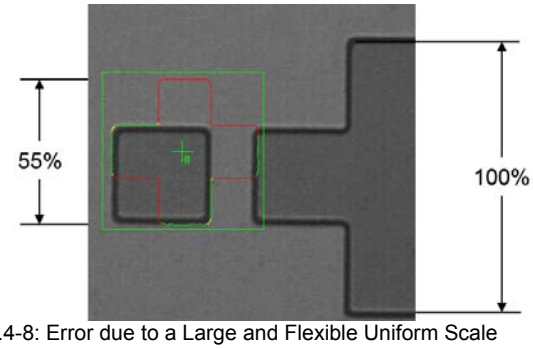


Fig.4-8: Error due to a Large and Flexible Uniform Scale Parameter

Exception:
There are a very few applications like wet etch, were you may be forced to use DOF parameters because the targets vary in size. - For "line alignment" you must set the angular DOF to ±3° because it is used to measure the rotational error of the wafer.

Note:

Flexible Uniform Scale, X Scale and Y Scale parameters do not work well in parallel. Also the calculation time is endless. It is better to allow only one of them to be flexible.

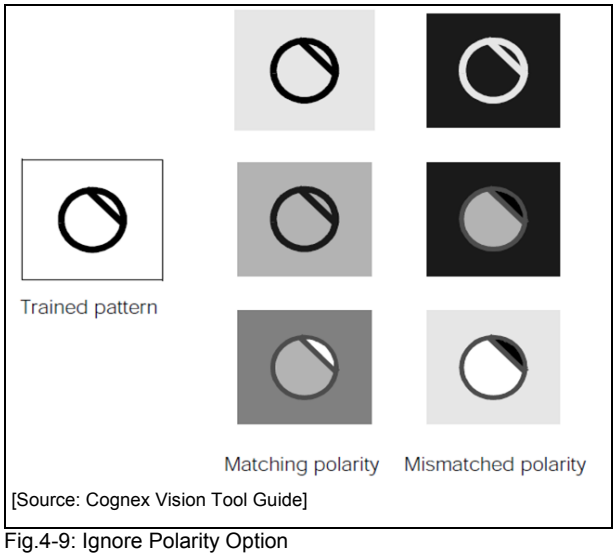
Rule:

- **Default DOF settings = Nominal (arrows left) (0-1-1-1)**

4.6. Ignore Polarity

Edges have a polarity, i.e. the transition from left to right is bright to dark. An inverted polarity would then be from dark to bright.

- Ignore Polarity can only be set in VisionPro Editor Train Params Tab.



[Source: Cognex Vision Tool Guide]

Fig.4-9: Ignore Polarity Option

- With IgnorePolarity being OFF, the polarity is respected and inverse edge elements are either ignored (ScoreUsingClutter off) or scored negatively (ScoreUsingClutter on).
-
- With IgnorePolarity set to ON, the polarity of all edge elements is ignored and they are scored positively, if they are in the proper position.

Rule:

- **Ignore Polarity should be switched OFF; so far we have not seen an exception.**

4.7. Elasticity

The elasticity is kind of a counterpart to the DOF parameters. While the DOF allows linear transformation, the Elasticity enables a non-linear transformation. The dimension is pixels.

- The Eleasticity can only be set in VisionPro Editor Train Params Tab.

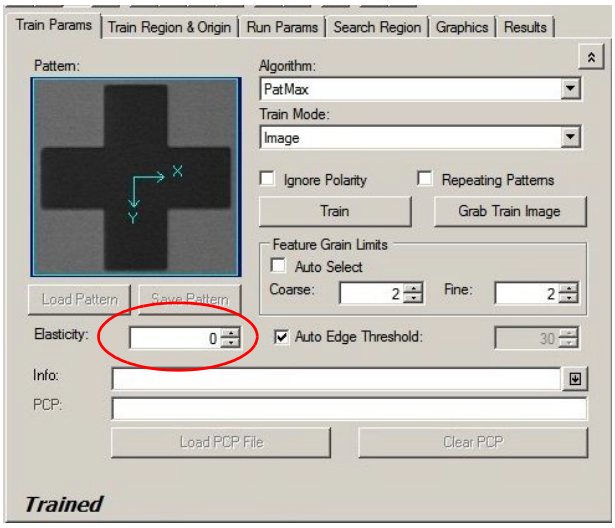


Fig.4-10: Elasticity Setting

It does not increase the search time. We have the serious impression that it works only during the fine search.
Elasticity has no impact on accuracy, but the risk of mistakes is increased, the score of mistaken features may become higher. Up to now, we have not seen a positive impact of the Elasticity and recommend setting it to zero always.

Rule:

- **The default value for Elasticity is zero (0).**

4.8. Timeout

In some cases like flexible DOF the calculation times may reach minutes. It is not possible to interrupt that process, there is no stop button. Therefore we recommend setting a timeout of 5 to 10 sec (5000 - 10000 ms) in the Run Params Tab of the VisionPro Editor.

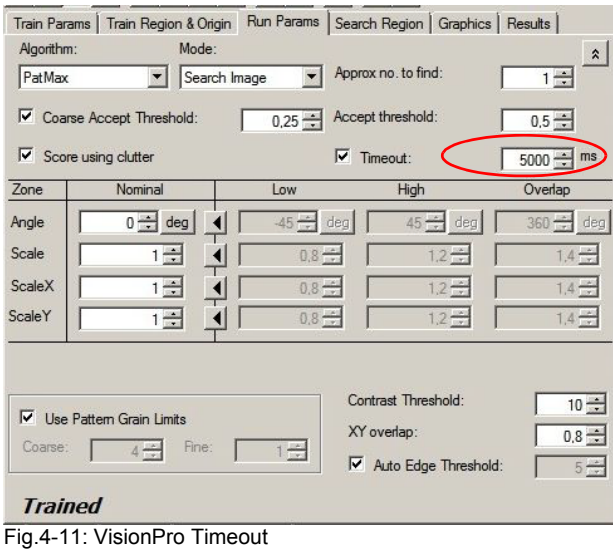


Fig.4-11: VisionPro Timeout

Settings:
Timeout: Checkbox must be ON: 5000 - 10000 ms
No Timeout: Checkbox is OFF

4 TARGET SEARCH

5. TARGET TESTING

Testing the model, search the targets, producing the first wafers and optimizing the alignment cannot be clearly separated from each other. During the iterative improvement process you will often repeat test searches, pattern and parameter adjustment, make mistake tests and analyze alignment errors.

- Test search (5.1)
- Visual assessment of models and match codes (5.2)
- Setting the Accept: Proper machine configuration (4.1.1)
- Setting the Accept: Mistake test (4.1.2)
- Testing with many wafers = production of the first batches (5.3)
- (Test run with images from the image log 5.4)
- Adjustment of the search parameters (2.6)
- Failure analysis (6)

5.1. Test Search

The first search right after training should result in scores close to 100%. If it is less, you can assume a problem somewhere.
It is no problem to reduce the Accept Threshold initially, but in production higher values like 75% are generally better.

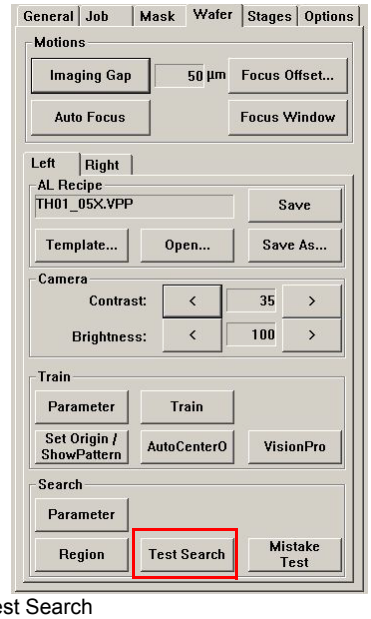


Fig.5-1: Test Search

Note:
If you press  in VisionPro or "Test Search" in the AL-Editor a new image is acquired from the camera. This is normally no problem, but you may get a slightly different score value. Also the position may change by a few 0.1µm depending on time, drift and vibrations.
In VisionPro the target is searched within the Current.Input Image.

Pressing <Live> aquires new images from the camera. If loaded a graphics file the button <Live> does not effect anything.

In VisionPro the score is displayed in the Result Tab,

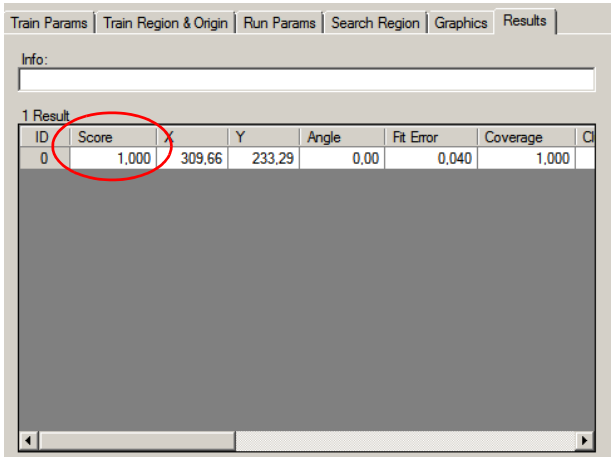


Fig.5-2: Results Display in Result Tab of VisionPro

in the AL-Editor a pop up window displays the „Score".

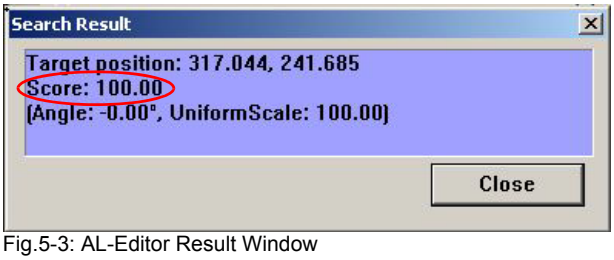
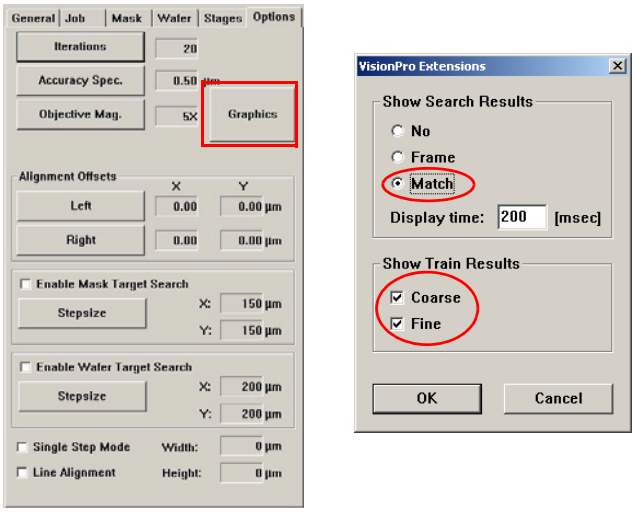


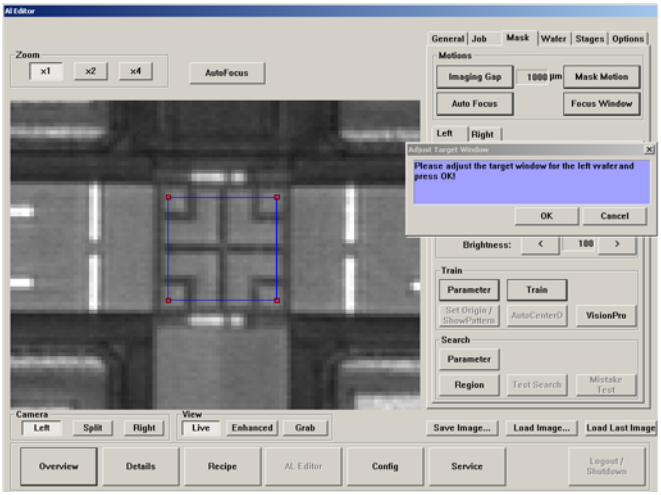
Fig.5-3: AL-Editor Result Window

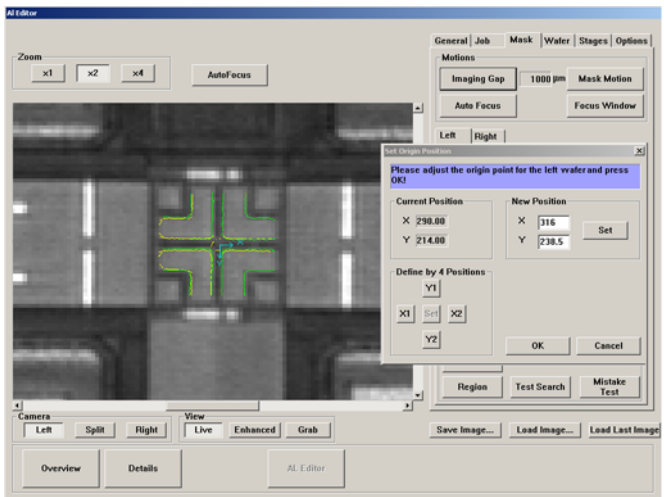
5.2. Visual Assessment of Model /Match Code

5.2.1. In AL-Editor

<table>
<tr>
<td>
</td>
<td>• To display the results of coarse and fine model go to AL-Editor Options Tab.
• Press <Graphics>
• In the Sub window „VisionPro Extensions“ set:

  • <Match> in „Show Search Results“
  • <Coarse> and <Fine> in „Show Train Results“

• Confirm with <OK<</td>
</tr>
<tr>
<td></td>
<td>• Start Training and press <OK> to confirm.

• Then press the button <Set Origin/Show-Pattern.</td>
</tr>
<tr>
<td></td>
<td>• The sub window for Origin Setting pops up and you will get a graphical feedback of both coarse (yellow) and fine (green) model.

• Assess:

  • Do the edges of the coarse and fine model match the target?
  (To switch from the coarse model to the fine one and back use the control boxes, see adjacent figure)
  • Are both models (almost) identical?
  • Are the models "good"?</td>
</tr>
</table>

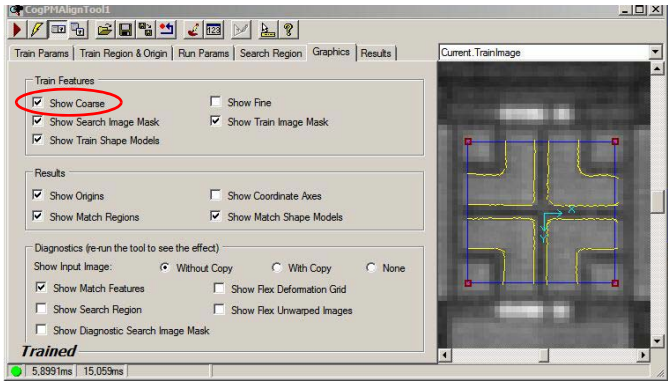


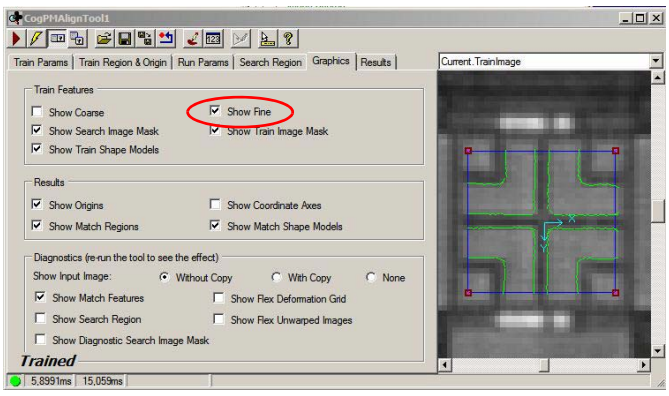
Now you can perform a test search.

- Press the button test search in the wafer tab.
- View the result:
  - Do the edges of the match code fit well to the target found?
  - Does the match consist mainly of green and yellow edge elements?
  - Is the score high (> 90%)?

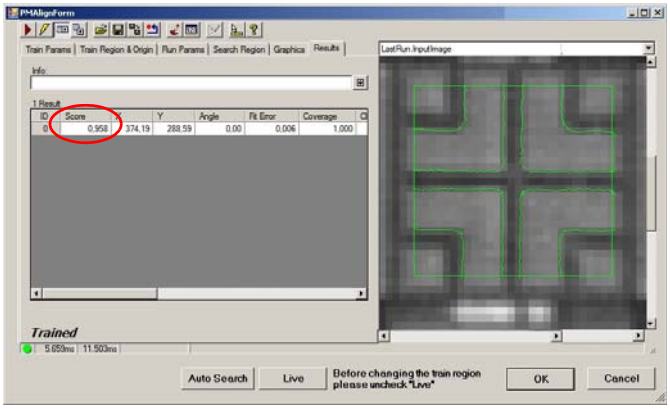
Repeat the test search on other targets, other dies, other wafers, on the other side.

5.2.2. In VisionPro Editor



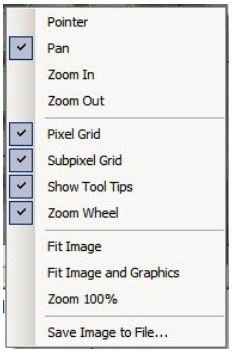


- Go to VisionPro, Graphics Tab. Here you can switch between display of coarse and fine model.
- View the Current.TrainImage.
- Assess:
  - Do the edges of the coarse and fine model match the target?
    (To switch from the coarse model to the fine one and back use the control boxes, see adjacent figure)
  - Are both models (almost) identical?
  - Are the models "good"?



- Press  in the VisionPro Editor.
- Got to Result Tab
- View LastRun.InputImage
- Assess:
  - Do the edges of the match code fit well to the target found?
  - Does the match consist mainly of green and yellow edge elements?
  - Is the score high (> 90%)?

Note:
The visual assessment is easier if you use zoom and pan which appears if you click in the image with the right mouse button



Repeat the test search on other targets, other dies, other wafers, on the other side.

5.3. Test Run with Wafer and AL-Check, Production

Once the target delivers acceptable scores and the Accept is defined, one can start producing wafers. It is recommended to set the AL-Check to ON for a while and to monitor the production, especially the correct alignment of wafer and mask in AL-Check and the scores.
In AL-Check you are supported by the possibility to play with the focus and image grabbing tool. For more details, see the operator manual.

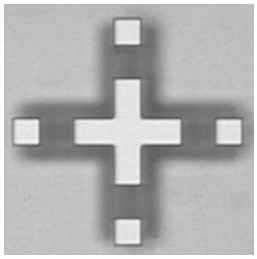
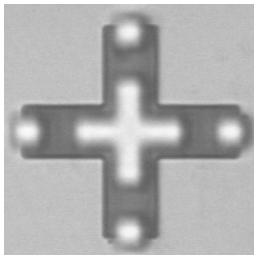
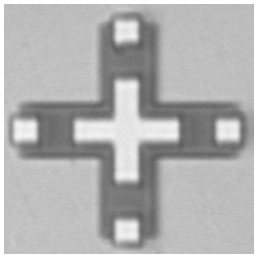
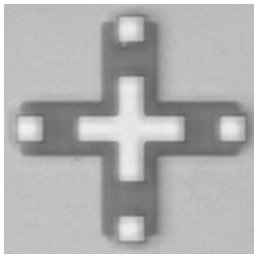
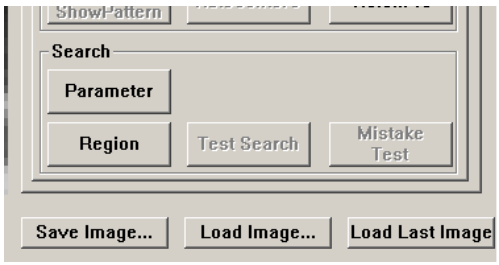
View	Example
Mask View	
Wafer View	
Focus between Mask and Wafer	
Stored Wafer Image over Live Mask Image	

Table 5-1: Example Test Run of AutoAlign

5.4. Test Run with Images out of Image Log

You can load images and test the models with them. You may read the according section in the manual for the "Enhanced AutoAL" mode.
An advantage of the image log is that you do not need to reload and rerun all wafers again after you have modified model and parameters.

5.4.1. Operation

	• Open the AL-Editor • Press <Load image...> to load any image. or • Press<Load Last Image> to load the last image of the image log file.
	• Analyze • Load the next image …

5.4.1.1 Selecting Images

- The image log is split in directories, one for each batch.
- The name is defined as Date_Time_LotID
- The file names are defined as follows:

„Date_Time_Milliseconds_LotID_WaferID_MachineActivity_Target_Iteration_Repetition_000_000.bmp“

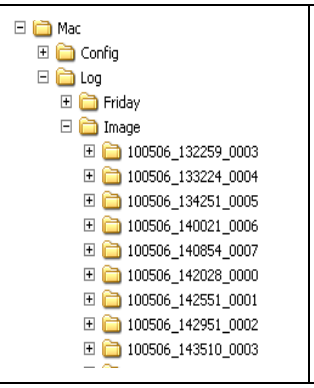
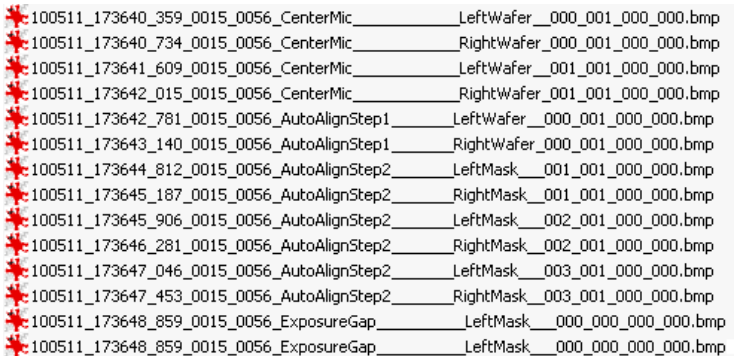
	

Table 5-2: Image Log

6. ALIGNMENT FAILURE ANALYSIS

6.1. Types of Errors and Recovery

Error	Symptoms	Error Handling
Target not found	Error message "Target not found"	**Analysis in VisionPro**: Better model Better parameters
Alignment routine stops	Error message "number of iterations exceeded"	Your tolerance (allowed alignment accuracy) is too tight. You may have contact between mask and wafer - alignment gap too small.
Alignment inaccurate - Up to 5 microns off	During the visual AL check or later during the overlay measurement you detect a misalignment typically well below 5 µm.	It makes sense to check the match between model and target, but mostly the problem and solution are mechanical, optical or thermal. Curing that is not part of this paper here.
Alignment inaccurate by much more than a few µm - Due to a mistake	You see a large misalignment in AL check or the runout is exceeded and stops the machine. Typically the error is large i.e. above 5 µm.	Mistake Test in AL-Editor **Analysis in VisionPro:** Better model Better parameters
Runout exceeded	Error message "Runout tolerance exceeded". Typical real runout values are below 5 µm	Apparent Runout: Bad origins - can be fixed with AutoCenterOrigin, with Set Origin or in OmiWin. Optical problem: Microscope axes are not vertical Focus problem: Focus axis not vertical; image blurred (focus badly trained) Real runout: Mismatch between mask and wafer layout. Real runout: Thermal problem - let the mask cool down. Real runout: Thermal problem - change chuck chiller temperature

Table 6-1: Types of Errors and Recovery

Error recovery will always start the same way:

- Quit the error message,
- open the AL-Editor, go to the proper page (e.g. wafer, left) reduce the Accept Threshold and perform a test search.

6.2. Error Messages - No Automatic Motions

In all mask aligners the mask moves back from the clear field position if the wafer target is not found. This avoids pressing the "Move Teach" button. But the self-evident conclusion is wrong, that the wafer was not found because the mask was present. So this observation may lead you on the wrong trace.

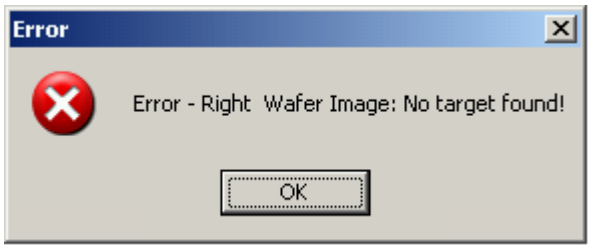


Fig.6-1: Reading Error Messages

In some machines there is an AL recipe parameter called "No Automatic Motions" (AL-Editor, page "Options"), which skips the moving back of the mask.

Note:

This is a temporary parameter; it is not saved during power off.

Rules:

Read the error message:

- **Did the error happen when searching Mask or Wafer, Left or Right side?**

Wafer Not Found:

- **has the mask moved back?**

6.3. Using the AL-Editor for Failure Analysis

The AL-Editor is a powerful tool for failure analysis.

6.3.1. How it works

- Cancel the error message
- Start the AL-Editor, select mask/wafer and left/right properly
- Reduce the Accept Threshold
- **Perform a test search:**
  - Is the score above the Accept Threshold of the fine search (acceptance threshold)? Does the match code fit well?
- **Press "Show Pattern":**
  - Are both models good? (you may have to change back and forth between fins and coarse model, see options page)
- **If the wrong feature was found, make the mistake test:**
  - Is the model unique and good?
  - Is the difference in score between proper and wrong target high enough?
  - If not, modify model and search parameters
- **If the target was not found:**
  - Is the proper target really in the field of view?
  - Is the search area large enough (AL-Editor "Search Window")?
  - Set the Accept Threshold to zero, search again. (Don't forget to set the Accept Threshold back later.)
  - Reduce the Contrast Threshold
  - Enable some flexibility (DOF Uniform Scale, Elasticity) - and set it back later
  - Load another model, retrain the model

6.4. Last Image

A weakness of the above failure analysis method is that the exact situation where the target was not found is not fully reproducible. For example during DirectAlign and Enhanced AutoAL the actual gap and focus may be different from that used by the AL-Editor. Or mechanical, electrical and optical glitches that caused an AL error are gone when analyzing.

Therefore you can load the exact last image that was sent to the pattern recognition and that caused the AL error:

- Go to AL-Editor
- Press the button <Load last Image...)

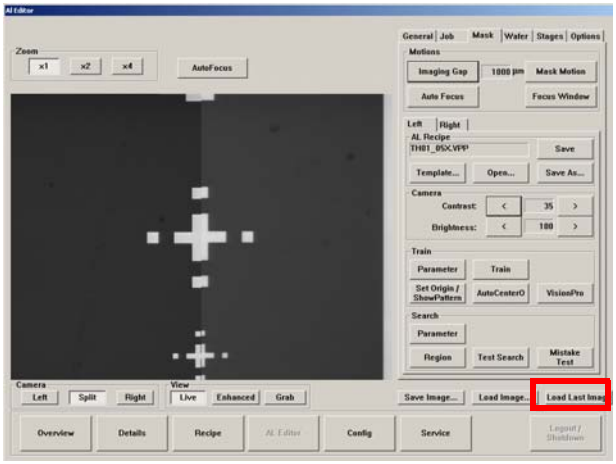


Fig.6-2: Load Last Image in AL-Editor

Rule:

If you have AL errors during DirectAlign or Enhanced AutoAL or if you feel you have some dynamic phenomena: Load Last Image, look at it: Does it look strange? Make a test search with the last image.

6.5. Single Step

Sometimes you may have the phenomenon that your alignment makes "strange" motions. This is a sign either for a wrong calibration or a mistake during alignment. Wrong calibration parameters can be created if you encounter mistakes during the calibration procedure.
The single step mode (enable it in AL editor, page options; not all machines) combined with the split field and non-split field camera display can be a good tool to detect such mistakes. Also a mistake test may give you hints.

Note:

If you observe strange motions and you do not find the reason, you should consider redoing the calibration and check what happens. You can force the machine to execute a calibration by pressing "Save Teach" and "Autoalign".

6 ALIGNMENT FAILURE ANALYSIS

7. IMPROVING MODEL AND SEARCH - SUMMARY

7.1. Rules to Create a Good Model

Rule/ Task	To Do
Patience • **Training is not completed quickly** • **Proper model and parameters are created in an iterative improvement process**	• Training • Search • Test many wafers • AL error analysis • Repeated improvement steps
Illumination	• Compare incident and ring light, broad band (Halogen) and LED illumination.There should be no completely white areas in the target. If necessary reduce the light intensity. • Increase the contrast only if you do not see anything. The pattern recognition is better than men; a high contrast may be counterproductive. • Train the mask without wafer under it if possible.
Use AL-Editor for standard applications	
Use the default parameters	• Make sure that you really have the default values including Contrast and Brightness

Selecting targets that are well suited for training	• The target should fulfill the rules for a good model (below)
	• Look for the "best looking" target,
	  • compare the left and right one,
	  • move the microscope to the next die
	  • or load another wafer

Train a „good model“	You better invest your time on a good model than optimized search parameters. • The target - or at least the model - should have a simple shape (box, frame, circle, cross, diamond) • The size should be between 50 and 120 µm (@ 480 µm Field of View) • It has only those edge elements that are common to all wafers • It has no random features • It has only true, but no apparent edges • It consists of long, steady, uninterrupted lines, and no tiny details • It is unique - difference in score 30% - it cannot be mistaken

7 IMPROVING MODEL AND SEARCH - SUMMARY

Rule/ Task	To Do
Modify the parameters in the VisionPro Editor, if no good model was created	• Coarse and fine model should be equal or very similar • Both model should match the targets well • Coarse and fine grain limits (TrainParams) of 2.0 are a good start (AutoSelect OFF) • Do not touch the grain limits in RunParams (Use Pattern Grain Limits = ON) • Increase the grain limits, if the image is noisy, granular or has low contrast • Decrease the grain limits if the target consist of thin lines or has double edges • Reduce the contrast threshold if you have low contrast (4.2)
If you do not get a good model with above means	• Set the rubber band rectangle that is used during training, closer to the target (2 - 3 pixel distance) • Defocus slightly (later for the search you focus well again) (3.5) • Cover unwelcome features with a mask during training (3.4)
Synthetic training, if no wafer "looks good" (3.6)	• Be aware that synthetic modeling is difficult • You create an idealized image (pixel graphics) of the target, which you load and train. Then you switch back to the camera and search in the real world. • It is easier to paint the synthetic target over the screenshot of a real target • You may need flexible DOF to adjust the model to the real target. Copy the scale values found and enter them as fixed, nominal values. - If your model consists of lines (instead of areas), i.e. if the model will have double edge, then you may have to play with the line width. - Train crosses without the end of their arms. (4.5)

Table 7-1: Rules to Create a Good Model

7.2. Rules - Summary

Rule/ Task	To Do
Visual Assessment (5.2)	• Look at the Coarse Model, the Fine Model, and the Match Code • Do both models and match fit well? Does the model fulfill the rules for a "Good Model"?
Test Search	• Is the proper target in the field of view? • Is the search area large enough?
Test with many wafers, production (with AL Check ON) is the best test (5.3)	
Accept Threshold (4.1)	• Reduce the Accept Threshold carefully if mistakes can happen • The Accept Threshold must be smaller than the lowest score of the proper target • The Accept Threshold must be larger than the highest score of any mistaken feature • Switch WTS of if not really needed. • 2nd Threshold = ON • Threshold for coarse search (Search Threshold) = 25% • Typical threshold for fine search (Accept Threshold) = 75%
ScoreUsingClutter	• Is ON by default. Is off, if you have noisy images, low contrast, granular targets or background, or if you have used masking, DirectAlign or Enhanced AutoAL
Uniqueness - Mistakes (3.7)	• Make the mistake test • Improve the uniqueness by combining multiple features, reducing the search area, setting the parameter ScoreUsingClutter = ON (4.4)
Modify the PMAlignTool parameters in VisionPro if the test search is not good or successful	• Reduce the Accept Threshold carefully - sometimes the Accept Threshold for the coarse search must be smaller than for the fine search (in that case check for equal grain limits and no elasticity) (4.1) • Try to switch the ScoreUsingClutter off (4.4) • Play with DOF, not with Elasticity (4.5, 4.7), set IgnorePolarity = Off (4.6) • Low contrast images: Reduce Contrast Threshold (4.2)
AL Errors	• VisionPro is the analysis tool • Do you have selected properly mask / wafer and the side left / right? • Reduce the Accept Threshold if you do not find anything • Was the name string deleted in the "Image" object • ScoreUsingClutter = OFF, if the image is noisy, has low contrast or grain, if masking, DirectAlign or Enhanced AutoAL is used (4.4)
Modify the model and parameters if the mistake test shows the risk of mistakes	• Other shape or size of the target used for training, add further features • Switch ScoreUsingClutter on, switch all DOF, IgnorePolarity and Elasticity OFF

Table 7-2: Rules for Test Search, Search Parameters and AL Error Analysis

7 IMPROVING MODEL AND SEARCH - SUMMARY

8. LITERATURE

When installing VisionPro the following files are saved to the hard disk:

- Vision Tool Guide (theoretical background): chapter on PatMax
- PMAlignTool Reference (operation):

Both are accessible: Start / Programs / Cognex VisionPro / VisionPro Documentation.

There is also the VisionPro Help System available:

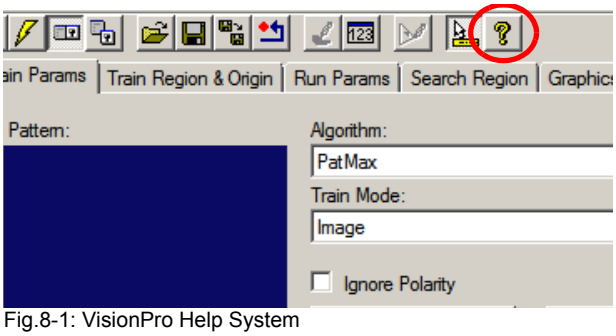


Fig.8-1: VisionPro Help System

- Clicking the icon  , „Tool Tips“ will be activated.
  As soon as you point on a certain feature within the PMAlignTool it will be explained within one line. (see Fig. 8-2)

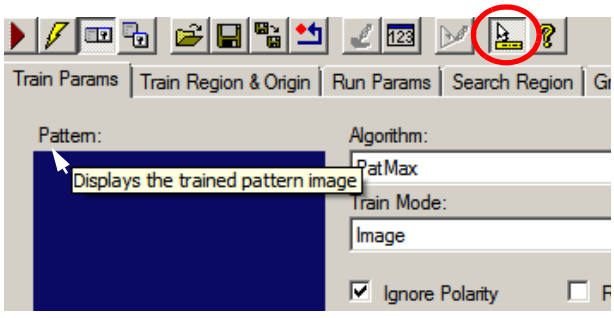
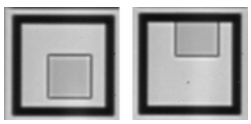
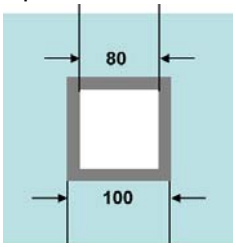


Fig.8-2: Tool Tips

7 LITERATURE

9. TARGET DESIGN RECOMMENDATIONS

9.1. Design Recommendations for Mask and Wafer

Parameter	Instructions
Size: 50µm ....125µm (Camera 640x480 pixel, 1µm/pixel magnification)	• Small target deliver not enough information and the accuracy drops • Large targets may be larger than the field of view depending on the prealignment of first layer error • 125 µm is better than 50 µm, because the percentage fraction of a damage (missing corner...) is smaller
Simple shapes: Square „Box“, frame, diamond, hexagon, circle, ring 	• Simple shapes are affected by the process less than tiny features • The process induced size and shape change of a simple shape can be compensated with the DOF Uniform Scale parameter.
Point symmetric	• The function AutoCenterOrigin puts the origin in the center of the target much more accurate than the operator can do it. This increases the accuracy but requires a symmetry with respect to the center point.
No small features and details Steady, uninterrupted edges	• This reduces the impact of focus changes
Good contrast, no noise, no grains	
Unique, unmistakable	
Avoid these double edges	
Example „Frame in Frame“ 	• Should be not overlapping (occluding) • The smaller frame has a thin double edge requiring Grain Limits of 1.0/1.0 • Well suited for DirectAlign • Not suited for visual control
Example „Box in Box“ 	• Well suited for DirectAlign if there is at least 10µm separation between wafer and mask • Very simple shape - stands process variation well • For visual control we recommend a second target pair with 5µm separation

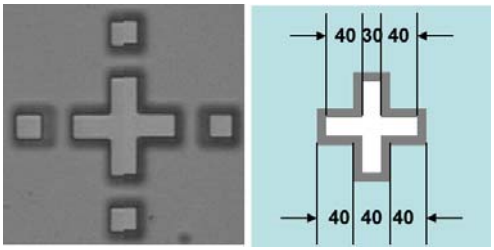
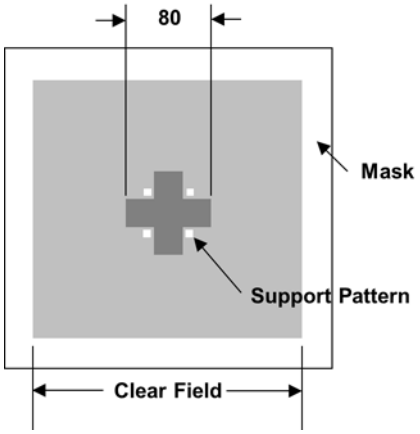
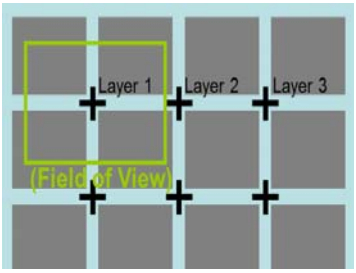
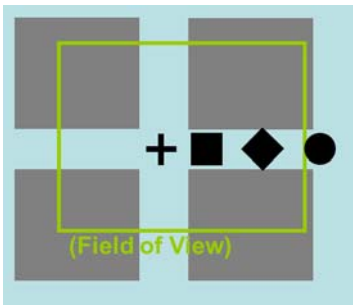
Parameter	Instructions
Example „Cross in Cross“ 	• Good for visual control if separation from wafer edge to mask edge is ca, 5 µm • Suited for normal alignment, but not for DirectAlign • Has 12 corners, while a square has 4. Therefore the impact of process variations is larger.
Example „Cross in Box“ 	• Auxiliary features • For visual alignment check only • Can be masked during training • Can be neglected during the search if it does not cover more than ca. 10% • Clear field inside of the mask target
Targets for multiple Layers (1) 	• Identical targets with a large separation in between • Here you risk mistakes if the neighboring target comes into the field of view • Therefore this solution works reliable only if the separation is much larger than the field of view
Targets for multiple Layers (2) 	• Different target shapes and sizes can be close together if they can be mistaken • Make the mistake test

Table 9-1: Target Design Recommendations

SUSS MicroTec - First Line Contacts

	Service	Parts / Logistics	Technical Support
	**** Request for service engineer*** **** Quotation for service visit***	**** Quotation for spare parts*** **** Spare parts order*** **** Billing***	**** Technical advice during tool down*** **** Parts identification*** **** point of contact for application support***
Mask Aligner Customer Care Center SMTL Garching	**alignerservice.de@suss.com** Phone: +49 89 32007 - 281 or 304 Fax: +49 89 32007 - 245	**alignerparts.de@suss.com** Phone: +49 89 32007 - 285 or 214 Fax: +49 89 32007 - 245	**alignerservice.de@suss.com** Mario Franziszi, Phone: +49 89 32007 - 211 Fax: +49 89 32007 - 245
Bonder/Coater/Developer Customer Care Center SMTL Sternenfels	**bonderservice.de@suss.com** **coaterservice.de@suss.com** Phone: +49 7045 41 - 982 Fax: +49 7045 41 - 605	**bonderparts.de@suss.com** **coaterparts.de@suss.com** Phone: +49 7045 41 - 232 or 259 Fax: +49 7045 41 - 239	**bonderservice.de@suss.com** Tobias Gerber, Phone: +49 7045 41 – 985 Hotline, Phone: +49 7045 41 – 983 Fax: +49 7045 41 – 605 **coaterservice.de@suss.com** Georg Kurz, Phone: +49 7045 41 - 736 Hotline Phone: +49 7045 41 - 697 Fax: +49 7045 41 - 605
PhotoMask Customer Care Center SMT PE Sternenfels	**photomaskservice.de@suss.com** Phone: +49 7045 41 - 982 Fax: +49 7045 41 - 239	**photomaskparts.de@suss.com** Phone: +49 7045 41 - 232 or 259 Fax: +49 7045 41 - 239	**photomaskservice.de@suss.com** Tobias Wehrle, Phone: +49 7045 41 – 257 Hotline Phone : +49 7045 41 – 254 Fax: +49 7045 41 – 239
Old Generation Tools SMT Reman Oberschleissheim - MA150RH/ML/CC - MA14/16/56/100 - MJB3, 21, 45, 55 - MA56, 25,26 - MA1006, RA120	**service.smtr@suss.com** Phone: +49 89 32007 - 567 Fax: +49 89 32007 - 555	**service.smtr@suss.com** Phone: +49 89 32007 - 551 Fax: +49 89 32007 - 555	**service.smtr@suss.com** Phone: +49 89 32007 - 550 Fax: +49 89 32007 - 555

Note: To ease procedures please always provide the equipment and serial number.

Escalation:
Customer Care Center Garching: Stefan Greithanner, stefan.greithanner@suss.com, +49 89 32007 - 302
Customer Care Center Sternenfels: Sasa Getlicher, sasa.getlicher@suss.com, +49 7045 41 - 254

MO Exposure Optics: IFP - Guide

General Remarks

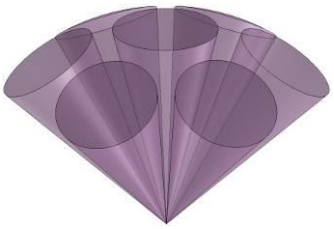
The Illumination Filter Plates (IFPs) are responsible for the creation of defined illumination angles at the mask plane. The shape of the aperture is transformed into an angular distribution of the light at the mask plane.

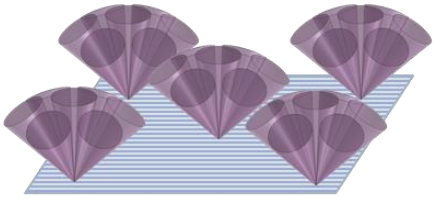
Example D-IFP:



The D-IFP is a metal aperture with 7 holes

Inserted into the MO Exposure Optics the light on the mask plane comes from seven directions





Every point on the mask plane is hit by an identical angular light distribution and intensity.

The angular distribution affects the resist image. Therefore it can be optimized for every process. Process parameters as resist-type, resist thickness, structure shapes and structure sizes and proximity gap have a major impact on the resist-image formation and have to be taken into account. Due to this it is just possible to give some advices for the choice of the right IFP for a process.



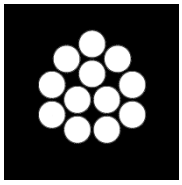
General rules for the right choice of IFPs

1. **The IFP should be chosen for the most important process parameter**: Different shapes can improve different aspects of your lithography result. If there are different structures on the mask but just a certain structure is critical for the function of your device, you should choose an IFP to improve this certain structure. If different shapes of structures on the mask are important for the function of the device and critical to transfer into the resist, a more universal solution as the HR-IFPs or a circle fitting to your gap should be chosen.

2. **Bigger openings can decrease diffraction effects:** If diffraction effects have a bad influence on the resist images (e.g. side lobes) such effects may be minimized by using an IFP with a big opening.

3. **Small openings can improve resist images for big gaps and resist steepness:** To receive proper lithography results using bigger proximity gaps (>100 µm) you need to have small illumination angles, thus small openings of the IFPs. In the most cases the shape of structures and the sidewall steepness can be increased with decreasing opening sizes.

IFP Design	Description	Page
	HR – A - IFP	4
	LGO - IFP	5
	Medium Circle - IFP	6
	Big Circle - IFP	7
	D – IFP	8
	Quadrupole – IFP	9
	Quadrupole-45°-IFP	10
	Small Ring – IFP	11
	Big Ring – IFP	12



Description:

HR – A - IFP

Recommended gap range:

Contact – 50 µm

Recommended application:

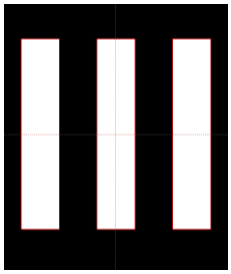
Replacement of classic "HR-A-Optics"

Remark:

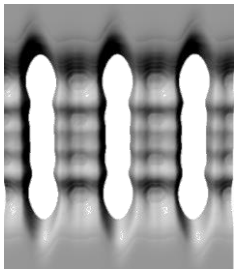
The IFP creates illumination angles equal to the SUSS High Resolution Optics (HR-Optics) in the so called A-Configuration (12 Lenses in triangular alignment). Therefore this IFP is the best choice for **working processes** that were running with an A - Optics before an MO Exposure Optics upgrade. In general the HR - IFPs, as the classic HR-A - Optics, is a good choice for relatively **small gaps** and **various structure shapes** and **sizes** on one mask.

Example:

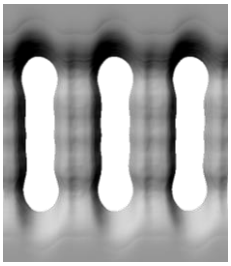
- Simulation 1 µm AZ1518
- 30 µm proximity gap
- 3 µm lines and spaces (horizontal periodic)



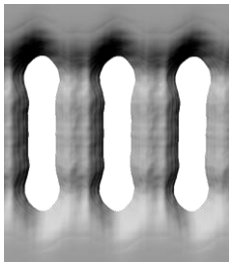
Mask pattern



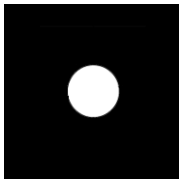
LGO-IFP



HR-A-IFP



HR-A-Optics



Description:

LGO - IFP

Recommended gap range:

> 80 µm

Recommended application:

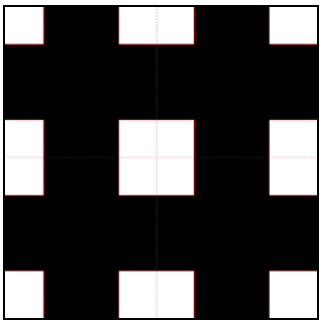
Big Gaps / Replacement of LGO-Optics / Steeper sidewalls

Remark:

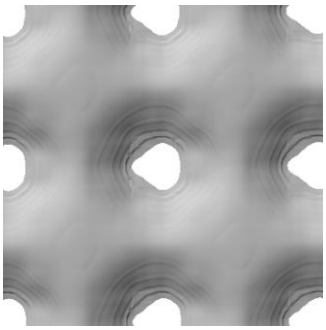
The LGO - IFP is designed to improve lithography results for big gaps. Compared to IFPs with bigger openings it can allow to print structures down to the physical resolution limit for larger gaps and increase wall steepness for standard DNQ positive resists. At smaller gaps diffraction effects can appear more strongly using this IFP compared with IFPs with a bigger opening.

Example:

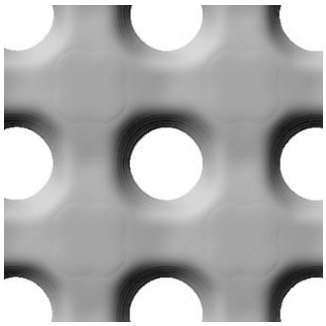
- Simulation 1 µm AZ1518
- 100 µm proximity gap
- 7 µm squares (2D-periodic)



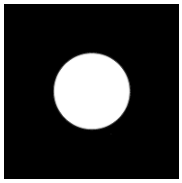
Mask pattern



HR – A - IFP



LGO - IFP



Description:

Medium Circle - IFP

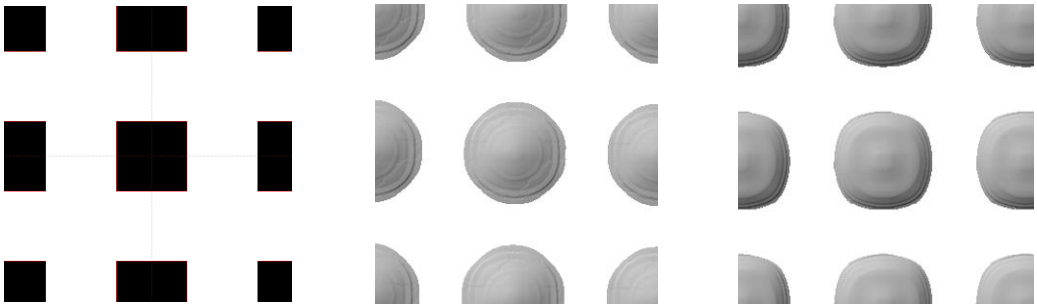
Recommended gap range:
50 µm -150 µm

Recommended application:
Compromise for throughput at medium to big gaps

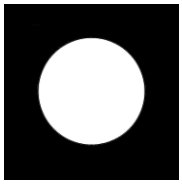
Remark:
The LGO IFP will in the most cases provide the best results for big gaps. The bigger opening of the Medium Circle – IFP compared to the LGO - IFP causes a higher intensity and therefore shorter exposure times with slightly less effect on the sidewalls than the LGO - IFP.

Example:

- Simulation 1 µm AZ1518
- 100 µm proximity gap
- 8 µm squares (2D-periodic)



Mask Pattern | HR – A - IFP | Medium Circle - IFP



Description:

Big Circle - IFP

Recommended gap range:

Contact – 50 µm

Recommended application:

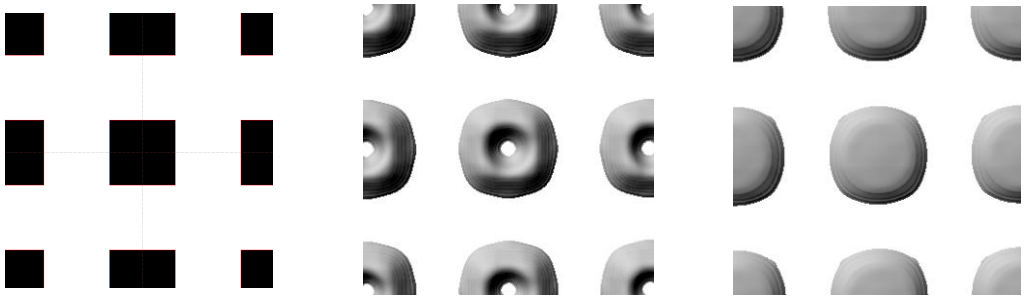
Maximum throughput for uncritical layers

Remark:

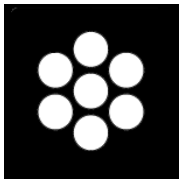
The big aperture leads to the **highest intensity** of all IFPs and therefore the highest throughput. In the recommended gap range the IFP decreases diffraction effects as side lobes. Caused by the bigger illumination angles it can cause worse results than other IFPs (e.g. sidewall steepness, image quality), especially for thick resists and big proximity gaps.

Example:

- Simulation 1 µm AZ1518
- 50 µm proximity gap
- 5.5 µm squares (2D-periodic)



Mask Pattern LGO- IFP Big Circle IFP



Description:

D – IFP

Recommended gap range:
Contact – 50 µm

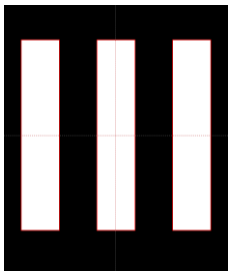
Recommended application:
Replacement of classic “D-Optics”

Remark:

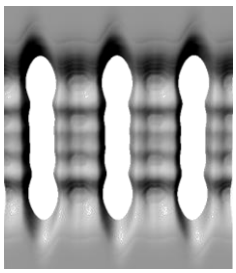
The IFP creates illumination angles equal to the SUSS Optics in the so called D - Configuration (7 Lenses in hexagonal alignment). Therefor this IFP is the best choice for **well-established lithography steps** that were running with a D - Optics before a MO Exposure Optics upgrade. In general the HR-IFP, as the classic HR – A - Optics, is a good choice for relatively **small gaps** and **various structures shapes** and **sizes** on one mask.

Example:

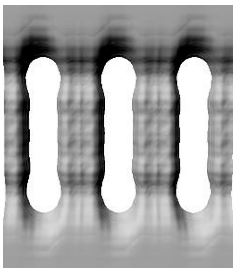
- Simulation 1 µm AZ1518
- 30 µm proximity gap
- 3 µm lines and spaces (horizontal periodic)



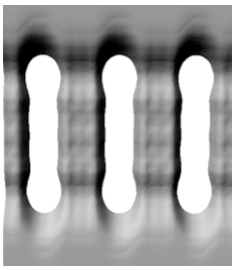
Mask pattern



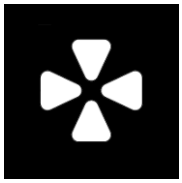
LGO-IFP



HR-D-Optics



HR-D-IFP



Description:

Quadrupole – IFP

Recommended gap range:
50 µm - 100 µm

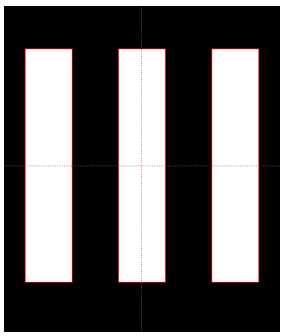
Recommended application:
Squared structures and corners

Remark:

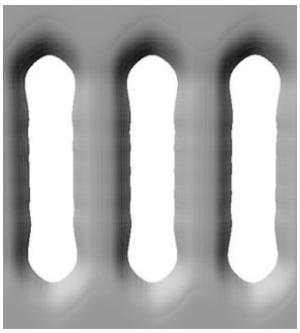
The Quadrupole - IFP is designed for structures with a quadratic shape or in a quadratic arrangement. Depending on the gap and on the specific structures it can work for orthogonal structures parallel to the mask grid or structures with 45° rotation.

Example:

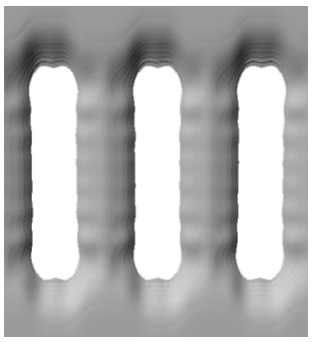
- Simulation 1 µm AZ1518
- 100 µm proximity gap
- 7 µm lines and spaces (horizontal periodic)



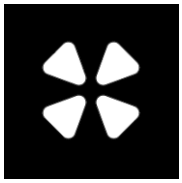
Mask Pattern



LGO Optics



Quadrupole-0°-IFP



Description:

Quadrupole-45°-IFP

Recommended gap range:
50 µm - 100 µm

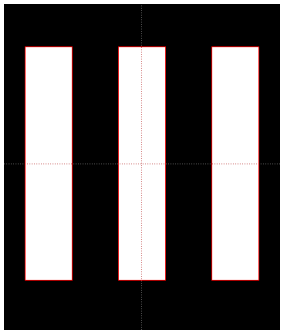
Recommended application:
Squared structures and corners

Remark:

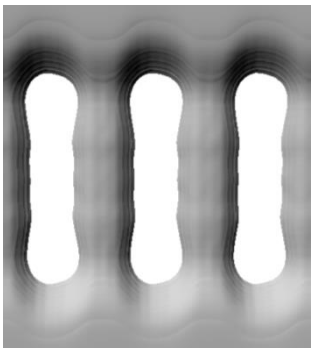
The Quadrupole - IFP is designed for structures with a quadratic shape or in a quadratic arrangement. Depending on the gap and on the specific structures it can work for orthogonal structures parallel to the mask grid or structures with 45° rotation.

Example:

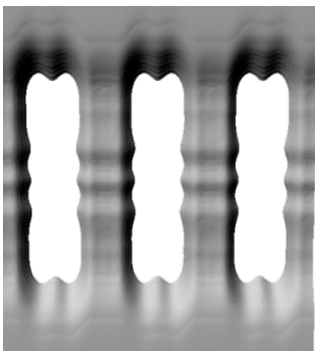
- Simulation 1 µm AZ1518
- 50 µm proximity gap
- 4 µm lines and spaces (horizontal periodic)



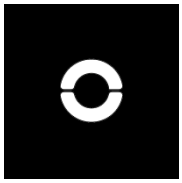
Mask Pattern



HR-A-IFP



Quadrupole-45°-IFP



Description:

Small Ring – IFP

Recommanded gap range:
50 µm - 150 µm

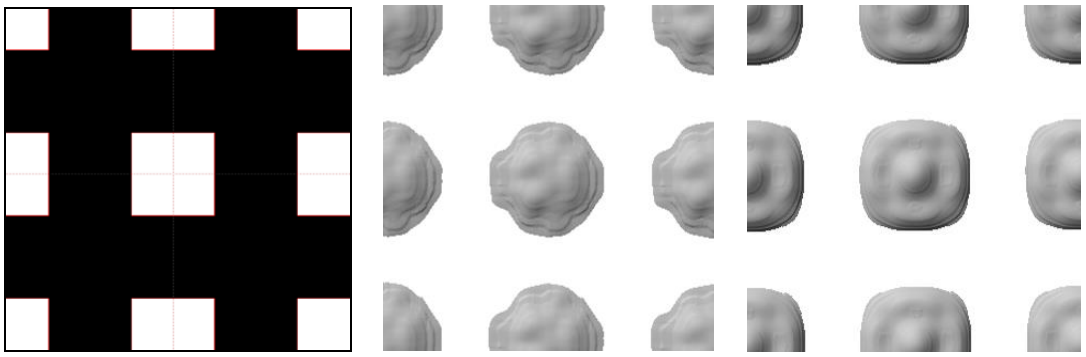
Recommended application:
Rotation-symmetric structures

Remark:

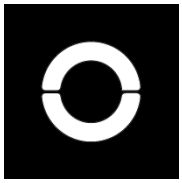
The ring formed IFPs are designed to reduce diffraction effects and they can work best amongst others for rotation symmetric structures for bigger gaps.

Example:

- Simulation 1 µm AZ1518
- 100 µm proximity gap
- 8 µm squares (2D-periodic)



Mask HR-A-Optics Small Ring IFP



Description:

Big Ring – IFP

Recommended gap range:
20 µm - 50 µm

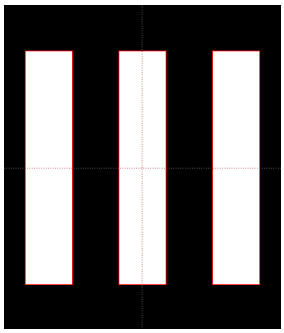
Recommended application:
Rotation-symmetric structures

Remark:

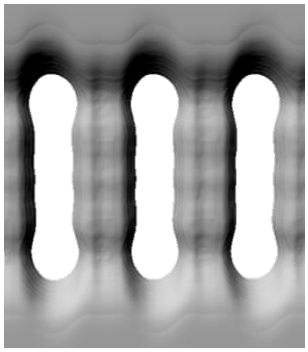
The ring formed IFPs are designed to reduce diffraction effects and they can work best amongst others for rotation symmetric structures. The bigger ring formed IFP mostly works better for smaller proximity gaps.

Example:

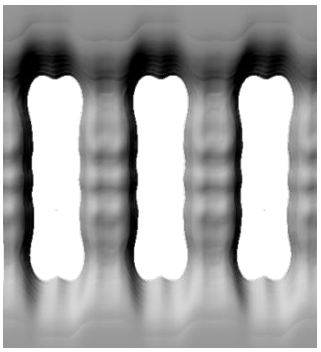
- Simulation 1 µm AZ1518
- 30 µm proximity gap
- 3 µm lines and spaces (horizontal periodic)



Mask Pattern



HR-A-IFP



Big Ring - IFP

Current IFP-Sets

IFP Design	Description	MJB4	MA6 MA100/150e Gen2	MA/BA Gen4 Pro MA/BA Gen4	MA200 Gen3 LH5000	MA200 Gen3 LH1500 MA300 Gen2 MA12
	D – IFP	--	**100004089**	--	--	--
	HR – A - IFP	**100005921**	**100004090**	**100006249**	--	**100018761**
	LGO - IFP	**100005922**	**100004092**	**100006251**	--	**100018762**
	Big Circle - IFP	**100006454**	**100004094**	**100006572**	**100006793**	**100006793**
	Medium Circle - IFP	--	--	--	**100006792**	**100019000**
	L19 - IFP	--	--	--	**100019001**	**100019001**

IFP-Sets (before July 2013)

IFP Design	Description	MJB4	MA6 MA150 MA56	MA8Gen3 MA6Gen4	MA200 MA200Co	MA300
	D – IFP	100006456	100004089	100006557	100006794	100006794
	HR – A - IFP	100005921	100004090	100006249	100018761	100018761
	LGO - IFP	100005922	100004092	100006251	100018762	tbd
	Medium Circle - IFP	100006453	100004093	100006558	100006792	100006792
	Big Circle - IFP	100006454	100004094	100006572	100006793	100006793
	Quadrupole – IFP	100006458	100004095	100006571	100006795	100006795
	Quadrupole-45°-IFP	100006459	100004096	100006570	100006796	100006796
	Small Ring – IFP	100006461	100004097	100006464	100006797	100006797
	Big Ring – IFP	100006463	100004098	100006549	100006798	100006798