# Operating manual

# X-ray scanner DEX 02

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# 1 Application

The X-ray scanner is an exposure station designed for deep-etch X-ray lithography using synchrotron radiation to write structures in X-ray-sensitive polymers (resists). Shadow projection is used to transfer the absorber structures of a mask membrane into a light-sensitive resist layer coated on a base plate.

To enable the defined selection of an exposure area, motor-driven aperture blades have been installed in horizontal and vertical direction.

Deep-etch X-ray lithography and synchrotron radiation represent the key elements to high-precision micropatterning performed by means of LIGA (LIGA being the German acronym for lithography, electroplating and plastic molding). It provides capabilities for generating three-dimensional microstructures of extreme height and large aspect ratios.

# 2 Safety instructions



**Warning!**

To perform irradiation of objects, the X-ray Scanner is attached to an X-ray source which forms part of a synchrotron or an electron storage ring. Radiation is emitted tangentially from an outlet point and guided through an evacuated tube (beam line) to the X-ray Scanner. The tube can be sealed off by a beam shutter. To allow exposure, the synchrotron operator opens the beam shutter when requested by the X-ray Scanner's user.



**Warning!**

No warranty is assumed for material or personal damage caused by any kind of X-radiation emerging from the Scanner. The responsibility for such damage lies with the operators of X-ray Scanner and radiation source.

When the beam shutter is opened to allow free beam passage into the Scanner, operator personnel working in the surrounding zone may be subject to hazards from radiation which is not completely absorbed by the Scanner wall. When operating the Scanner, the following radiation protection requirements should, therefore, be complied with:

To prevent human access to hazardous radiation, the Scanner owner must adhere strictly to the



**Radiation Protection Laws valid in his country**

(at the location where the Scanner is installed and operated)

and to the



**Radiation Protection Requirements of the Synchrotron Source Operator.**

The Operator is obliged to inform himself about any such regulations. He shall coordinate Scanner operation with the Owner of the radiation source so as to comply with all applicable protection requirements.

The installation procedure shall include



**Measurements for X-ray emissions**

which may occur in the Scanner surroundings. The results of such measurements shall be used to work out a

**Radiation protection guideline**

which must exclude any hazards to operator personnel. The Radiation Protection Guideline shall be kept on record.

We suggest lead-wall panels as a standard version to screen off the environment. The operator personnel shall receive an instruction on the radiation protection requirements applicable at the Scanner site, and shall sign off for such instruction as documentary evidence to be kept on file.

The beam shutter control lies within the responsibility of the radiation source operator.



Safety precautions are required to ensure that the chamber door cannot be opened when the beam shutter is open. This is achieved

through an interlock keeping the door-mechanism fixed as long as the beam shutter is open.

Depending on which combination of response signals is delivered from beam shutter and chamber door, the Scanner electronics will (or will not) activate an interlock. This ensures that the beam shutter will be closed or remain closed if the chamber door has been opened for some reason or remains open (e.g. when the Scanner is in off-state).

We recommend using this interlock capability for increased safety.



**Warning!**

Operation of the system involves considerable mechanical forces, vacuum, and moving parts.

Follow the instructions in technical documentation parts and on the system's warning labels when starting up or operating the system, or performing maintenance work or in the event of a malfunction!



**Caution!**
**Danger of electrical shock!**

Any intervention into the system's electric/electronic unit can be hazardous (230 V or 400 V line voltage). Such work should only be done by trained service personnel.

Do not make any alterations or breaks in the protective ground wiring inside or outside the system!

Be careful not to let liquids come into contact with the System, particularly its electronic parts!



**Warning!**
**Danger of overheating!!**

Make sure the ventilation slots of the electronic chassis always provide unhindered air passage!



**Warning!**
**Sensitive electronics!**

Turn off power before you plug in a cable.

Service work must not be done on the DEX 02 by anyone other than the Technical Service of JENOPTIK Mikrotechnik GmbH or duly authorized persons who have attended and successfully completed a service training course.

Service training programs to enable the customer's personnel to carry out service and maintenance work will be provided on a contractual basis. Trainees who have qualified for technical service will receive a certificate authorizing them to perform service jobs.

Only certified customer technicians are allowed to perform service work (except for work items described in section 8.1) on the DEX 02 (non-compliance will void any warranty claims!).



**Warning!**
**Operational Safety!**

Do not remove, manipulate, defeat or otherwise replace by makeshift solutions any safety guard, protective device or limit switch. This is necessary to prevent physical injury of operating personnel and mechanical damage to the DEX02.

# 3 Description

## 3.1 Main components

**Chamber with frame**

**Pressure compensation, pneumatic**

**End window valve, option**

**End window**

**Filter chamber**

**Vacuum system**

- vacuum system workchamber
- vacuum system end window
- vacuum system filter chamber

**Table drive**

**Object stage**

- vertical aperture blades
- horizontal aperture blades
- mask and substrate holder

**Separable electronics**

- control crate
- separable electronics
- UPS (uninteruptible power supply) for power failure flooders

## 3.2 Parameter

### 3.2.1 Chamber with frame

Dimensions (including filter chamber) chamber hood opened, chamber door closed

- length: approx. 2400mm
- width: approx. 600mm
- height: approx. 1930...2030mm
- accepted beam height 1300 ± 50mm
- assembly area between chamber wall and object stage: length in beam direction approx. 250mm.

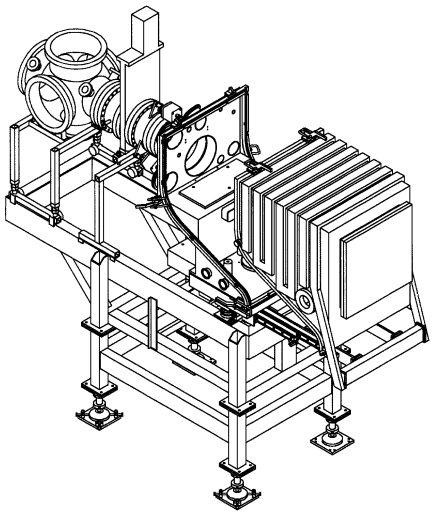


*Figure 3-1: Frame, chamber; filter chamber*

### 3.2.2 Pressure compensation, pneumatic

- flexible coupling: NW 200 CF
- generation of counterpressure by means of 3 pneumatic cylinders
- a counterforce equivalent to an air pressure for a nominal diameter of 200 mm is achieved at approx. 6 bar pressurized air in the pneumatic cylinders

– control of counterforce: proportional - pressure – regulating valve (voltage - pressure - converter)

## 3.2.3 End window valve (Option)

– gate valve: NW 200 CF
- drive: electropneumatic
– feedback signals: separated for closed and open

## 3.2.4 End window unit

### Straight connector:

– Standard flange dimension: NW 200 CF

### End window:

– seal: double sided flange NW 200 CF, see Appendix

## 3.2.5 Filter chamber

– number of filters: 5
– effective filter area: 112x91mm
– drive: electropneumatic

## 3.2.6 Vacuum system

### a) Vacuum system working chamber

– vacuum pump: vane-type rotary pump 63m³/h
– pump time: atmospheric pressure up to 0,1mbar: ≤ 5min
– final pressure in workchamber: approx. $10^{-2}$ mbar
– drive of valves: electropneumatic
– feedback signals of valves: display opened
– vacuum measurement independent of type of gases (membrane vacuum meter): approx. 10...1000 mbar
– vacuum measurement Pirani: when used: approx. $10^{-3}$...ca. 10mbar
– differential pressure measurement against atmospheric pressure
– power failure flooder

### b) Vacuum system, end window valve, Option

– drive: electropneumatic
– feedback signals: separated for closed and opened
– vacuum measurement independent of type of gases: approx. 1...1000 mbar
– power failure flooder

### c) Vacuum system filter chamber

– pre-vacuum pump: vane-type rotary pump 5m³/h
– turbo pump: 150l/s
– pump time atmospheric pressure up to $<10^{-6}$ mbar: 1h
– final pressure in filter chamber: approx. $10^{-8}$ mbar
– vacuum measurement Pirani: $10^{-4}$...approx.1000mbar
– vacuum measurement cold cathode: $10^{-9}$...$10^{-2}$mbar
– power failure flooder

## 3.2.7 Table drive

– spindle pitch: 4mm
– encoder resolution: 0.2µm
– adjustment range: approx. 240mm

## 3.2.8 Object stage

### a) Vertical aperture blades

– upper and lower vertical aperture blades
– spindle pitch: 1mm
– encoder resolution: 1.2µm
– adjustment range: ≥ 90mm
– velocity: 5 mm/s
– positioning accuracy: ≤ 0.1mm

### b) Horizontal aperture blades

– left and right horizontal aperture blades
– spindle pitch: 1mm
– encoder resolution: 1.2µm
– adjustment range: ≥ 90mm

– velocity: 5 mm/s
– positioning accuracy: ≤0.1 mm

### c) Mask and substrate holder

#### Working area

– diameter: 80mm

#### Mask holder

– wafer format 4 inches, 5mm thick
– The IMT-mask-adapter can be built in for a rectangle mask 50 x 80mm (see Appendix).

#### Substrate holder

– silicon wafer, ∅100mm with flat, 525µm thick
– ceramic plate, ∅100mm with flat, 1..3 mm thick
– mask 5 mm thick, ∅ 4“
– Be - membrane 500µm thick
– metal plate, ∅100 mm with flat, 10 mm thick
– mold insert substrate 84 x 54 mm, 6 mm thick

## 3.2.9 Separable electronics

### a) Electronic cabinet 19 inches

#### AC power distributor

– main switch
– main fuse
– emergency-off - control (activation and display)
– safety cut-outs for all system components
– On/Off - Button for circulation thermostat
– On/Off - Button for selected electronic components
– On/Off-Button for sorption trap 1 (SF1)
– internal 3 - phase mains filter

#### Control crate VAK2

– turbo pump control (NT20), TP2 of filter chamber

#### PC

– industrial PC, keyboard, monitor

#### Control crate VAK1

– vacuum gauge (DM12)
– vacuum display figure
– vacuum gauge (CM31)

### b) Electronic components at the basic system unit

#### ST1, left on basic system unit

– digital position controller and servo-end amplifier for scanner drive
– motor drive: horizontal aperture blades
– motor drive: vertical aperture blades

#### ST2, right on basic system unit

– vacuum controller
– filter exchange controller
– supply units

# 4 Installation and utility requirements

## 4.1 Main components

### Basic unit DEX

- Length: approx. 2400 mm (hood opened, door closed)
- Width: approx. 600 mm
- Height: approx. 1930...2030 mm

### Electronics DEX

- Length: approx. 600 mm, with keyboard approx. 850 mm
- Width: approx. 600 mm
- Height: approx. 1650 mm

### Roughing pump 1

- Length: 1140 mm (with filter and vacuum connection)
- Width: 260 mm
- Height: 350 mm

### Roughing pump 2

- Length: 420 mm
- Width: 260 mm (with sorption trap)
- Height: 350 mm (with sorption trap)

### Refrigerated circulator 1 and 2

- Length: 560 mm
- Width: 230 mm
- Height: 600 mm

## 4.2 Electric power supply

- 1 x 3 / N / PE 50Hz 400V 16A

## 4.3 Pressurized air or nitrogen

- Pressure: 6 bar
- Quality: filtered, oil-free
- Connection: PAN 6x1 (inside diameter 4mm, outside diameter 6 mm)

## 4.4 Vacuum exhaust line

- Installation of the exhaust pipe of the pre-vacuum pump
- Line: 13 mm inside diameter

## 4.5 Installation site

### Floor

Verification of floor load capacity to sustain the weight of the system and the hoisting and transportation facilities is necessary before shipment and installation of the system.

### Quality of environment

- Standard design according to IP 31 (like office room, precision mechanical workshop area and laboratory)
- Avoid shocks, vibrations, and electromagnetic interferences
- Operating temperature: 15...35 °C
- Transportation and storage: 25 °C...+55 °C
- Relative, humidity: ≤ 65%

# 5 Functional description

## 5.1 Description of components

### 5.1.1 Workchamber with support frame, Pressure compensation

#### Workchamber with support frame

The support frame is designed to carry workchamber, filter chamber and scanner stage drive. It can be varied in height so as to level the Scanner to radiation sources with beam outlet heights from 1300 mm ± 50 mm. A fine-adjustment mechanism located at the frame allows adjustment of the mask plane to the synchrotron beam with an accuracy of better than 0.1 mrad.

The chamber serves as a vacuum enclosure and involves the base plate for the object system. The chamber has its own vacuum system capable of creating a final vacuum as low as $10^{-2}$ mbars. The required pump-down level can be selected arbitrarily. The entire vacuum mantle is tempered by a special cooling cycle. The workchamber has an ISO-flange NW 200 as intersection with the filter chamber.

Resist and mask carrier can be accessed for exchange via a door with quick-lock/release shutters which, when open, uncovers the entire workchamber space.

The use of  a large-sized seal enables the motion of a part of the vacuum chamber by approx. 600mm. Thus, the exposure area is freely accessible for service purposes.

An assembly area between chamber wall and object stage allows the installation of additional components in the beam path.

#### Pressure compensation, pneumatic

A flexible coupling is built in between the workchamber and the filter chamber or the optional end window valve respectively. An ISO flange NW 200 forms the intersection with the workchamber and a CF flange NW 200 the intersection with the filter chamber or the optional end window valve respectively. The flexible coupling adjusts inaccuracies relatively to the beamline that occur during the installation of the system. It also enables adjustment of the workchamber with the object table in the direction of the beamline and dampens vibrations going from the beamline to the Scanner station.

The construction is stationary from the beamline up to that flange of the flexible coupling that is situated on the side of the filter chamber. If the workchamber was evacuated, the air pressure would be applied to the flexible coupling. The air pressure would, thus, effect an area corresponding to the nominal width of the flexible coupling. This force would result in tilting the workchamber and the object table. To counteract this movement,  there is a pneumatic force compensation at the flexible coupling. It compensates the force that is caused by the pressure difference between workchamber and atmospheric pressure.

### 5.1.2 End window valve (Option), end window unit, filter chamber

#### End window valve, Option

To protect the end window from high pressure differences, an additional gate valve can be installed  between the end window unit and the flexible coupling. If the valve is closed, a volume is created between the end window and the valve – the end window volume. The pressure in this volume can be held ≤ the exposure pressure in the

working chamber (e.g. 100 mbar) by means of the installed vacuum components. To the other side of the end window, high-vacuum is applied. As a result, the differential pressure that has to be supported by the end window is held as low as possible.

## End window unit

The end window unit consists of a straight connector and the end window flange.

The straight connector NW200 CF is located between the pressure compensation or the optional valve and the end window. The straight connector carries another small flange connection (KF connector) which serves for checking the state of the vacuum between the end window and the optional gate valve, the state of the end window volume.

The end window flange is a double-sided CF flange NW 200 onto which the end window is built. The end window flange 200 CF (drawing number 011026-232-10) and the end window cover (drawing number 011026-233-10) are included in the delivery.

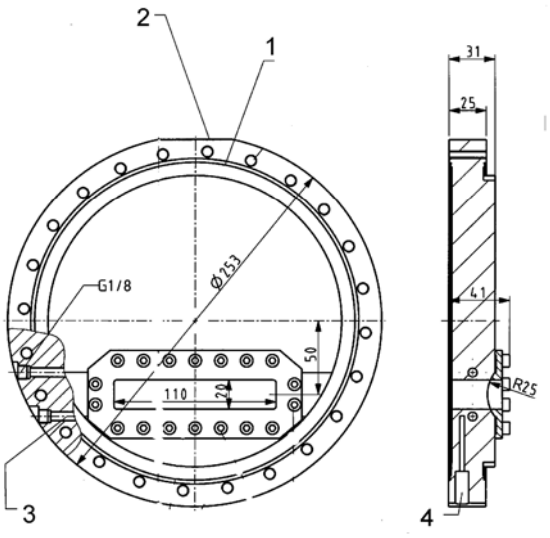



*Figure 5-1: End window flange*

1: Seal area NW 200 CF
2: Reference area
3 Cooling bore
4 Bore for thermometer

## Filter chamber

The filter chamber located between beamline and end window operates under high vacuum and serves to accomodate filter foils which can be moved into the beam to limit or manipulate the radiation spectrum (Figure 5-2).

A filter handling mechanism is available that allows 5 different filters to be slide in and out of the beam separately or in any combination without venting the system. It is energized by electro-pneumatical drives.

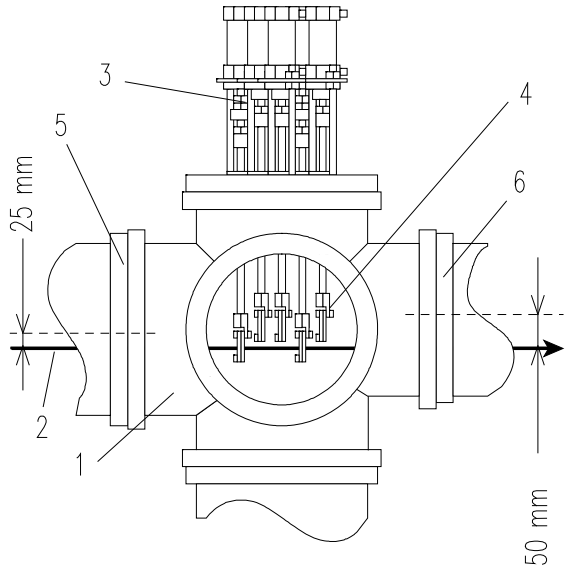



*Figure 5-2: Construction of filter chamber, schematics*
*1: Filter chamber*
*2: Radiation, not deflected*
*3: Filter exchanging device*
*4: Filter holder*
*5: Intersection with beamline, CF250*
*6: Intesection with end window, CF200*

The filter chamber is based on a sixfold cross and is UHV-resistant. The intersection with the beamline is NW 250 CF, the intersection with the end window stage is NW 200 CF. The distance between the synchrotron beam (not deflected) and the center of the beamline is 25mm, the distance between the beam (not deflected) and the center of the end window flange is 50mm, see Figure 5-2.

## 5.1.3 Vacuum system

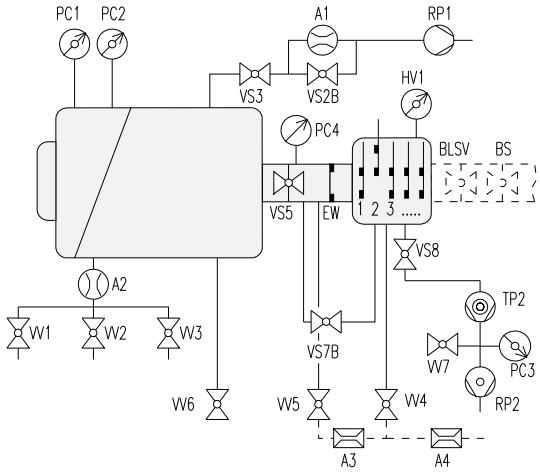



*Figure 5-3: Vacuum system*

| | |
|---|---|
| *RP* | *Roughing pumps* |
| *TP* | *Turbo molecular pump* |
| *PC1,PC4* | *Membrane vacuum gauge* |
| *PC2,PC3* | *Vacuum measurement, Heat conduction, Pirani* |
| *HV1* | *High vacuum measurement, Cold cathode, Penning* |
| *VV1...VV3* | *Ventilation valves* |
| *VV4...VV6* | *Power failure flooder* |
| *BS* | *Beamshutter* |
| *BLSV* | *Beamline safety valve* |
| *EW* | *End window* |
| *VSx, VSxB* | *Valves, Bypass valves* |
| *A1, A2* | *Apertures, Vacuum equipment* |
| *A3, A4* | *Throttles, Pneumatics* |

### Vacuum system workchamber

Roughing pump RP1 evacuates until the desired end pressure has been reached. Pumping-down is effected in two steps:

(i) Soft evacuation

VS3: open; VS2B: closed

To avoid turbulences in the workchamber when pumping down, evacuation is effected through aperture A1 up to a pressure of 800 mbar.

(ii) Evacuation, entire cross-section

VS3: open; VS2B: open

The workchamber is evacuated using vacuum pump RP1 across the entire cross-section of the connection.

The workchamber is vented using aperture A2 and optionally using the ventilation valves VV1, VV2 or VV3. Thus, a definite amount of e.g. air, nitrogen or helium can be let into the workchamber.

The vacuum is measured with a membrane vacuum gauge PC1 and a Pirani measurement tube PC2. At pressures of > approx.10 mbar, the the membrane vacuum gauge is used for measuring. Thus, insecurities in the measurement of heat conduction that occur at high pressures and with different media are avoided. Heat conduction measurement is used for control of the system at pressures of < approx.10mbar.

A differential pressure sensor (M1) has been installed to define the vented state of the workchamber. The sensor sends an electrical signal at a difference of < approx. 5 mbar against the outer air pressure.

A power failure flooder (VV6) has been installed in order to achieve defined pressure states within the system in case of emergency situations.

### Vacuum system end window valve, end window volume, Option

This vacuum system protects the end window. When the system is operated or when it is serviced, the vaccum components ensure that the differential pressure that has to be supported by the end window is held as low as possible.

The gate valve VS5, the straight connector CF200 and the end window flange with the end window form their own volume, the end window volume. Under normal operation, the bypass valve VS7B is closed and the end window volume is evacuated and vented using VS5. The control ensures that valve VS5 only opens if the pressure in the workchamber falls below a set pressure of e.g. 130 mbar. As a result, the maximal pressure in the end window vacuum is also lower than this pressure (e.g. 130 mbar).

When the filter chamber is evacuated, the filter chamber volume and the end window volume are connected by opening the bypass valve VS7B. This again ensures that the differential pressure that needs to be supported by the end window is held as low as possible.

Vacuum measurement is executed with membrane vacuum gauge PC4 that, in its construction, is similar to the vacuum gauge PC1 of the workchamber. This allows an exact comparison between the pressures in the workchamber and in the end window vacuum. Both pressures are detected in the control unit.

A power failure flooder (VV5) has been installed to ensure venting of the filter chamber and of the end window vacuum and to allow for the realization of defined pressures within the end window volume in case of emergency situations.

### Vacuum system filter chamber

The vacuum system of the filter chamber consists of a roughing pump RP2 and a turbo molecular pump TP2. This enables the realization of an ultra high vacuum that is compatible to the vacuum of the irradiation source. This system works independently of the vacuum system of the workchamber.

Vacuum measurement is executed with a Pirani measurement tube PC3 at the roughing pump of the filter chamber and with a high vacuum measurement HV1 (cold cathode) in the filter chamber.

A power failure flooder (VV4) has been installed in order to achieve defined pressures in the filter chamber and in order to operate the turbo pump in accordance to regulations in case of emergency situations.

The ventilation valves of the end window vacuum and of the filter exchange device are driven with a common signal and are short-circuited at the inlets. In case of an emergency situation an immediate pressure compensation is effected. As a result, no differential pressure that needs to be supported by the end window is built up.

In addition, the system DEX02/TR is equipped with a gate valve VS8 between filter chamber and turbo pump. The valve is driven parallely to the turbo pump.

## 5.1.4 Scanner stage

### a) Table drive, scanner stage

The scanner stage is designed to provide a uniform vertical motion of mask and substrate holder relative to an impinging synchrotron beam. Linearity of stage motion is ensured by perpendicular linear roller-bearing guideways. By the uniform vertical motion in front of the the synchrotron beam, an even integration of the beam intensity across the entire exposure area is achieved. The scanner velocity is at the maximum 50 mm/s. The resulting linearity of motion accounting for all runways is ≤ 0.1mrad. It is due to pitch & roll errors of the stage relative to the beam.

The scanner stage is moved by a recirculating ball spindle. The spindle is located in the vacuum. The drive is a direct current motor with speedometer and encoder.

A temperature measurement has been installed on the stationary part of the scanner stage.

### b) Vertical aperture blades

The vertical aperture blades serve to block out the synchrotron beam when the stage reverses its motion. Both blades are driven by direct current motors with encoder and a spindle-nut-group. The blades themselves are special steel plates that reflect the entire beam cross-section onto the upper and the lower reversion point of the scanner motion (Figure 5-4). Thus, the vertical blades determine any desired vertical section of the substrate over which exposure takes place.

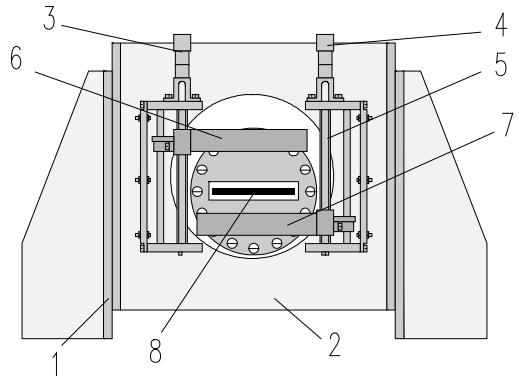



*Figure 5-4: Vertical aperture blades, schematics*

*1: Guideways of the scanner stage*
*2: Scanner stage*
*3: Drive upper blade*
*4: Drive lower blade*
*5: Spindle*
*6: Upper blade*
*7: Lower blade*
*8: Beam cross-section*

### c) Horizontal aperture blades

The horizontal aperture blades (optional) determine the horizontal synchrotron beam section over which exposure takes place. Prior to exposure, they are automatically positioned to an accuracy of 0.1 mm of the parameter setting. They are mounted on the stationary part of the stage and allow the operator to select any desired horizontal gap within the beamline limits.

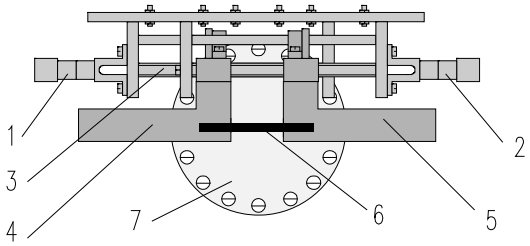



*Figure 5-5: Horizontal aperture blades, front view, schematics*

*1: Drive left aperture*
*2: Drive right aperture*
*3: Spindle*
*4: Left aperture*
*5: Right aperture*
*6: Beam cross-section*
*7: End window flange*

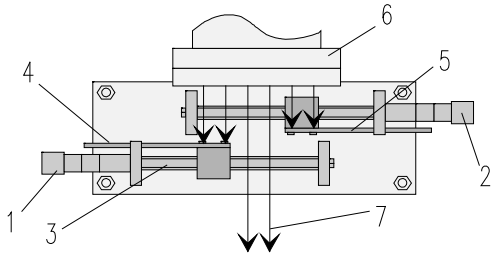



*Figure 5-6: Horizontal aperture blades, top view, (schematics)*

*1: Drive left aperture*
*2: Drive right aperture*
*3: Spindle*
*4: Left aperture*
*5: Right aperture*
*6: End window flange*
*7: Radiation*

## 5.1.5 Separable Electronics

### a) Electronic cabinet
### AC power distributor

The AC power distributor is the lower-most plug-in unit at the control crate (below the keyboard).

S1 Main switch
S2 Activation of Emergency-Off-Button
H1 Display: Drives on (green)
H2 Display: Emergency or Emergency-Off-Button pressed (red)
S3 Switch circulating thermostat (CRYOSTATIC)1
S4 Switch circulating thermostat (CRYOSTATIC) 2
S5 Switch electronics
S6 Switch VP1: vacuum pump workchamber, roughing pump 1
S7 Switch for sorption trap
P1 operating hours counter
F1 main fuse
F2 VP1, vacuum pump of workchamber (RP1)
F3 VP2, pre-vacuum pump of filter chamber (RP2)
F4 SF2, sorption trap of the workchamber pump (option)
F5 PC
F6 STL2: plug-in unit VAK2
F7 TP1, turbo pump
F8 ST1: control plug-in unit 1 at basic system unit
F9 ST2: control plug-in unit 2 at basic system unit
F10 CM, DM: plug-in unit VAK1

### Plug-in unit VAK2

The ‘vacuum plug-in unit‘ VAK2 is the center plug-in unit below the keyboard.

NT20 control unit of the filter chamber turbo pump.

### PC, monitor and keyboard

PC and monitor are situated at the level of the keyboard.

### Plug-in unit VAK1

The ‘vacuum plug-in unit‘ VAK1 is the upper-most plug-in unit at the control crate.

- DM12 measurements FV1 and FV4: membrane vacuum gauge
- Display figure
- CM31 measurements FV2 and FV3: heat conduction vacuum gauge, measurement HV1 high vacuum of the filter chamber

### b) Separable electronics
### Plug-in unit ST1

The plug-in unit 1 is on the left-hand side of the basic system unit.

IMC digital position regulator and servo end stage for scanner drive
ABX1, ABX2 motor control horizontal aperture blades
ABY1, ABY2 motor control vertical aperture blades

### Plug-in unit ST2

The plug-in unit 2 is on the right-hand side of the basic system unit.

- Vacuum controller
- Filter exchange controller
- Supply units

# 5.2 Functional description

## 5.2.1 Radiation manipulation

Filter chamber and workchamber are separated by a vacuum-sealed yet X-ray trans-

parent end window. Separate vacuum systems can be used to evacuate filter chamber and workchamber separately.

The two aperture blades that are moveable in horizontal direction determine any desired section of synchrotron radiation that impinges on the X-ray-sensitive layer of the substrate. The two vertical aperture blades carry out the same vertical movement like the entire mask/resist-carrier-unit. With the help of these blades, the synchrotron radiation (in its entire horizontal and vertical extension) is absorbed in the reversion points of the vertical movement even before it impinges on the X-ray sensitive layer of the substrate. These vertical aperture blades define any desired vertical section of the substrate over which exposure takes place. The interaction of horizontal and vertical aperture blades determines any desired rectangular section on the substrate over which exposure takes place.

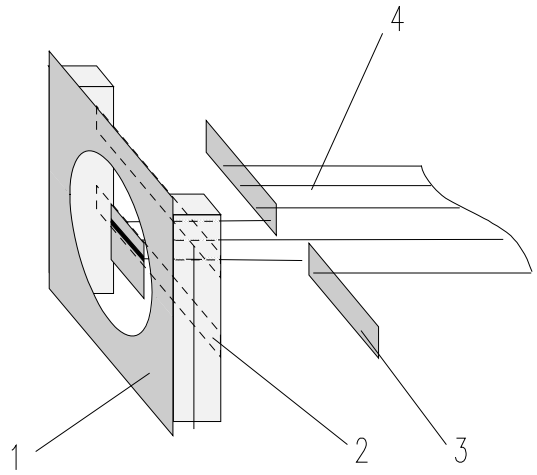



*Figure 5-7: Schematics of aperture blades*

*1: Scanner stage with exposure area*
*2: Vertical aperture blades (dashed)*
*3: Horizontal aperture blades*
*4: Synchrotron radiation*

## 5.2.2 Exposure

Synchrotron radiation from an electron storage ring or an electron synchrotron is utilized as irradiation source. The X-ray beam which is emitted tangentially with respect to the electron path direction passes through a beamline to enter the filter chamber and finally the workchamber of the Scanner Station. The beamline represents a steel pipe operating under vacuum and fitted with an isolator window at its end to protect the vacuum in the accelerator ring. Exposure is accomplished by X-rays causing the shadow of absorber structures on a mask membrane to be projected onto a base plate with X-ray-sensitive resist which has a constant proximity gap of around 50 µm. (Figure 5-8).

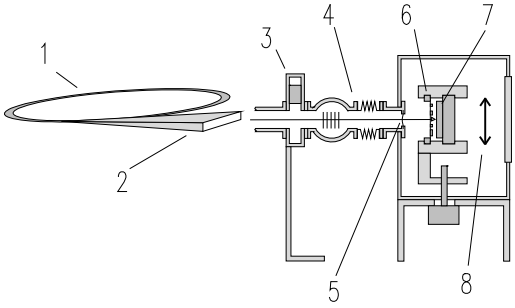



*Figure 5-8: Construction of the exposure system*

*1: Electron path*
*2: Synchrotron radiation*
*3: Beamline end valve*
*4: Filter*
*5: End window*
*6: Mask*
*7: Substrate*
*8: Scanner movement*

The radiation reaching the non-vignetted portions causes the resist structure to be changed so that in a subsequent development step the exposed areas will be stripped off (positive resist) from the remaining resist material.

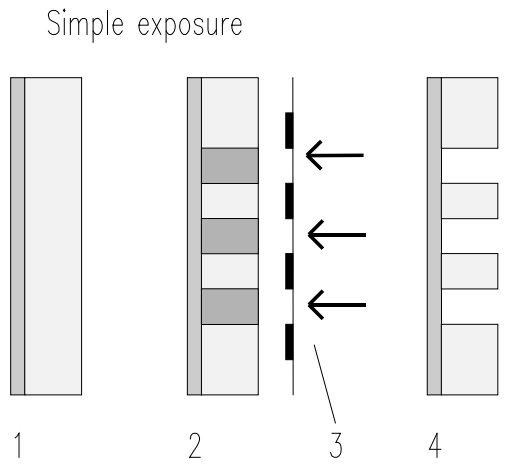



*Figure 5-9: Principle of simple exposure*

*1: Initial condition*
*2: Radiation*
*3: X-ray mask and radiation*
*4: Result*

Uniformity over the resist area under exposure is accomplished by vertical motion of the mask/resist carrier unit (package) relative to the stationary synchrotron beam which typically extends around 100 mm in horizontal and approx. 5 mm in vertical direction (half width of Gaussian distribution).

# 6 Operating the system

## 6.1 Operating modes of the system

### 6.1.1 Hardware operating modes

The modes SERVICE or NORMAL are selected with a key-operated switch on the electronic cabinet (vacuum display figure). These two selection modes serve to protect the vacuum in the beamline as well as the end window.

**NORMAL**

Valve VS7 cannot be opened. (connection between end window vacuum and filter chamber). The valve also does not open in case of a software error, i.e. if the command to open the valve is sent to the control unit. When exposure takes place and end valve and beamshutter are opened, it is, therefore, impossible to open bypass valve VS7 and to vent the beamline by using the system control unit.

**SERVICE**

Valve VS5 cannot be opened (connection between end window vacuum and workchamber). The valve does also not open in case of a software error, i.e. if a command to open the valve is sent to the system control unit. It is, therefore, impossible to create a connection between the workchamber and the end window volume during pump-down of the filter chamber when the bypass valve VS7 situated between end window volume and filter chamber is opened. A connection of this kind would create the possibility to vent the beamline because the opened valve VS7 connects end window volume and filter chamber.

### 6.1.2 Software operating modes

The log-on procedure of the operating system Windows NT defines the software functions accessible to the individual user.

The exact definition of the software functions for the individual users will be set down as agreed between JENOPTIK Mikrotechnik and the user of the Scanner station.

see also 6.9.3

## 6.2 Installation

Flange NW 250 CF of the filter chamber forms the intersection with the beamline. The position of the beamline within this cross-section is 25 mm below the center of the flange. After installation of the station, the flanges of the beamline and the filter chamber are connected so as to make them UHV-impenetrable.

Installation work is performed completely by manufacturer's staff who will turn the system over to the user in proper operating condition and provide instructions to operating personnel.

## 6.3 Coupling with electronics of the irradiation source

Coupling is established by means of the following signals:

**Outputs (of the exposure system):**

- request: open beamshutter
- request: open end valve

**Inputs (required by the exposure system):**

- display: beamshutter closed
- display: beamshutter opened
- display: end valve closed
- display: end valve opened
- additional signals
- beam current signal

For system-independent locks, the system possesses contacts that indicate the states of the chamber door and of the chamber hood (For a detailed description see Appendix).

# 6.4 Starting and turning off the system

## 6.4.1 Start with filter chamber vented, SERVICE mode of the hardware

After installation, after a complete shut-down and after an emergency turn-off, the system is started using SERVICE mode.

**Initial state**

- main switch S1 is turned OFF
- switches S3 to S7 are turned OFF
- The uninterruptible power supply (UPS) is voltage-free at the output that means the power failure flooders are open
- The system is vented using the power failure flooders. (filter chamber, end window volume and workchamber)
- The service switch is in ‘Service’ position.

**Starting:**

- turn on main switch S1
- turn on switch S3 ’circulating thermostat 1 (CRYOSTATIC)‘
- turn on switch S4 ‘circulating thermostat 2 (CRYOSTATIC)‘
- turn on switch S5 ‘Electronics‘
- turn on switch S6 ’VP1‘ (pump workchamber)
- activate EMERGENCY – OFF with switch S2
- turn on PC and monitor if needed

**Make system ready for operation**

Start software program DEX.EXE.

Execute function EvacFilterChamber() (see 7, Software Description).

Follow the instructions that are output by the software program.

After this procedure and after HV1 signal reports ON, the system is ready for operation in NORMAL mode and the service switch can be turned to NORMAL position.

## 6.4.2 Start in NORMAL mode of the hardware

**Initial state:**

- main switch S1 of the system is turned ON
- service switch is in ‘NORMAL’ position
- switch S3 ‘circulating thermostat 1 (CRYOSTATIC)‘ is turned ON
- switch S4 ‘circulating thermostat 2 (CRYOSTATIC)‘ is turned ON
- switch S5 ‘Electronics‘ is turned OFF
- switch S6 ‘VP1‘ (pump workchamber) is turned OFF

**Starting:**

- turn on switch S5 ‘Electronics’
- turn on switch S6 ‘VP1‘ (pump workchamber)
- activate EMERGENCY-OFF with switch S2
- turn on PC and monitor if needed

After the PC has been turned on, the operating system WINDOWS NT is started and all users can log-on.

Start software program DEX.EXE.

At the beginning, a start macro is executed (see also 7.): StdStart.mcr. This procedures includes the initialization routines of the mechanical axes.

### StdStart.mcr

Initialize ScanStage (true/false =0)
Initialize Aperture (true/false =0)

*The axes are initialized on request (scan stage and aperture blades). If an axis has already been initialized, no new initialization procedure is run. As a result, there is no delay when the procedure is run for a second time.*

The system is ready for operation if the vacuum state achieved is compatible to the vacuum state in NORMAL mode.

## 6.4.3 Turning off in NORMAL mode of the hardware

### Initial state:

- main switch S1 of the system is turned ON
- service switch is in 'NORMAL' position
- switch S3 'circulating thermostat 1 (CRYOSTATIC) ' is turned ON
- switch S4 'circulating thermostat 2 (CRYOSTATIC)' is turned ON
- switch S5 'Electronics' is turned ON
- switch S6 'VP1' (pump, workchamber) is turned ON

### Turning off

- Turn system program off: An exit macro is executed (see 7.): StdExit.mcr. This procedure moves mechanical axes of the system to defined positions.
- shut down operating system Windows NT
- turn off switch S5 'Electronics'
- turn off switch S6 'VP1' (pump workchamber)

In this 'standby' mode, the high vacuum in the filter chamber is maintained and the mechanisms for the protection of the end window remain activated. After the PC and the software program have been restarted, the system is immediately ready for operation. When the system software is closed, an exit macro is executed: (see also 7) StdExit.mcr. The mechanical axes are moved into defined positions during this procedure.

### StdExit.mcr

Move Scan Stage Absolute(Pos=-50mm,Vel=20mm/s)

*The scan stage moves into a defined position.*

## 6.4.4 Complete shut down of the system, SERVICE mode of the hardware

The aim of a complete shut down is venting the entire system and detaching all integrated users from the mains supply.

### Initial condition:

- main switch S1 of the system is turned ON
- service switch is in 'NORMAL' or 'SERVICE' position
- switch S3 'circulating thermostat 1 (CRYOSTATIC)' is turned ON
- switch S4 'circulating thermostat 2 (CRYOSTATIC)' is turned ON
- switch S5 'Electronics' is turned ON
- switch S6 'VP1' (pump, workchamber) is turned ON

### Turning off

- Executes the function FloodFilterChamber (see 7, software description)
- follow the software instructions

– turn off uninterruptible power supply of the power failure flooders, then, the system is vented
– finish system program
– shut down operating system WINDOWS NT
– turn switch S3 ‘Electronics’ OFF
– turn switches S3 to S7 OFF
– turn main switch S1 OFF

## 6.5 Adjustment of exposure system

During installation, the beamline will initially miss or hit the Scanner plane either incompletely or under a false angle. Special adjustment points are used for indicating the adjustment of the exposure apparatus.

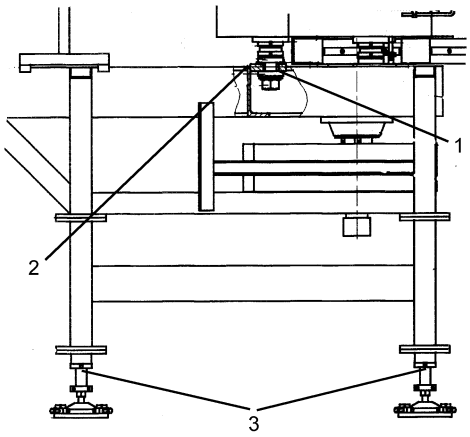



*Figure 6-1: Adjustment points for adjustment*

*1: Height adjustment of workchamber, 3 points*
*2: Lateral positioning of workchamber*
*3: System bases*

The chamber is roughly positioned using the bases of the frame (Figure 6-1).

Precise adjustment of the normal mask axis in relation to the synchrotron beam is effected with adjustment elements 1 and 2, Figure 6-1.

## 6.6 Exchanging filters

### 6.6.1 Install and remove filters of the filter chamber

Preconditions for the assembly of filters are: venting the entire system. (complete shut down according to 6.4.4). This is only possible when using

SERVICE mode.

Dismount blind flange NW 250mm on the left side of the filter chamber (when the operator stands in front of the system). All the 5 filter frames can now be dismounted by releasing the screw.(2, see figure 6.2).

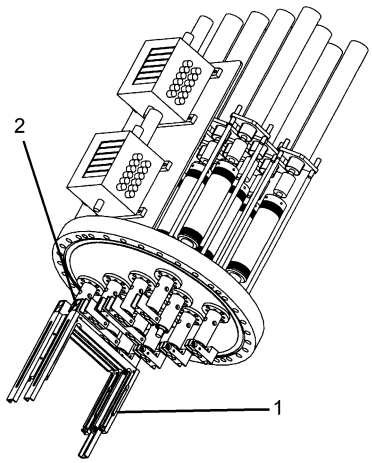



*Figure 6-2: Filter chamber with filter frame*

*1: Frame*
*2: Screw for releasing the frame*

The individual filter foils are each clamped between 2 rails. Then, the foil can be exchanged.

When the filter frames have been built into the filter chamber, it is not necessary to adjust the filter position.

– free opening of the frame elements: 112 mm x 91 mm

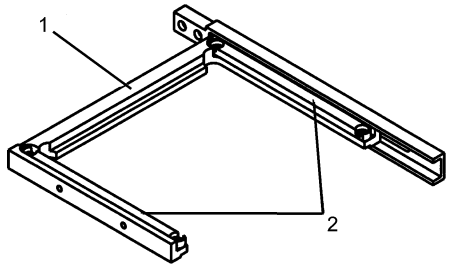



*Figure 6-3: Filter frame*
*1: Frame*
*2: Rail*

After the blind flange has been closed, the system is again ready for operation. Operation must be started with the filter chamber vented as explained in 6.4.1 (SERVICE mode).

## 6.6.2 Handling of the built-in filters

Filter handling is software-controlled and requires no filter chamber venting.

# 6.7 Mask- and substrate handling

## 6.7.1 Appropriate mask- and substrate holders

### Mask holder

– Wafer format 4 inches, 5 mm thick
– The IMT-mask adapter can be built in for a rectangular mask with dimensions 50 mm x 80 mm.

### Work area

– diameter 80mm

### Proximity distance

The distance between mask plane and substrate surface (proximity distance) is fixed at 50 or 100 µm. This distance is determined by distance foils.

### Substrate holder

– Silicon wafer, □ 100 mm with flat, 525 µm thick
– ceramic plate, □ 100 mm with flat, 1 to 3 mm thick
– mask 5 mm thick, □ 4 inches
– Be-membrane 500 µm thick
– metal plate, □ 100 mm with flat, 10 mm thick
– mold insert substrate 84 mm x 54 mm, 6 mm thick

## 6.7.2 Mask assembly

Building the mask into the mask chuck:

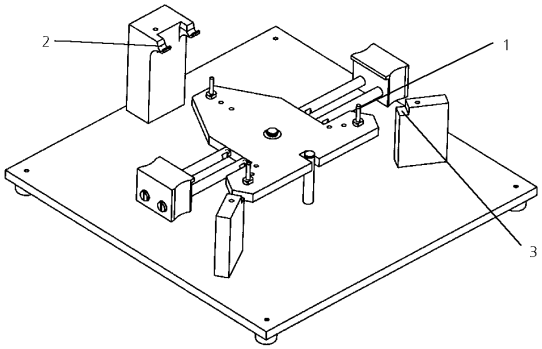



*Figure 6-4, Lifting device without mask chuck*

*1: Pins*
*2: Hinge bearing*
*3: Stop*

– Hold mask holder in vertical position and insert it first into the hinge bearing. (2, Figure 6-4). Then, put it onto the stops (3, Figure 6-4).

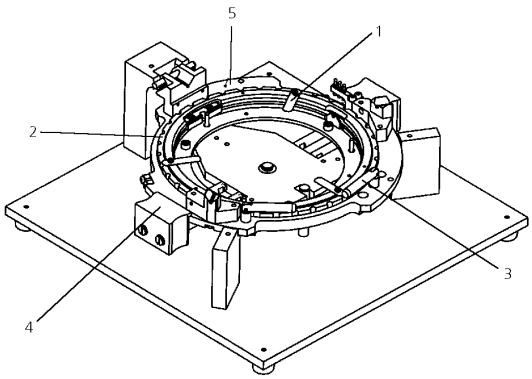



*Figure 6-5, Lifting device with mask chuck*

*1: Proximity foil*
*2: Threaded ring*
*3: Handles of mask chuck*
*4: Handles of lifting device*
*5: Bayonet*

– If the threaded ring (2, Figure 6-5) has not yet been unscrewed, unscrew it by turning the star handle (Figure 6-6) counter-clockwise
– swing proximity foils away (1, Figure 6-5)

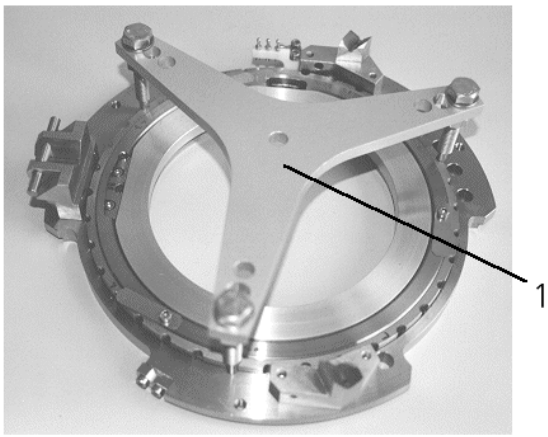



*Figure 6-6, Star handle*

*1: star handle*

– insert mask or the mask carrier with the mask
– The threaded ring is turned clockwise using the star handle until the mask is fastened.
– swing in proximity foils (1, Figure 6-5)
– Take the mask holder out. Use the two handles of the mask chuck (3, Figure 6-5) These handles can be folded back.

## Assembly of mask chuck in the scan stage

– precondition for the assembly of the mask chuck: substrate holder is in handling position, i.e. it lies in horizontal position on the support.
– In contrast to the schematics in Figure 6-7, the mask chuck is inserted into the bayonet of the scan stage in a position that is turned approx. 30° counterclockwise. The base plate of the mask chuck lies now behind the base plate of the scan stage. (Figure 6-7).

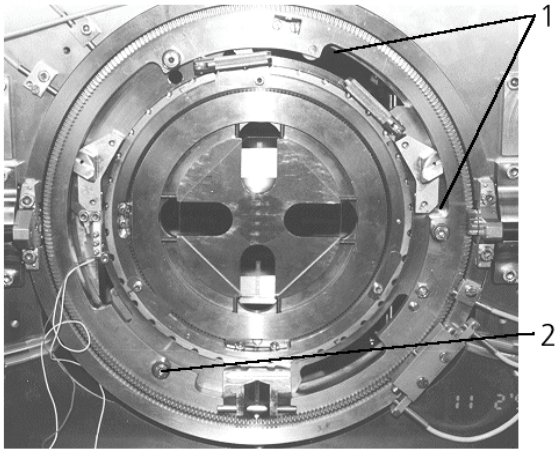



*Figure 6-7:Built-in mask chuck*

*1: Relief into which the bayonet of the mask chuck is inserted*
*2: Captive screw*

– Using the handles, the mask chuck is turned clockwise approx. 30° until it locks noticeably.
– fold away handles 3, Figure 6-5.
– The mask chuck is fixed in the scan stage by fastening the 3 captive screws (2, Figure 6-7). Thus, the assembly of the mask chuck is finished.

## 6.7.3 Inserting the substrate

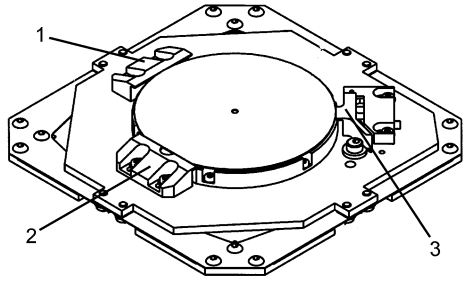



*Figure: 6-8: Substrate holder*

*1: Stop main flat*
*2: Stop secondary flat*
*3: Pressure toggle*

– Precondition for dismounting the mask chuck: substrate holder is in handling position, i.e. it lies in horizontal position on the support.
– Prepare the substrate holder according to the respective formats used.
– Insert the substrate into the substrate holder. Take care that the entire main flat fits to the system (stop main flat). The secondary flat needs to touch the stop of the secondary flat.
– Fix the substrate using the pressure toggle.

## 6.7.4 Clamping of mask and substrate

– Insert the hinge bearing (1, Figure 9-6) of the substrate holder into the bolt (2, Figure 6-9) of the mask holder.
– Turn the substrate holder into a vertical position. (as shown in the side view, Figure 6-9).

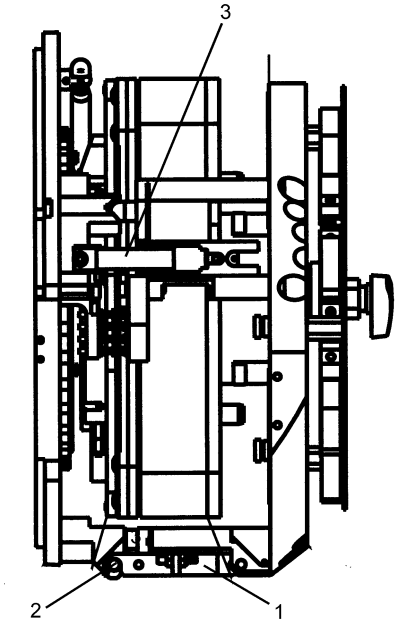



*Figure 6-9: Side view of positioning device*

*1: Hinge*
*2: Bolts*
*3: Clamp clip*

– By arresting the two clamp clips (1, Figure 6-10) substrate holder and mask holder are fixed in relation to each other.

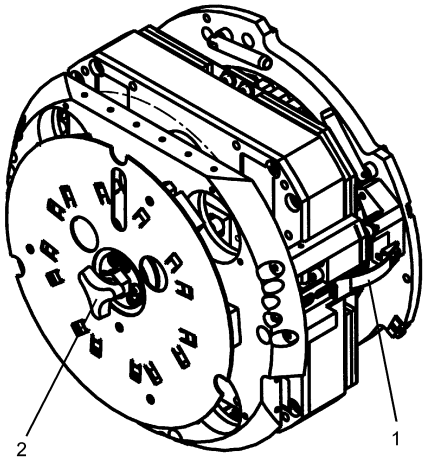



*Figure 6-10: Perspective object stage*

*1: Clamp clip*
*2: Fixing device*

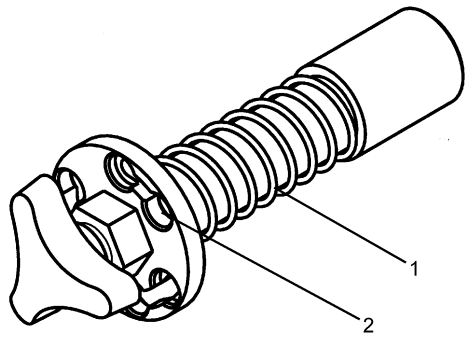



*Figure 6-11:Fixing device*

*1: Spring*
*2: Hole*

The fixing device (bayonet) is built into the mask and substrate holding device as shown in Figure 6-10. If the bayonet is built in correctly, screw heads stand up into the holes (2 figure 6-11) of the fixing device (Figure 6-10).

### 6.7.5 Turn substrate holder into handling position

- Remove fixing device (bayonet, Figure 6-11).
- Open clamp clips (1, Figure 6-10) and move the substrate holder into horizontal position.
- If the mask also needs to be removed, uncouple the hinge bearing (1, Figure 6-9) of the substrate holder and the bolt (2, Figure 6-9) of the mask holder.

### 6.7.6 Taking out the substrate

- Release the pressure toggle (3, Figure 6-8).
- Remove the substrate.

### 6.7.7 Removing the mask

#### Removing the mask chuck from the scan stage

- precondition for removing the mask chuck: the substrate holder is in handling position, i.e. in horizontal position on the support.
- Release the 3 captive screws (2, Figure 6-7) to detach the mask chuck from the scan stage.
- Use the folded-back handles to turn the mask chuck approx. 30° counter-clockwise.
- In this position, the mask chuck can be taken out.

#### Remove the mask from the mask chuck

- Hold mask holder in vertical position and insert it first into the hinge bearing (2, Figure 6-4) and, then, put it onto the stops (3, Figure 6-4).
- Release the threaded ring by turning the star handle (Figure 6-6) counter-clockwise.
- Swing proximity foils away (1, Figure 6-5)
- Use both hands to draw back the handles (equipped with springs, 4, Figure 6-5) as far as they will go. Move them over the base plate of the mask chuck and put them down, exactly in this position, onto the base plate of the mask chuck. (Position as shown in Figure 6-5).
- Lift mask using the 3 pins on the lifting plate. The mask lies there freely and can be taken out now.

## 6.8 Exposure

### 6.8.1 General parameters

Before exposure can take place, the accelerator-dependent parameters and

further general parameters need to be defined. These parameters are listed in the system software in the menu *Exposure/Extended* (see 7.1.5, software description).

### Beamline, name of irradiation source

- Beamline name
- Beamline energy: energy of irradiation source
- Magnetic field (if available)

### Beam geometry, definition of beam geometry

- Beam width
  Beam width is dependent on the vertical beam characteristics. Since the beam is of Gaussian shape, scanning begins „beamwidth/2“ mm prior to start position and continues until „beamwidth/2“ mm after final position to ensure a uniform exposure dose across the entire scan width. As a result, the desired substrate length is safely covered by the dose required.
- Offset
  As part of the installation procedure, the beamline is adjusted to the stage's zero position. If a beam is subject to variations, a shift relative to zero position may be entered here.
- Beam current
  The Scanner is calibrated to the intensity of the incoming beam, using a voltage signal from the synchrotron. The following beam current parameters are available to perform initial settings for voltage-to-beam-current conversion.
- Scale in mA/V
  Scale expresses a proportional ratio (in mA/V) of applied voltage level (in V) to the beam-current level (in mA) represented through this voltage signal.
- Maximum in mA:
  Beam current setting which is typical for the given synchrotron. Prevents stage overspeed in velocity-scaled scan mode.
- Offset in V
  If the equivalent to 0 mAmps is found to be e.g. 1 Volt rather than 0 Volts, 1 Volt has to be entered as initial setting (in V) here. The beam current is then calculated by the Scanner software according to this conversion formula:

  i = scale * (voltage - offset).
- Break exposure < in mA
  This value defines the beam current at which a running exposure is interrupted.
- Continue exposure > in mA
  This value defines the beam current at which an interrupted exposure is continued.

### Vacuum, Definition of vacuum control during exposure

- Evacuate
  Defines pressure up to which the system is evacuated. Defines further whether evacuation is executed automatically or after an inquiry has been completed and whether VS5 is to be opened during evacuation.
- Flood
  Defines the type of gas and the pressure up to which the system is flooded after evacuation. Defines further whether flooding is executed automatically.
- Ventilate
  Defines whether venting of the workchamber is executed automatically.

## 6.8.2 Standard exposure

Before the program is started, mask and substrate are mounted into the exposure system.

The standard exposure procedure is set down in the macro StdScan.mcr. The procedure is started with Exposure/Start in the menu or by opening and starting the macro StdScan.mcr or by activating the button EXPOS(ure) in the tool bar. In the following, the procedure for standard

exposure (the macro StdScan) is described:

## StdScan.mcr

Show Macro Window(Show/Hide=0)

*This parameter enables closing the macro window that shows the running procedure.*

Show Exposure Window(Show/Hide=1)

*The windows necessary for exposure are shown. This ensures that the WINDOWS user surface is not overcrowded with windows.*

Edit Exposure Parameter()

*Before exposure, the following parameters are defined:*

*Information*

- *Substrate: name of the substrate*
- *Mask: name of the mask (optional)*
- *Operator: name of the operator (optional)*
- *Proximity: proximity distance (optional)*
- *Remarks: general remarks (optional)*

*Exposure parameters*

- *Dose in mAmin/cm*
- *Scan position in mm: center of the exposed area (in vertical direction)*
- *Scan width in mm: vertical extension of the exposed area*
- *Velocity in mm/s: target velocity during exposure*
- *Acceleration in mm/s²: acceleration at reversion points*
- *ApertXposition in mm: center of the exposed area on the substrate (in horizontal direction), definition through horizontal aperture blades*
- *ApertXwidth in mm: horizontal extension of the exposed area, definition through horizontal aperture blades*
- *ApertYposition in mm: center of the exposed area on the substrate (in vertical direction)*
- *ApertYwitdth in mm: vertical extension of the exposed area*

*How to define velocity*

- *variable: In 'Variable' mode, exposure takes place at a scaled velocity. With each scan, the same dose of beams impinges on the substrate independent of the present beam current. When the beam current reaches its maximum, the Scanner moves with the preset target velocity*
- *constant: The scan velocity is constant and equivalent to the preset target velocity.*
- *approx. constant: In mode 'approx. constant,' exposure takes place at a velocity that is approximately equivalent to the preset target velocity. At this velocity, however, the exact target dose is reached if the number of scans is integer.*
- *zero: exposure with the scan stage not moving (Dose definition is interpreted in mAmin)*

*Filter*

- *Definition of filter positions*

Evacuate WorkChamber(Press=0.1mbar, flag=VS5)

*Function waits until the workchamber has been evacuated.*

Set ScanStage()
Set Aperture()

*Sets geometry (scan stage and aperture blades) as defined for exposure.*

Set Filter()

*Sets filter combination as defined for exposure.*

Flood Work Chamber over VV3(Press=100, flag=default)

*Flooding with protective gas: 100 mbar (He) (typical) over venting valve VV3.*

WHILENOT Test Exposure Dose()

*Opens a loop that is run through until the target dose has been reached. If the target dose has been reached, the program procedure is continued after the ENDWHILE command.*

Wait Exposure Possible()

*Procedure waits until exposure at defined parameters can be started or continued (Procedure waits, e.g. for a beam current > than the defined minimal beam current).*

VS5(Close/Open=1)

*Opens valve V5 (gate valve between workchamber and end window volume) if it is closed.*

Separate Valve(Close/open=1)
Wait Separate Valve(Close/Open=1)

*Command for opening the separate valve is sent to the overriding control. Procedure waits until the feedback signals of the overriding control indicate that the separate valve is open.*

Beam Shutter( Close/Open=1)
Wait Beam Shutter(Close/Open=1)

*The command for opening the beamshutter is sent to the overriding control. Procedure waits until the feedback signals of the overriding control indicate that the beamshutter is open.*

Exposure()

*Starts exposure. Function Exposure finishes when the exposure has been finished or when the exposure has been interrupted because of a still missing condition.*

Beam Shutter( Close/Open=0)
Wait Beam Shutter(Close/Open=0)

*Command for closing the beamshutter is sent to the overriding control. Procedure waits until the feedback signals of the overriding control indicate that the beamshutter is closed.*

Separate Valve(Close/open=0)
Wait Separate Valve(Close/Open=0)

*Command for closing the separate valve is sent to the overriding control. Procedure waits until the feedback signals of the overriding control indicate that the separate valve is closed.*

VS5(Close/Open=0)

*Valve V5 (gate valve between workchamber and end window volume) is closed.*

ENDWHILE

*End of loop, jump back to WHILENOT.*

Airing Work Chamber()
Move ScanStage Home()

*After successful exposure, the workchamber is vented (airing()) and the scan stage moves into home position. Handling of substrate and mask is possible now.*

### 6.8.3 Macro-defined exposure

The available functions can be freely combined. When the macro procedure is running, the functions are checked with respect to their compatibility with the current state. The functions are only started if they are compatible. Contradicting commands or commands that may lead to dangerous states during the procedure result in stopping the program, not in realizing the dangerous states.

The available functions are further outlined in the software description (see under 7).

## 6.9 Locks

The system provides mechanisms to limit the pressure difference that the end window needs to support. For this purpose, several hard- and software locks are used.

### 6.9.1 Hardware locks

These locks work independently of the running system software. The names are shown in Figure 5-3.

#### Valve VS5

Valve only opens if:

- the service switch is in NORMAL position
- vacuum measurement: PC4 < 200mbar,
- vacuum measurement: PC1 < 200 mbar,
- pressure in filter chamber (HV1) is OK,
- bypass valve VS7 is closed.

#### Bypass valve VS7

Valve only opens if

- service switch is in SERVICE position,
- vacuum measurement: PC3 > 1...5 mbar,
- pressure in filter chamber(HV1) is not OK,
- valve VS5 is closed

### Turbo pump control of filter chamber

If the service switch is in NORMAL position, the turbo pump of the filter chamber works only if the following conditions are fulfilled:

- vacuum measurement: PC4 < 200 mbar and
- vacuum measurement: PC3 < 1...5 mbar

As soon as one condition is not fulfilled, there is danger for the end window. The lock turns off the control of the turbo pump. After approx. 10 min., the uninterruptible power supply (UPS) opens the flooding valves of the system.

## 6.9.2 Software locks

### Valve VS5

Valve only opens if:

- service switch is in NORMAL position,
- vacuum measurement: PC4 < 150 mbar
- vacuum measurement: PC1 < 150 mbar,
- pressure difference: PC4-PC1 < 30 mbar,
- pressure in the filter chamber (HV1) is OK,
- bypass valve VS7 is closed.

### Bypass valve VS7

Valve can only open if:

- service switch is in SERVICE position,
- vacuum measurement: PC3 > 30mbar,
- pressure in the filter chamber (HV1) is OK,
- valve VS5 is closed,
- feedback signals from the beamshutter indicate CLOSED and
- feedback signals from the end valve of the beamline indicate CLOSED.

## 6.9.3 Deactivating locks

Manufacturer and operator of the system have agreed that an additional system program may be activated when a users logs on to the operating system WINDOWS NT.

Within this program, it is possible to deactivate the software locks as described under 6.9.2. Hardware locks remain active.



If the pressure thresholds (described under “6.9.1 Hardware locks”) at the measurement gauges DM12 and CM31 are raised, the respective functions are also executed with higher pressures at the end window. The pressure that the end window needs to support may be equal to atmospheric pressure.

**Warning!**



In this version, the functions for protecting the end window (as included in the standard version) have been cancelled!

# 7 Software description

The system software is operated using WINDOWS NT. When a user logs onto the operating system WINDOWS NT, the software functions available to this user are defined. The exact definition of the software functions available to the individual users is laid down as agreed by JENOPTIK Mikrotechnik and the user of the Scanner station.

The software for controlling the system is fully compatible with standard MS Windows™ in terms of the graphical user interface and available operator functions. Accordingly, a menu, a movable toolbar and the status line are integrated into the main window.

In the button list, active icons are colored whereas passive icons are shown in gray. While the program is running, only one of the active icons may be selected.

All windows may be moved to any position on the screen. If required, they may also be closed.

## 7.1 Menus

The menu list is automatically adapted to the active window. According to standard terms, the list contains the following menus:

### 7.1.1 File

**New Macro**
**Open Macro...**
**Close Macro**
**Save Macro**
**Save Macro As...**

Macrofile management

**New Exposure File**
**Open Exposure File...**

Exposure file management

**Open Protocol...**

Opens a protocol file *.prn.

**Print...**
**Print Setup...**

For control of document printing.

**1 xxx.mcr**
**2 yyy.mcr**
**3 zzz.mcr**

List of most recently used macros.

**Exit**

Terminates equipment control program.

### 7.1.2 View

**Macro Functions Exposure**

The functional pool for exposure control. Refer to section 7.3.3 for a description of individual functions.

**Macro Condition Functions**

A functional pool for controlling the macro execution process. Refer to section 7.3.4 for a description of individual functions.

**Exposure Measurement**

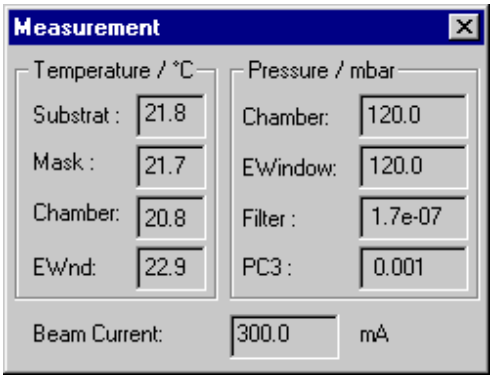



*Figure 7-1: View/Exposure Measurement*

The window shows the temperature, pressure and the present beam current measured in the system.

## Scan picture

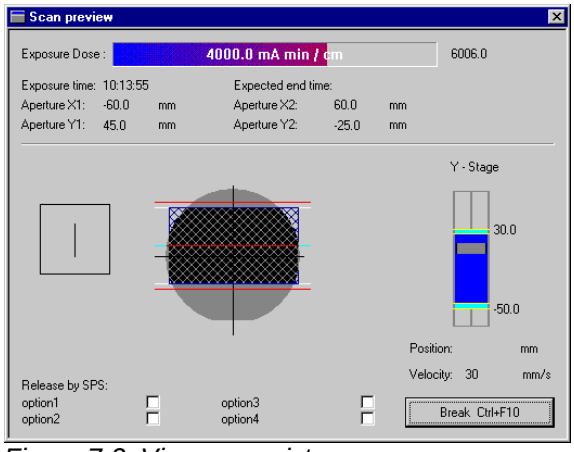



*Figure 7-2: View scan picture*

– center:
  Graphic shows the view onto the substrate. The main flat is on the bottom, the area that will be exposed is in full view. The wafer shown in the graphic has a diameter of 100 mm. with the graphic being true to scale. It shows the exposed areas on the wafer as they are realized with the current parameters for scanposition and scanwidth (white line) and the motion area of the stage (red line; it is the scanwidth plus the beam width). It also shows the exposed area on the wafer as they are realized with the current parameters for the aperture blades: ApertXPosition, ApertXWidth, ApertYPosition and ApertYWidth (hatched area, blue).
– upper part:
  information on the apertures
– right part:
  information on the scanning stage (Y - stage)
– top:
  shows exposure in progress: The progress made is visualized as a bar and also given as a value.
– lower part:
  status of four beamline signals, break button

## VAC picture

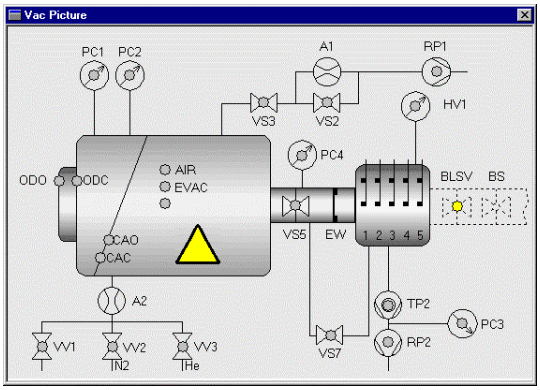



*Figure 7-3: View/VAC picture*

Graphic visualizes the vacuum state of the system.

Valves (except end valve)

| | |
|---|---|
| gray: | Closed |
| green: | Open |

Beamshutter (BS) and end valve (end valve = beam line safety valve = BLSV)

| | |
|---|---|
| gray: | Closed |
| red: | Open |
| flashing: | Undefined |

Pumps

| | |
|---|---|
| green | On |
| gray: | Off |

Vacuum measurement points

| | |
|---|---|
| green: | below threshold value |
| gray: | above threshold value |

States

| | |
|---|---|
| green: | Active |
| gray: | Inactive |
| ODO: | Outside Door Open (respose signal) |
| ODC: | Outside Door Close (activation of door lock) |
| CAO: | ChAmber Open (response signal) |
| CAC: | ChAmber Close (activation of chamber lock) |
| AIR: | Chamber vented |
| EVAC: | Chamber evacuated |

If the beamshutter is open, the radiation symbol is flashing.

In the graphic, the position of the filters indicates whether they are in the beamline or not.

### Tool bar

Tool bar on/off

### Status bar

Status bar on/off

## 7.1.3 Execution

These functions serve for starting customer-specific macros. For standard operation, the menu options *Exposure Start* and *Continue* have to be used.

### Start at First

The macro starts and is executed from position 1.

### Start at Position

The macro starts with a selected function.

### Step By Step

The macro starts with a selected function. On completion of this function, the operator may decide if he wants to continue or terminate execution.

### Abort

Various options are provided for interrupting the execution of a macro.

## 7.1.4 Edit

### Accept Sub Macro

For inserting a submacro (subroutine) at a marked position, this submacro (subroutine) can be selected in a 'File Dialog'. The macro line contains MACRO as the code word.

### Set no Selection

This function can be used to reset a marked position. 'Set no Selection' can also be used to insert lines above the first macro line.

### ENDIF
### ELSE
### ENDWHILE

These functions are used to insert the key words for indicating the end of a macro function.

### Copy
### Cut
### Paste

'Copy', 'Cut' and 'Paste' allow functions to be copied, cut out or inserted. These actions can also be triggered with the toolbar or with a corresponding combination of tools.

## 7.1.5 Exposure

### Start
### Continue
### New

Starts or continues standard exposure; loading or input of new exposure parameters. These menu options are preferably used for starting a new exposure or for continuing an interrupted exposure. Standard exposure should be influenced by changing the exposure parameters and the extended exposure parameters. It should not be influenced by editing the macro.

### Parameter

Definition of exposure parameters. This dialog is identical to the dialog called up with the function ‘Edit Exposure Parameter()’ (see 7.3.4).

### Extended

General parameters for exposure are defined here. These are the parameters that remain constant at the irradiation source or that remain constant during a large number of exposures. The dialog is structured like an index card box:

Index card beamline:
Name of the irradiation source

- *Beamline Name*
- *Beamline Energy: Energy of irradiation source.*
- *Magnetic field (if available)*

Index card beam geometry:
Definition of beam geometry

- *Beam width:*
  *Beam width is dependent on the vertical beam characteristics. Since the beam is of Gaussian shape, scanning begins „beamwidth/2“ mm prior to start position and continues until „beamwidth/2“ mm after final position to ensure a uniform exposure dose across the entire scan width. As a result, the desired substrate length is safely covered by the dose required.*
- *Offset*
  *As part of the installation procedure, the beamline is adjusted to the stage's zero position. If a beam is subject to variations, a shift relative to zero position may be entered here.*

Index card beam current:
Characterization of the beam current signal

- *Scale in mA/V*
  *Scale expresses a proportional ratio (in mA/V) of applied voltage level (in V) to the beam-current level (in mA) represented through this voltage signal.*
- *Maximum in mA:*
  *Beam current setting which is typical for the given synchrotron. Prevents stage overspeed in velocity-scaled scan mode.*
- *Offset in V*
  *If the equivalent to 0 mA is found to be e.g. 1 Volt rather than 0 Volts, 1 Volt has to be entered as initial setting (in V) here. The beam current is then calculated by the Scanner software according to this conversion formula:*

  *i = scale * (voltage - offset).*

- *Break exposure < in mA*
  *This value defines the beam current at which a running exposure is interrupted.*
- *Continue exposure > in mA*
  *This value defines the beam current at which an interrupted exposure is continued.*

Index card vacuum:
Defines the vacuum control of the exposure

- *Evacuate*
  *Defines the pressure down to which the system is evacuated and whether evacuation is executed automatically or after an inquiry. Defines further whether VS5 is to be opened.*
- *Flood*
  *Defines the medium and the pressure to which the system is flooded after*

*evacuation. Defines further whether flooding is executed automatically*

- *Ventilate*
  *Defines whether the work chamber is vented automatically.*
- *Break exposure >:*
  *This value defines a pressure at which a running exposure is interrupted.*

Index card filter:

*Defines the filter positions and the filter names.*

## 7.1.6 Tools

The functions available in the menu *Extras* should only be used by experienced operators.

### Scan stage dialog

With these dialogs, the individual axes of the system can be moved, initialized, and driven to definite positions for service and test purposes. The dialog is structured like an index card box:

- Scan stage/Y-stage
- Scan stage/Aperture
- Scan stage/Y-scan test

The index card Y-scan test executes a test scan.

### Vacuum commands

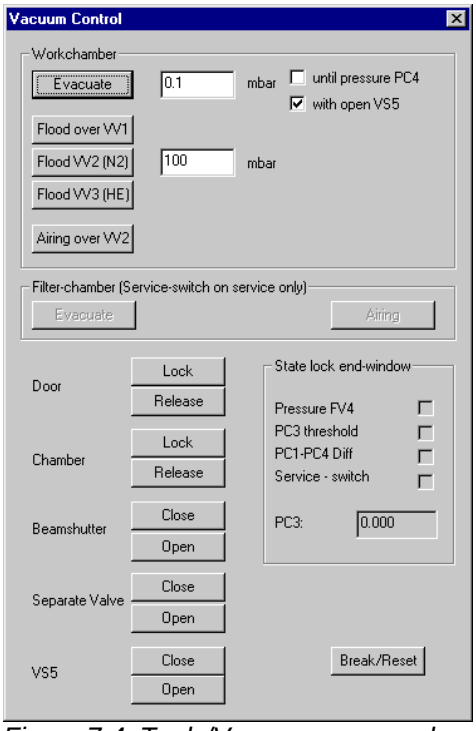



*Figure 7-4: Tools/Vacuum commands*

With this dialog, some parts of the vacuum system can be controlled independent of a macro procedure. All locks are activated. In addition, the state of the beamline and the signals of the beamline control are shown.

### Init Scan – Axis

Execute the InitializeScanStage() command, see 7.3.3.

### Beam profile

Measurement of the input voltages for beam profile mapping.

## 7.1.7 Service

### ADW

Observation of the measurements of the input voltages (for example for beam profile measurement).

### Others

Additional windows can be opened here for service purposes . They are used for communicating directly with hardware components. These windows may only be used by trained service personnel of JENOPTIK Mikrotechnik.

### 7.1.8 Windows

Functions for window administration.

### 7.1.9 Help

The system program version is shown here. Contains also the online-help function.

## 7.2 Tool bar

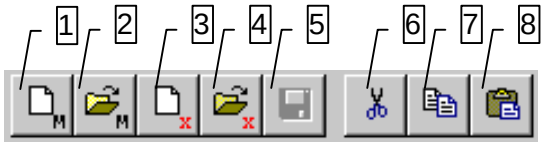



*Figure 7-5: Tool bar, part 1*

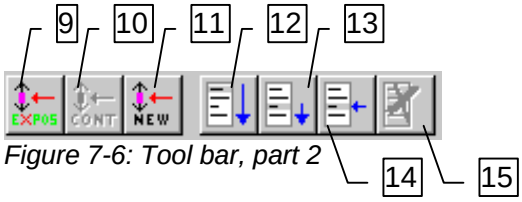



*Figure 7-6: Tool bar, part 2*

The elements of the tool bar stand for the following functions:
(parts 1 & 2):

*1: Create new macro*
*2: Open macro*
*3: Create new exposure file*
*4: Open exposure file*
*5: Save file*
*6: Cut selected function out of the macro*
*7: Copy selected function in the macro*
*8: Insert function into the macro*
*9: Start exposure*
*10: Continue exposure*
*11: Start new exposure (with definition of a new exposure file)*
*12: Start macro with the first function*
*13: Start macro with selected function*
*14: Work through macro procedure function by function, Step by Step*
*15: Abort macro*

## 7.3 Macro programming

A macro consists of functional statements, functions with code words, code words or submacros in one list. A function may be preceded by a code word (IF, IFNOT, WHILE, WHILENOT). These code word functions have the following correlated code words: ELSE, ENDIF, ENDWHILE. A submacro is distinguished by a MACRO code word.

### 7.3.1 Compiling macros

To compile a new macro, an empty macro must be opened before. Entries can then be made in this macro as desired. By selecting 'File/Open Macro...' an existing macro may also be opened and edited.

A new entry is added to the macro at the beginning after a selected function. Selections in the macro list can be cancelled with 'Edit/Set no Selection'.

A macro function may be marked or highlighted by a simple mouse-click. If a function is marked in this way, it can be deleted from the control data set by pressing „Del“ on the keyboard.

#### Function without Code Word

By clicking 'View/Macro Functions Exposure‘, a function pool can be opened. A desired function can then be selected from this pool and added to the macro with 'Accept'.

#### Function with Code Word

By clicking 'View/Macro Condition Functions', a special function pool can be opened. A desired function can then be selected from this pool and added to the macro with IF, IFNOT, WHILE, WHILENOT.

### Code Words

For each code word function, the correct code word for end identification must be specified according to syntax terms. This can be done using the ELSE, ENDIF, ENDWHILE buttons in 'View/Macro Condition Functions' or in the menu option 'Edit'.

### Submacro

A desired submacro can be specified by clicking 'Edit/Accept Sub Macro' and then selecting it in a file dialog. It contains a MACRO code word. Once in execution, a view box for this submacro appears and remains open until execution is finished. A submacro may contain more submacros.

### Copy, Cut and Paste

'Edit/Copy', 'Cut' and 'Paste' allow functions to be copied, cut out or inserted.
The same actions can be triggered at the toolbar or with a corresponding combination of keys.

## 7.3.2 Executing macros

A macro can be executed in different ways:

- Start from the beginning
- Start from a selected position
- Start from a selected position in 'Step By Step' mode.

Mode selection can be achieved with a respective entry in the menu option 'Execution' or using the toolbar.

### Start from the Beginning:

The macro starts and is executed from position 1.

### Start from Selected Position:

The macro starts at a selected function.

### Start from Selected Position in 'Step By Step' Mode:

The macro starts at a selected function. On completion of this function, the operator may decide if he wants to continue or terminate execution.

### Aborting Macro Execution

Various options are provided for interrupting the execution of a macro. A mode may be selected using the toolbar or the menu option 'Execution'.

## 7.3.3 Macro functions for exposure

The functions available here are similar to the functions listed in the function pool ‚View/Macro functions exposure‘.

### Initialize ScanStage(true/false=)

true/false:

0 Initializes the system only if initialization has not yet been executed.
1 Initialization is always executed.

Initialization of the scan axis

### Initialize Aperture(true/false=)

true/false:

0 Initializes the system only if initialization has not yet been executed.
1 Initialization is always executed.

Initializes the 4 axes of the aperture blades (2 horizontal axes and 2 vertical axes).

### Select Exposure File(true/false=)

true/false:

0 If radiation is continued, this function is not executed.
1 This function is always executed.

Selection of a source for the exposure file:

- disk,
- hard disk,
- last data file that was used
- create a new data file

## Edit Exposure Parameter()

This function opens a dialogue for defining the exposure parameters.

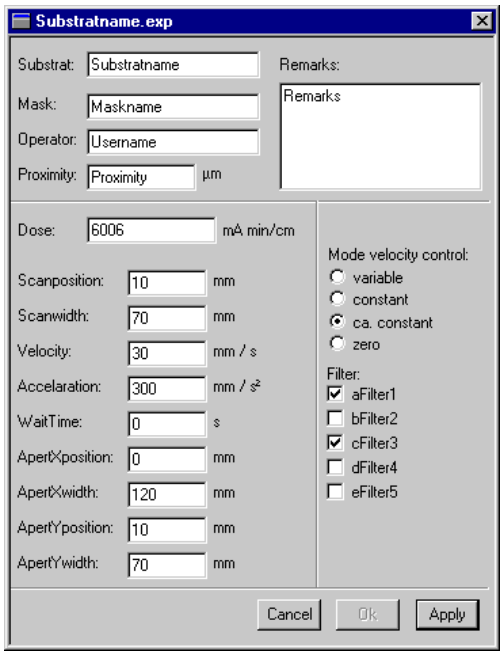



*Figure 7-7: Exposure parameters*

Information:

- Substrate: name of the substrate
- Mask: name of the mask
- Operator: name of the operator
- Proximity: proximity distance
- Remarks: general remarks

Exposure parameters

- Dose in mA*min/cm
- Scan width in mm: center of the exposed area (in vertical direction)
- Scan width in mm: vertical extension of the exposed area
- Velocity in mm/s: target velocity during exposure
- Acceleration in mm/s²: acceleration at reversion points
- Wait time: wait time at reversion points
- ApertXposition in mm: center of the exposed area on the substrate (in horizontal direction), defined by the horizontal aperture blades
- ApertXwidth in mm: horizontal extension of the exposed area, defined by the horizontal aperture blades
- ApertYposition in mm: center of the exposed area on the substrate (in vertical direction)
- ApertYwidth in mm: vertical extension of the exposed area

Mode velocity control

- variable: In mode 'variable', exposure is executed at a scaled velocity. With each scan motion, the same dose is impinged on the substrate independent of the present beam current. When the beam current reaches its maximum, the scanner moves at the preset target velocity.
- constant: The scan velocity is constant and equal to the preset target velocity.
- ca. constant: In mode 'ca. constant', exposure is executed at a velocity that is approximately equal to the preset target velocity. At this velocity, however, the exact target dose is reached if the number of scan motions is integer
- zero: exposure with the scan stage not moving (Dose definition is interpreted in mA * min)

Filter

- Definition of the filter positions

**Set Scan Stage()**
**Set Aperture()**
**Set Filter()**

These functions move the specified axes and units to the positions defined before exposure.

### Set Vacuum()
### Set Flood()
### Set Airing()

These functions evacuate, flood and vent the system as defined in the menu ‚Exposure/Extended' (index card vacuum commands). When the option in the index card is 'automatic', the action runs without further question.

### Wait Separate Valve(Close/Open=)

Close/Open:

0 Wait for closed state.
1 Wait for opened state

This function waits for a preset time until the separate valve reaches the state indicated above and the overriding control of the valve sends the respective signal to the system.

### Wait Beam Shutter(Close/Open=)

Close/Open:

0 Wait for closed state
1 Wait for opened state

This function waits for a preset until the beamshutter reaches the state indicated above and the overriding control sends the respective signal to the system.

### Test Exposure Possible()

This function tests whether the parameters defined in the exposure file are compatible with the mechanical state of the system.

If exposure is impossible, the operator receives a message.

### Wait Exposure Possible()

The function waits for a preset time until the conditions necessary for exposure have been fulfilled. The function also waits for a sufficient beam current as defined in the menu option „Exposure/Extended", index card „Beam Current". It also waits for 4 optional beamline signals whose names can be edited in the registry.

### Exposure()

The function starts an exposure or continues an interrupted exposure. The progress made during exposure is shown in the window "View/Scan Figure" (see 7.1.3).

### Move ScanStage Home()

The scan stage moves into a position that allows the handling of mask and substrate.

### Move ScanStage Absolute(Position=, Velocity=,Wait=)

Position:

Target position of absolute motion in mm

Velocity:

Velocity of absolute motion in mm/s

Wait:

0 After the positioning motion has been started, the macro procedure continues.
1 Macro procedure stops until the target position has been reached.

Absolute motion of the scan stage. At 0 position, the center of the object stage is located 25 mm above the nominal height of the non deflected beam. The locks that prevent collisions when the object stage is tilted or turned remain activated.

### Move ScanStage Relativ(Position=, Velocity=,Wait=)

Position:

Target position of relative motion in mm

Velocity:

velocity of relative motion in mm/s

Wait:

0 After the start of the positioning

motion, the macro procedure is continued.

1 The macro procedure stops until the target position has been reached.

Relative motion of the scan stage. The locks that prevent collisions when the object system is tilted or turned remain activated.

### MoveApertureHorizontal (Position=, Width=)

Position:

Target position in the center of the opened horizontal area in mm.

Width:

Width of the opened horizontal area in mm.

### MoveApertureVertical(Position=, Width=)

Position:

Target position in the center of the opened vertical area in mm.

Width:

Width of the opened vertical area in mm.

### Evacuate WorkChamber (Pressure=,def/=VS5/open VS5=)

Pressure:

Target pressure for evacuating the work chamber in mbar

def/=VS5/open VS5:

0 Pumps down to the pressure (in mbar) that was defined in ‘Pressure‘.

1 Pumps down to a pressure that is equivalent to the end window vacuum. The input in ‘Pressure‘ is irrelevant.

2 Pumps down to the pressure (in mbar) that was defined in ‘Pressure‘ If an appropriate pressure has been reached, V5 is opened.

Alternative functions to *Set Vacuum().* Evacuates workchamber independent of radiation parameters. The program procedure waits until the workchamber has been evacuated.

### Flood WorkChamber over VV1(Pressure=,default/=VS5=) Flood WorkChamber over VV2(Pressure=, default/=VS5=) Flood WorkChamber over VV3(Pressure=, default/=VS5=)

Pressure:

Target pressure during flooding of the workchamber

default/=VS5=:

0 Floods up to the preset pressure.

1 Floods up to the end window vacuum.

Alternativ Function to *SetFlood().* Floods workchamber independent of radiation parameters. With this function, the medium for an exposure (for example helium) is usually left in the workchamber. If the flag is 1, the pressure is limited to 130 mbar. If the pressure difference between the target pressure *(‘Pressure’)* and the actual pressure in the end window vacuum is more than 30 mbar, the system is flooded up to the pressure of the end window vacuum. (instead of the preset pressure).

### Venting WorkChamber()

Vents the workchamber.

### BeamShutter(Close/Open=)

Close/Open:

0 The demand for the beamshutters is sent to the overriding control.

1 The demand for opening the beamshutters is sent to the overriding control.

Control of the demand signals for the beamshutter.

### SeparateValve(Close/Open=)

Close/Open:

0 The demand for closing the end valve = beam line safety valve is sent to the overriding control.
1 The demand for opening the end valve = beam line safety valve is sent to the overriding control.

Control and demand signals for the end valve.

### OutsideDoor(Unlock/Lock=)

Unlock/Lock:

0 Unlocks door of the workchamber
1 Locks the door of the workchamber

Manipulation of door and workchamber lock.

### Chamber(Unlock/Lock=)

Unlock/Lock:

0 Unlocks the hood of the workchamber
1 Locks the hood of the workchamber

Manipulation of the lock of the workchamber hood (service intersection).

### Filter1(Down/Up)

### ...
### Filter5(Down/Up)

Down/Up:

0 Moves filter into the beam current
1 Moves filter out of the beam current

Manipulation of the filter holder at the filter exchanger.

### VS5(Close/Open=)

Close/Open:

0 Close valve
1 Open valve

Control of vacuum valve VS5.

### Wait Time(Time=)

The program procedure waits the indicated wait time in s (0.05 s to 90000 s)

### VS7(Close/Open=)

Close/Open:

0 Closes valve
1 Opens valve

Control of vacuum valve VS7.

### Evacuate Filter Chamber()

This function evacuates the filter chamber and realizes a definite pressure state in the end window volume. The function is only executed if the service switch is on SERVICE. Before evacuation, the complete system needs to be flooded. The procedure is as follows:

- inquiry whether all conditions have been fulfilled,
- all valves are closed, release signals for end valve and beam shutter are cancelled,
- open VS7
- request for starting the turbo pump of the filter chamber, for turning on the uninterrupted power supply (USV) and for closing the hand operated valve VS8,
- pump until the pressure at the end window volume reaches 50 mbar,
- close VS7,
- Wait until the pressure in the filter chamber is < 0,1 mbar in order to reach a vacuum state that is compatible to the switch position NORMAL,
- request to turn the switch to NORMAL,
- wait until the switch is in NORMAL position.

### Flood Filter Chamber()

This function floods the filter chamber and the end window vacuum. The function is only executed when the service switch is turned on SERVICE. The procedure is as follows:

- all valves closed, release signals for end valve and beamshutter are cancelled,
- inquiry after the conditions,
- wait until the switch is turned on SERVICE,
- request to turn off the turbo pump of the filter chamber, to turn off the uninterrupted power supply (USV) if necessary and to open the hand operated valve VS8,
- wait until the system has been vented.

## 7.3.4 Macro functions for controlling the program procedure

Functions named Testxxxx() can and must be linked with one of these conditions: IF, IFNOT, WHILE or WHILENOT. This is done by opening the menu option ‘View/Macro condition function‘. Select the function first in the upper part of the window and then the condition in the lower part of the window. The logic return of these functions may be used for the linking macros under certain conditions. As a result, IF ... ELSE ... ENDIF, WHILE ... ENDWHILE or their negation are possible.

Blocks that are started with IF or WHILE have to be closed with the respective key word ENDIF or ENDWHILE.

Since ENDWHILE jumps back to the first WHILE in the function list, an interlocking of WHILE- loops is not possible.

Interlocking may be realized by saving the inner loop in a submacro.

There are further special functions for the program procedure.

### Test Return State(State=)

State:

The state that the submacro returns (see Return()) is compared to the state of an integer number:

Return:

True: The return of a submacro = state
False: The return of the submacro ≠ state

This function evaluates the return value of an processed submacro. The further processing of a macro procedure, thus, depends on the result of a submacro.

### Set Counter(Counter=)

Sets the value of a counter variable.

### Increment Counter(Incr=)

Increases the counter by Incr. (standard=1).

### Test Counter LT(Bound=)

Tests whether the counter is less than the parameter.

### Test Counter GT(Bound=)

Tests whether the counter is more than the parameter.

### Test Exposure Dose()

Return:

True: if exposure has successfully been completed
False: if exposure was not fully completed

The function tests whether exposure has been fully completed.

### Return(State=)

State:

integer value

This function defines the return of a submacro. The procedure of a subordinated macro may be influenced with this return value.

### Show Macro Window(Show/Hide=)

Show/Hide:

1 Open window
0 Close window

The currently processed macro is either shown in the window or not.

### Show Exposure Window (Show/Hide=)

Show/Hide:

1 Opens windows
0 Closes windows

The relevant windows for an exposure are either opened or closed.



### Show Text(Text=)

A text window shows any desired information (of up to 255 characters in length). With this window, special information and support may be inserted for the operator.

### Hide Text()

An information text is faded out (ShowText()).

### Ask User (Text=,Wait time=,Standard answer=)

A window with a defined text is opened. The operator can choose between the answers YES or NO. The return value of the function is:

0 if the answer is NO and
1 if the answer is YES

If the operator does not respond within the wait time (in s), the window is closed and the function responds return value = standard value (0 or 1). The return value can be tested with UserAnswer().

### User Answer()

The function tests the answer that the operator returns to the question Ask User(). In connection with IF and IFNOT, the further procedure of a macro is made dependent on the answer of the user/operator.

## 7.4 Parameters in the registry

All entries that are relevant for the system program are listed in the directory:

HKEY_LOCAL_MASCHINE/SOFTWARE/JENOPTIK_MIKTOTECHNIK

Only the entries listed here may be changed. Otherwise, the operation and functionality of the scanner station is endangered.

### Starting and finishing the system program

Subdirectory Alignment/Files

- StartMacro: 0, Start macro is not executed, 1, Start macro is executed
- StdInitMacro: Location and name of the start macro
- ExitMacro: 0; End macro is not executed, 1, End macro is executed
- StdExitMacro: Location and name of the end macro

# 8 Maintenance

## 8.1 Maintenance regulations

The maintenance regulations contain sanctions for maintenance and care of the x-ray scanning system. These sanctions serve for maintaining the function and security of the system and help to locate possible defects at an early stage. Users are themselves responsible for carrying out maintenance regulations and they have to document all measures taken.

The user is obliged not to make any improper changes to the system, in particular, no changes to its construction.

All spare parts should be thoroughly cleaned before they are installed. Vacuum-seal surfaces have to be cleaned using ehtanole or isopropanole and a nylon cloth. Round rings are only cleaned with a dry non-fluffy cloth.

### Daily Maintenance

- Check whether water tube connections are tight.
- Check water flow (There are 2 water flow meters).
- Check the preset temperature at the 2 thermostats
  Co. Haake 20°C
- Check whether the vacuum chamber seal ring and seal surface show any damages or contamination.

### Weekly maintenance

- Check cooling agent levels in circulating thermostats Haake (The cooling agent should reach the upper mark of the scale in the water basin).
- Clean the vacuum chamber.
- Check whether water connections are tight.
- Check whether pressurized air has the correct operating pressure of 6 bar.
- Check whether pressurized nitrogen has the correct operating pressure of 1 bar.
- Check whether pressurized helium has the correct operating pressure of 0.5 bar.
- Check the oil level of the workchamber pre-vacuum pump (RP1)
- Check the oil level of the filter chamber pre-vacuum pump (RP2)
- Check the oil levels in the pump outlets
- Check the filter of the work chamber pre-vacuum pump

### Yearly Maintenance

- Change oil in the roughing pumps (RP1, RP2).
- Change grease at the recirculating ball spindle of the scanner stage (The spindle is located in the vacuum). Attention: This work must only be done by trained service personnel of JENOPTIK Mikrotechnik.
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### On Demand

- Regenerate the sorption traps

## 8.2 Regulations for maintenance work – operating agents

### 8.2.1 Temperature regulation systems

The fill level of the circulating thermostats Haake F6C25 has to be checked weekly. There must not be any air bubbles in the circulating systems. If you want to exchange the cooling agent, open the outlet screw at the water basin. The cooling

system has to be completely drained. If necessary, pressurized air should be pumped through the water tubes for draining.

Please consult also the operating manuals for the single appliances.

Cooling agent:

- tapwater
- any anti-corrosion additive that may also be used for cars
- use according to the prescriptions of the respective additive or take approx. 250 ml per circulating thermostat.



**Attention:**

If pressurized air is used to clean the circulating systems, you have to be particularly careful at those points where the pressurized air escapes. If an anti-corrosion additive is used, pay attention to the manufacturer's instructions.

The pressurized air for draining the cooling systems should not exceed a maximum of 2 bar to avoid that the water tubes burst or are torn off the system.

## 8.2.2 Roughing pumps

The oil level has to be checked in the control window at the pump cabinet. The oil level should reach up to the middle of the control window or lie between the given marks. If the oil level is too low, oil has to be refilled using the oil filling port on the pump cabinet. The oil has to be changed after 2000 - 3000 operating hours, at least, once a year.



**Attention!**

The oil is hot when the pumps are operating.

Open the oil outlet screw to let the used oil out. Oil should be exchanged when the pump has its normal operating temperature. It is recommended to operate the pump for a short time with an open suction and a closed pressure connecting piece. Thus, the pump may be completely drained of the used oil. Sometimes it is advisable to rinse the pump using fresh oil. After the oil has been let out, close the outlet screw again. Fill in fresh oil (using the oil filling port) until the prescribed oil level has been reached.

### Prevacuum pump work chamber

- Type: ALCATEL 2063 SD
- Oil consumption: 7.0 l
- Type of oil: ALCATEL 100
- see also technical description of the pump

### Prevacuum pump filter chamber

- Type: LEYBOLD TRIVAC D5E11
- Oil consumption: ca. 1.0 l
- Type of oil: N62
- see also technical description of the pump

## 8.2.3 Sorption traps

### Regenerating the sorption trap of the filter chamber pre-vacuum pump

Operators are advised not to regenerate the aluminum oxide filling because regenerating should take place outside the trap. It is, therefore, more economical to use a new filling.

Filling:

- Type: LEYBOLD Absorption trap ND16KF
- Activated Al - Oxide (2 l), Leybold Kat. No. 85410
- see also the operating manual for the trap

## 8.2.4 Outlet - Filter



The filter has an inspection glass and an outlet screw. The oil level must not rise above the middle of the inspection glass. Let off the oil extracted by filtering if needed.

The exhaust filter of the pre-vacuum pump RP1 of the workchamber is fixed at the exhaust flange of the pre-vacuum pump.

Type: LEYBOLD AF40 - 65

### 8.2.5 Recirculating ball spindle

Only use lubricating grease ISOFLEX NBU 15 (Klüber Lubrication).

Once a year, the recirculating ball spindle needs to be dismounted to remove the old grease from the nut unit and to put in new grease. Attention: This work must only be carried out by authorized service personnel.

It is essential to avoid all impurities at the spindle and in the lubricating grease. Otherwise, the spindle-nut-unit may be damaged.

### 8.2.6 Workchamber

Once a week, the workchamber must be cleaned from remains of the resist and from other impurities using an appropriate vacuum cleaner. Keep all surfaces water and fat free. Contaminated areas need to be cleaned with ethanole.

## 8.3 Shutting down the system

For shutting down, the system must be completely detached from the mains supply. Remove possible sources of contamination, especially aggressive substances, if appropriate. Lock all utility supplies safely or disconnect supply lines (close valves). If no precautions are taken for stabilizing the room temperature over the downtime period, all water carrying tubes of the cooling unit must be carefully drained.

See the safety data sheet of the anti-corrosion additive for further information how to discharge the cooling agent. Protect the scanner station from contamination and moisture. Seal with plastic film on all sides if necessary.

## 8.4 Waste disposal

The system uses separable materials which can be sorted for reuse or recycling. Electronic and compound materials must be disposed of separately. This applies, in particular, to:

- circuit boards
- coolants

The cooling water has to be treated as hazardous waste because it is mixed with the anti-corrosion additive. See also the safety data sheet for further information.

When the scanner station is shut down, the operator of the station is personally responsible for complying with the special regulations pertaining to the use and shut down of a synchrotron irradiation source.