

eLINE Plus

System Manual



SOLUTIONS FOR NANOFABRICATION

Product:	eLINE Plus System
Document number	System Manual Release 1.0
Date of release:	January 2016

Declaration

All information in this manual has been carefully prepared and is considered to be accurate and complete. If there is any doubt about any detail or if you require additional information, please contact Raith or your responsible Raith representative.

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Chapter 1

Preface

This manual describes the **eLINE Plus** system.

The contents include an overview of the **eLINE Plus** safety information and a description of hardware-related operation and maintenance.

All information contained in this manual is believed to be correct at the time of publication. All specifications, as well as the information contained in this manual, are subject to change without notice.

1.1 Intended use of the **eLINE Plus**

The **eLINE Plus** is dedicated to electron beam lithography, nanofabrication and engineering for surface modifications in the nanometer range. It has been designed as a tool for nanostructuring, resist-based lithography, gas-assisted etching and deposition processes.

The **eLINE Plus** system is designed and manufactured in compliance with accepted worldwide practices and standards, to provide protection against hazards for the operator and personnel in the area surrounding the product. This includes protection against mechanical and electrical hazards.

The operation of the system is only approved under the specified environmental conditions (⇒ *Environmental conditions* on page 1-3).

It is only permitted to load samples of specified materials, dimensions and weight (⇒ *Correct use* on page 4-16).

For maintenance tasks, only use genuine Raith parts.

The **eLINE Plus** is designed and intended for professional use only, by skilled operators, for its intended purpose and according to all of the instructions, safety notices and warnings provided on the unit and in this document.

In addition to the instructions, notices and warnings given in this manual and on the system itself, all local precautions, laboratory rules and operation instructions for hazardous substances must be followed.

All users must be trained regularly by the system operator about emerging hazards. Access to the **eLINE Plus** system must be restricted to users who are trained accordingly.

Only system operators who are appropriately trained by Raith GmbH are permitted to carry out maintenance tasks described in this manual (⇒ *Maintenance* on page 9-1). All other maintenance and service tasks, which do not form part of this manual, may only be carried out by service personnel trained by Raith GmbH to Level 1.

1.2 Unintended use of the eLINE Plus

Unintended use and reasonably foreseeable misuse:

The eLINE Plus must not be used in any way, or for any purpose, that is not described as an intended use.

Do not operate the system under environmental conditions other than those specified.

Do not load samples or materials other than those specified. If other materials are considered, contact Raith first.

Do not load any material that is not suitable for vacuum conditions.

Do not disassemble or exchange any components of the system.

Do not open any system cover or operate the system while any cover is removed.

Do not operate the system with any interlock defeated.

Do not use any components of the system, such as the electronics components, outside the system, or for other purposes than those intended.

Do not use the optical fiber of the LIS-1F for any use other than those described as an intended use.

Do not use the vacuum chamber as a pressure vessel.

This is not intended as an exhaustive list of unintended uses.

1.3 Scope of this manual

This manual is provided to enable the operation of the system under normal conditions, according to the intended use.

All instructions, notices and warnings assume that an operator will not use any tool, other than those detailed in the relevant instructions.

The instructions, notices and warnings further assume that all operators clearly understand that the use of the system in any manner not specified in any manual or other documentation may impair the protection provided by the system and may expose operators and other personnel to hazards. The hazard symbols and terms used in this document are defined below.

To reduce or eliminate hazards, operators must fully understand the symbols used in this document and displayed on the system. Users must be trained regularly by the system operator about emerging hazards.

1.4 Warranty

No warranty of any kind is given regarding this material, including, but not limited to, the implied warranties of merchantability and fitness for a particular purpose. No liability will be accepted for errors contained herein or for incidental damages in connection with the furnishing, performance, or use of this material.

1.5 Environmental conditions

In accordance with BS EN 61010-1:2010, the normal environmental conditions to be maintained for all laboratory instrumentation will be described below.

This standard applies to equipment designed to be safe under the following conditions:

- a) indoor use
 - b) altitude up to 2000 m
 - c) temperature 5 °C to 40 °C
 - d) maximum relative humidity 80% for temperatures up to 31 °C, decreasing linearly to 50% relative humidity at 40 °C
 - e) mains supply voltage fluctuations up to +/- 10% of the nominal voltage
 - f) transient overvoltages up to the levels of Overvoltage Category II
-

NOTICE

These levels of transient overvoltage are typical for equipment supplied from laboratory building wiring.

- g) temporary overvoltages occurring on the mains supply
 - h) applicable pollution degree of the intended environment (Pollution Degree 2 in most cases)
-

NOTICE

Manufacturers may specify more restricted environmental conditions for operation, such as clean rooms; nevertheless the equipment must be safe within these normal environmental conditions.

1.6 Hazards, warnings and symbols

The terms DANGER, WARNING and CAUTION are used throughout this document. It is important that the user is familiar with the meaning of those terms in the context of this document and the meaning of the hazard symbols associated with potential hazards.

Hazard terms:



DANGER

Indicates a hazardous situation, which, if the necessary safety precautions are not adhered to, will result in death or serious injury. This signal word is limited to the most extreme situations.

The **DANGER** safety label will include a hazard symbol specific to the nature of the hazard, such as high voltages, magnetic fields, laser radiation.



WARNING

Indicates a hazardous situation, which, if the necessary safety precautions are not adhered to, could result in death or serious injury.

The **WARNING** safety label will include a hazard symbol specific to the nature of the hazard, such as high voltages, magnetic fields, laser radiation.



CAUTION

Such instructions warn of a possible injury to personnel. The instructions regarding avoidance of any danger must be followed.

The **CAUTION** safety label will include a hazard symbol specific to the nature of the hazard, such as magnetic fields or irritant substances.

NOTICE

This term is used with no hazard symbol, when highlighting preferred practices, or to warn of possible damage to the instrument, if instructions are not adhered to.



Special notes and background information are marked by using the light bulb symbol, as shown in this paragraph.



Such references refer to information in other documents, which will be clearly identified. Such documents may include system manuals or third party documentation.

- *NanoSuite Software Reference Manual*
 - *Technical Description*
 - *Site Preparation Guide*
 - *Third party manuals*
-

Hazard symbols:**High Voltage:**

High Voltage: Indicates any hazard relating to voltages that present a risk of electric shock.

Hot surfaces:

Hot surface: Indicates any hazard relating to hot surfaces that present a risk of burn injuries.

Flammable substances:

Flammable substance: Indicates any hazard relating to flammable solids, liquids or gase. Avoid contact with hot surfaces and keep away from naked flames. Store in a suitable flammables cupboard, away from oxidizing agents.

Corrosive substances:

Corrosive substance: Indicates any hazard whereby contact exposure with either a gaseous, liquid or solid substance can cause permanent damage to human tissues, such as eyes, lungs and skin, or corrosion damage to equipment and components.

Irritants:

Harmful or irritant substance: Indicates any hazard whereby the operator may be exposed to gaseous, liquid or solid substances that may be harmful or cause irritation or inflammation to the eyes, skin or respiratory system.

Toxic substances:

Toxic substance: Indicates any hazard whereby the operator may be exposed to gaseous, liquid or solid substances that may cause immediate or long-term, potentially fatal toxic effects.

Magnetic fields:

Magnetic field: Indicates any magnetic field hazard whereby personnel may be injured or equipment may be damaged by magnetizable tools or objects, which may be attracted towards a component of the system.



Magnetic field hazard: Indicates a magnetic field that presents risk of injury to personnel with pacemakers or other implanted devices. Persons with such devices must remain at a distance greater than that indicated by the specific warning displayed on the instrument or in associated documentation.

Optical radiation:

Laser radiation: Indicates the presence of laser radiation, presenting a risk of injury to eyes, skin or other tissues.



Optical radiation: Indicates the presence of optical radiation, presenting a risk of injury to eyes.

Ionizing radiation:

Ionizing radiation: Indicates hazards relating to ionizing radiation.

Mechanical hazards:

Crush hazard or sharp edges: Indicates any hazard relating to moving parts or sharp edges, which may lead to crush injuries or minor lacerations.



Trip hazard: Indicates the presence of obstacles at or close to floor level, which present a risk of tripping.



Do not step on the surface or object: Indicates that stepping or standing on an object or surface may result in injury or damage to equipment, or both.

General hazards:

General hazard: Indicates general hazards.

Safety symbols:

Use protective footwear: Indicates that special footwear is required to avoid risk of injury.



Use protective clothing: Indicates that protective clothing is required to avoid risk of injury or harm.



Use eye protection: Indicates that eye protection is required to avoid injury, by laser emission, or by irritant or corrosive substances.



Use protective gloves: Indicates that protective gloves are required to avoid injury, from moving parts, heavy objects, or by irritant or corrosive substances.

Chapter 2

System description

The eLINE Plus consists of a free-standing plinth, which supports the chamber, stage and electron optical system, as well as the high vacuum system, high voltage units and system control electronics. It is equipped with an integrated vibration isolation system.

An optional anti-vibration platform is available, to reduce the effect of any such environmental conditions at the installation site.

The column and lithography control computer system is housed in the electronics rack. The small footprint of the machine is advantageous when considering clean room space.

2.1 System overview

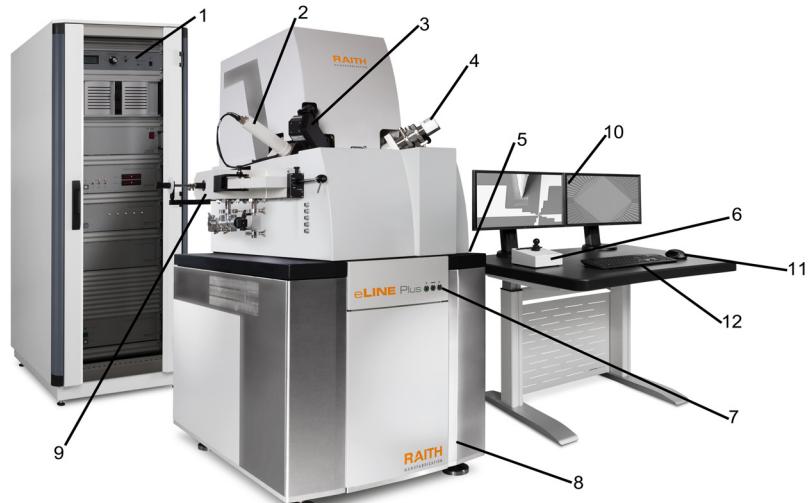


Figure 2-1: eLINE Plus system overview

Legend

- | | | | |
|-----------|-------------------------------|-----------|--|
| 1 | Electronics rack | 2 | Everhart Thornley detector |
| 3 | Laser height sensing (option) | 4 | Decontaminator / Plasma cleaner (option) |
| 5 | Emergency stop | 6 | Joystick |
| 7 | ON / STANDBY / OFF | 8 | Plinth |
| 9 | Semi-automated load lock | 10 | Computer display |
| 11 | Mouse | 12 | Keyboard |

2.1.1 Emergency Stop and BNC connectors

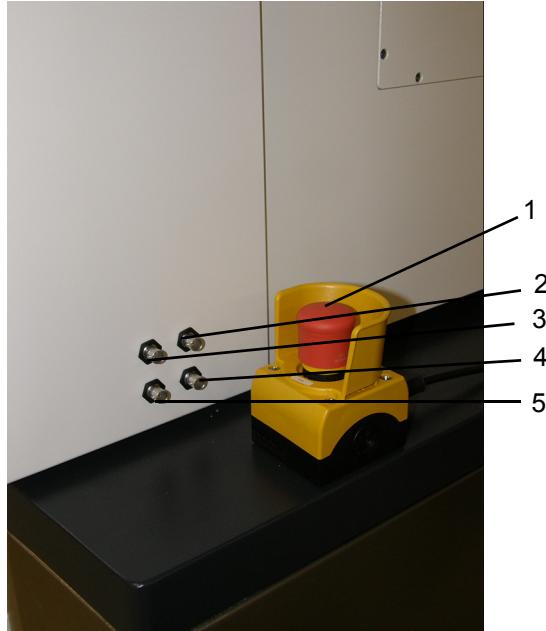


Figure 2-2: Emergency Stop and BNC connectors

Legend

- | | | | |
|----------|--|----------|--|
| 1 | Emergency Stop | 2 | BNC connector for laser signal measurement |
| 3 | BNC connector for laser signal measurement | 4 | BNC connector for laser signal measurement |
| 5 | BNC connector for laser signal measurement | | |

Each of the remaining components will now be described in sequence.

2.2 Semi-automated load lock (option)

Samples can be exchanged via the semi-automated **Load Lock** or via the front lock door. The load and unload procedure is described in detail (\Rightarrow *Exchanging samples via the load lock (optional)* on page 7-11)

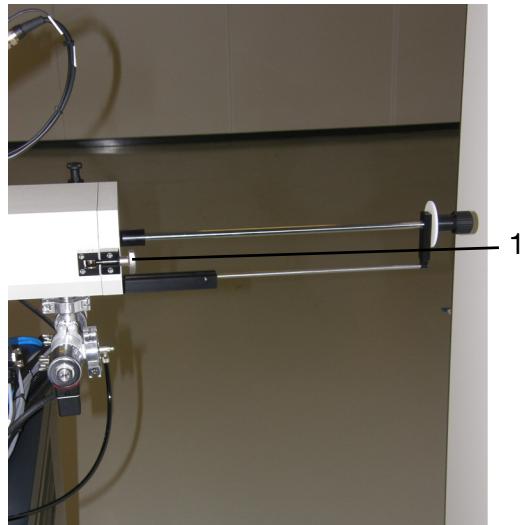


Figure 2-3: Load lock (rear view)

Legend

- 1** Twist knob to open / close the load lock door

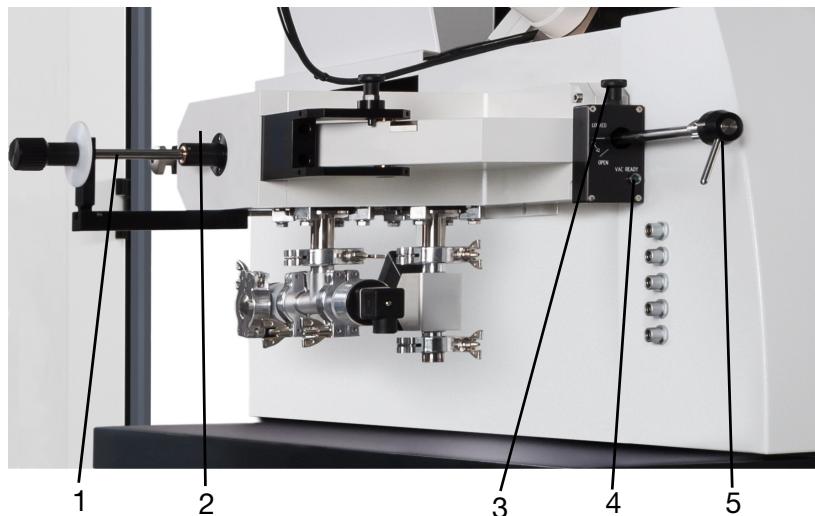


Figure 2-4: Load lock (front view)

Legend

- | | |
|--|--|
| 1 Transfer rod | 2 Loading door |
| 3 Release knob to enable opening
load lock valve lever | 4 Indicator for pumped / vented
load lock status |
| 5 Lever to change between lock /
unlock states | |

2.3 System Power

The mains switch is situated at the rear of the unit. The mains switch controls the power to the electronics in the electronics rack. (⇒ *Switching on the system* on page 7-1)

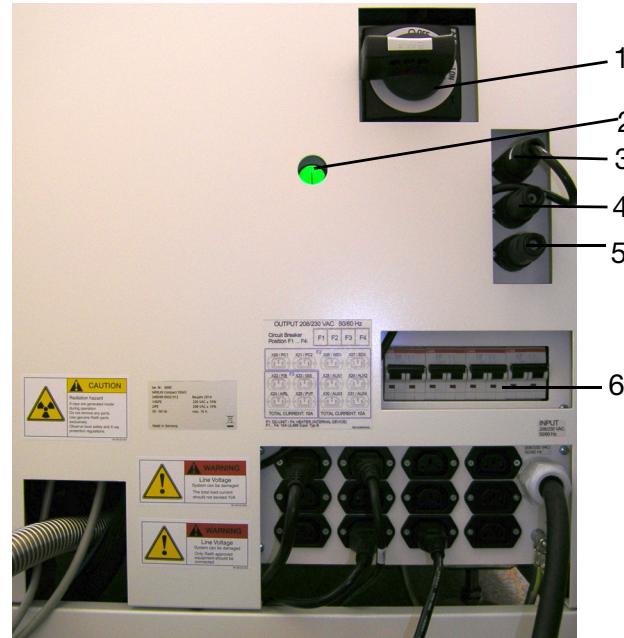


Figure 2-5: Connections at the rear of machine

Legend

- | | | | |
|----------|---|----------|---|
| 1 | ON / OFF switch | 2 | Start button |
| 3 | Air lock connectors
(only for service) | 4 | Air lock connectors
(only for service) |
| 5 | Air lock connectors
(only for service) | 6 | Mains breaker switches |

2.4 Supply connection

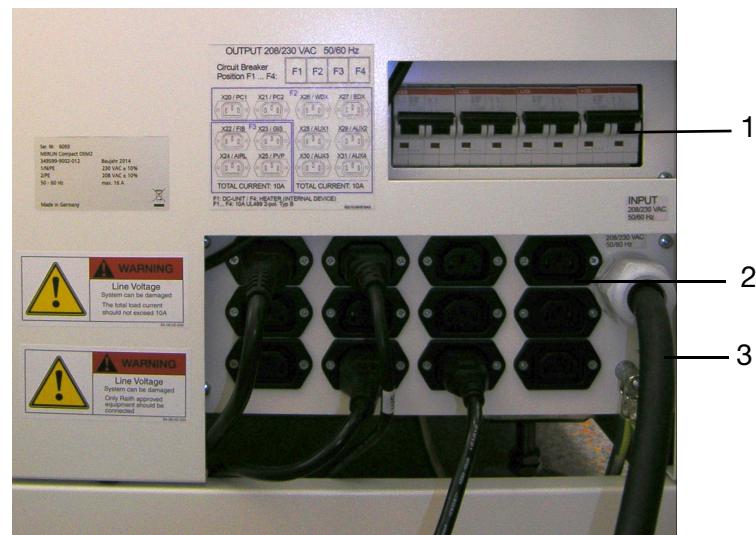


Figure 2-6: Power supply rear panel

Legend

- | | |
|---------------------------------|-----------------------------------|
| 1 Mains breaker switches | 2 Power output connections |
| 3 Power input | |

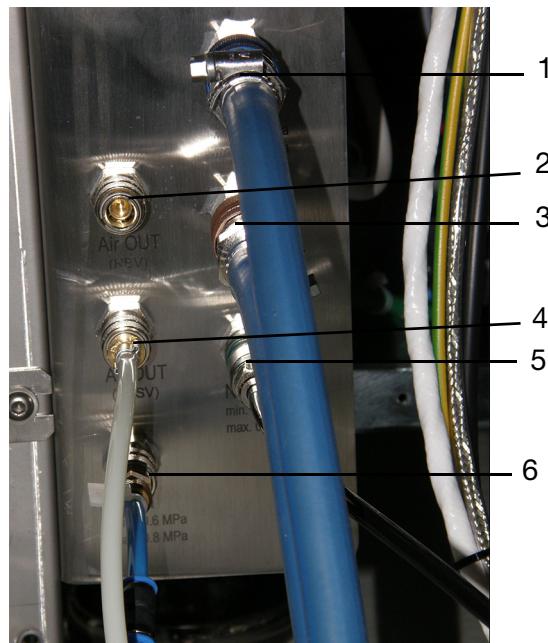


Figure 2-7: Water and gas connections

Legend

- | | | | |
|----------|-------------|----------|-------------------|
| 1 | Water in | 2 | Air out |
| 3 | Water out | 4 | Air out |
| 5 | Nitrogen in | 6 | Compressed air in |

2.5 Electronics rack

Access to the 19-inch electronics components in the rack zone of the **eLINE Plus** is via an access door. During maintenance or a support call, it may be necessary to read the status of various components via LED displays, or it may be necessary to restart them.

NOTICE

Only switch components on or off if directed to do so by Raith support.



Figure 2-8: Typical arrangement (depends on options chosen)

Legend

- | | | | |
|----------|-----------------------------------|----------|-------------------------------|
| 1 | Heating / cooling module (option) | 2 | System computer |
| 3 | Beam blanker electronics | 4 | Pattern processor |
| 5 | Stage controller | 6 | Load lock controller (option) |
| 7 | Laser interferometer source | 8 | Anti-contaminator (option) |

2.6 Description of working areas

2.6.1 Desktop working area

The main user interfaces are placed on a desktop. The user works in a seated position at this working area. The interface elements are described below.

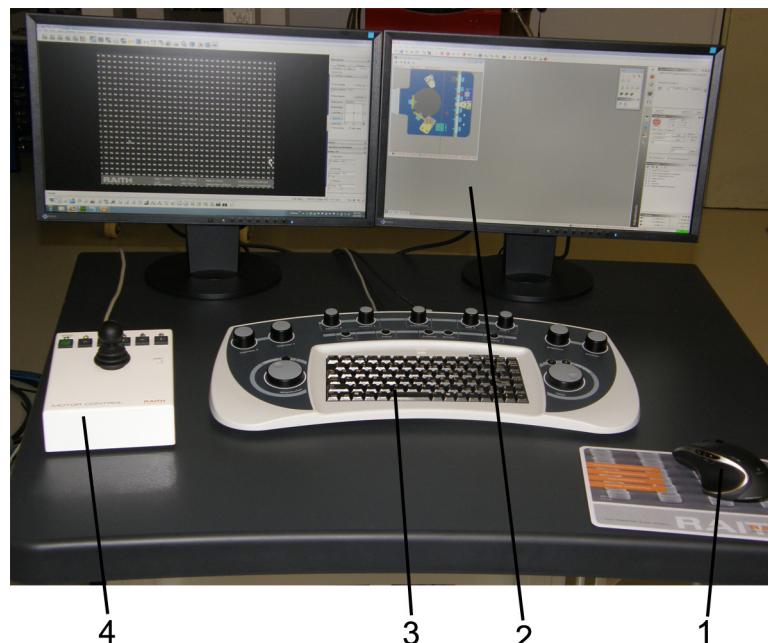


Figure 2-9: Desktop working area

Legend

- | | | | |
|----------|--|----------|---|
| 1 | Mouse | 2 | Monitor for graphical user interface |
| 3 | Electron optics control panel with integrated keyboard | 4 | Joystick for manual control of the sample stage |

2.6.2 Load lock working area

To load samples into the specimen chamber, they must be placed onto special sample holders (\Rightarrow Raith sample holder options on page 8-1). This is normally done in a sample preparation room or cleanroom. The user places the prepared sample holder on the load lock transfer rod, which is followed by closure of the load lock. The user initiates loading or unloading procedures via the Load or Unload button (\Rightarrow Main power switch, circuit breakers and ON/OFF button panel on page 3-4).

The user works in the standing position while placing the sample holder onto the load lock transfer rod. The interface elements are described below.

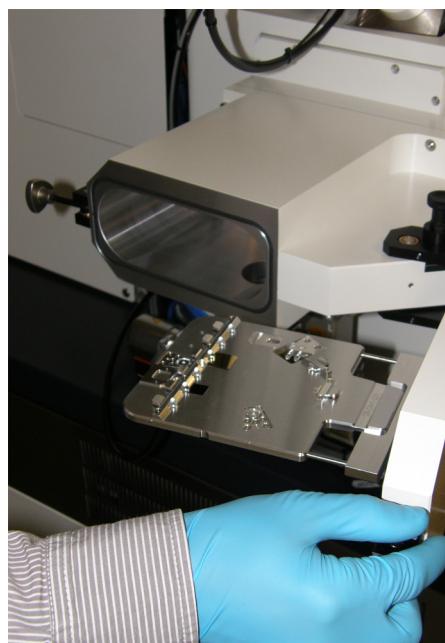


Figure 2-10: Opening the load lock door

2.7 Overall dimensions and site requirements

Table 2-1: Site requirements of the eLINE Plus

Supply voltage:	230 V
Power consumption:	2.5 kW
Net frequency:	50Hz / 60Hz
Weight:	1400 kg
Space requirement:	3.5 m x 4.85 m with a minimum ceiling height of 2.3 m

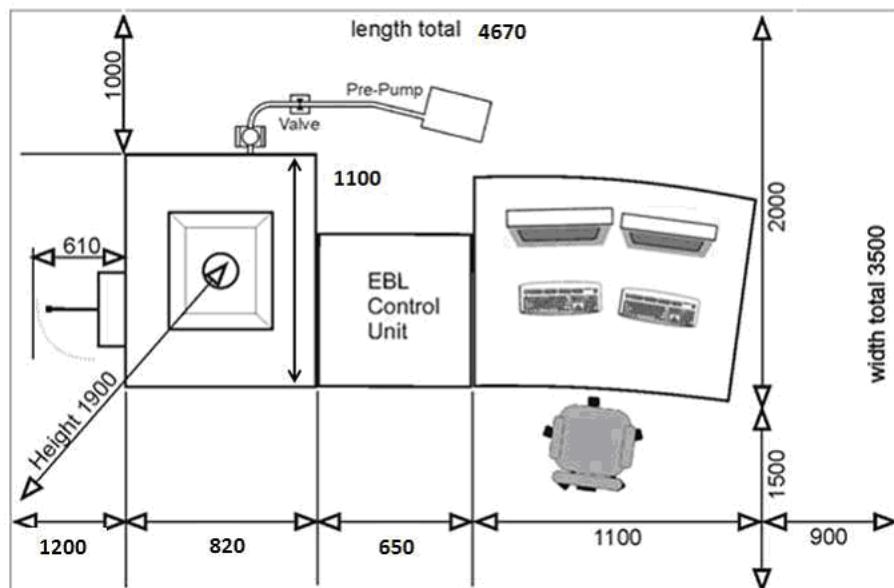


Figure 2-11: Overall dimensions and space requirement of the eLINE Plus

Chapter 3

Functional principle

This chapter provides an overview of the functional principle of the **eLINE Plus** and its individual components.

3.1 General functional description

The **eLINE Plus** is a ultra-high resolution electron beam lithography system used for imaging and as a nano-engineering workstation.

The **eLINE Plus** is a modular and expandable research tool, combining advanced electron beam lithography (EBL), nano-engineering, and ultra-high resolution imaging & analysis. The **eLINE Plus** system combines the classical workhorse EBL and multi-application tool capabilities, without compromising lithography specifications.

The **eLINE Plus** nano-fabrication system focuses on, but is not limited to, EBL resist exposure. The high degree of nano-scale integration in modern devices demands the availability of advanced multi-technique applications, including focused electron beam-induced processing (FEBIP, such as gas assisted deposition or etching), nano-manipulation, electrical probing, or imaging & analysis. The versatility of the **eLINE Plus** electron beam system is enhanced by its range of nano-engineering accessories, including:

- ▶ Gas-injection system (GIS), with up to 5 nozzles, to inject gases for electron beam-induced deposition (EBID) and etching, or efficient and cost-effective Mono-GIS
- ▶ Advanced FEBIP supporting options, including heating/cooling stage and anti-contaminator.
- ▶ Up to 4 nano-manipulators for electrical or mechanical nano-probing and profilometry.
- ▶ Multiple high-efficiency detectors, for surface, topographical, material, crystallographic or chemical information, with ultra-high resolution.
- ▶ Automated focus control by laser height sensing

The main hardware features of the **eLINE Plus** are:

- ▶ Ultra-high resolution, thermal field emission Schottky-source.
- ▶ Patented electron optics: 8 kV beam booster, giving state of the art low kV performance. Zero cross-over beam path with extremely high beam current density and compound electromagnetic-electrostatic immersion lens for exceedingly low beam aberrations.

- ▶ Fully digital electron optic column, with beam energy selectable between 20 V and 30 kV and a wide range of selectable writing field sizes.
- ▶ Fast electrostatic beam blanking.
- ▶ Laser interferometer-controlled stage with 1 nm positioning resolution over 100 mm x 100 mm travel range.
- ▶ Closed loop stage control mode, with DC-motors for the highest speed and shift piezos for the finest positioning control at all column settings. Calibration of stage movement or standard is not required.
- ▶ Kinematic, stress-free, 3-point sample mounting with several optional sample holders, such as wafer and mask holders, rotation-tilt inspection modules.
- ▶ Optional automated height sensing for auto-focus control using the objective lens or Z-stage travel.
- ▶ 20 MHz high speed pattern generator with digital signal processor technology and dynamic correction. Writing speed up to 20 MHz, minimum dwell time increment of 1 ns and 0.1 nm addressing increment.
- ▶ Dry vacuum system with optional loadlock.

The main software features are:

- ▶ Flexible system control, with a single high-end computer.
- ▶ Multi-user software platform for lithography patterning, as well as metrology runs.
- ▶ Interface with scripting language for extensive automation and customizing.
- ▶ Pattern generation: GDSII hierarchical editor with FLEXposure™ patterning mode attributes (line by line, meander, circular, raster, free angle, parallel axis, parallel element and sub-modes such as inwards, outwards, transverse, longitudinal.)
- ▶ Pattern attributes editor and dose assignment.
- ▶ Flexible graphical editor for "any shape design" with fully integrated proximity effect correction.
- ▶ Post-processing and resist exposure simulation.
- ▶ Lithography functions: easy-to-learn Windows-based exposure control with the capability for automation.
- ▶ Metrology functions, including line width and pitch detection. Methods can be combined to execute intra-field and long-range measurements with laser interferometer accuracy.

3.2 Sub-systems and individual components

The eLINE Plus consists of the following subsystems:

- ▶ The patented electron optical column with Schottky thermionic field emission filament. The eLINE Plus has an ultra-high resolution, robust electron optical column. The column is carefully shielded to prevent interferences from stray electro-magnetic fields. The Schottky thermionic field emitter combines high beam brightness and beam stability.
- ▶ Deflection system with scan generators for lithography and scanning-electron-based imaging. There are two methods of scan generation: the digital pattern generator, which is primarily used for lithography, and an independent raster scan generator, used for imaging.
- ▶ An X/Y/Z stage, utilizing a laser interferometer in the X/Y plane provides area coverage of a 4" wafer, i.e. 100 mm by 100 mm travel range.
- ▶ In the X- and Y-directions, a sophisticated and superior design combines DC motors and shift piezos, mounted on spindles. The DC motors are used for positioning within a few hundred nanometers, with the shift piezos used for fine adjustment within the increments of the DC motors.
- ▶ High performance options such as automated height sensing.
- ▶ Vacuum system and plinth. The oil-free high vacuum system is automatically controlled and monitored via the control computers. An ion getter pump maintains the gun pressure, whilst an automatic pneumatic column isolation valve separates the gun from the chamber. The main chamber is pumped by a 240 l/s turbo-molecular pump that gives a working vacuum better than 2×10^{-6} mBar. The turbo-molecular pump is backed by a dry vacuum pump to avoid sample contamination.
- ▶ Computer-based lithography user interface. Process control of lithography applications, scanning electron-based imaging and functions for metrology.
- ▶ Configurable nano-engineering tool set as an option.

3.3 Main power switch, circuit breakers and ON/OFF button panel

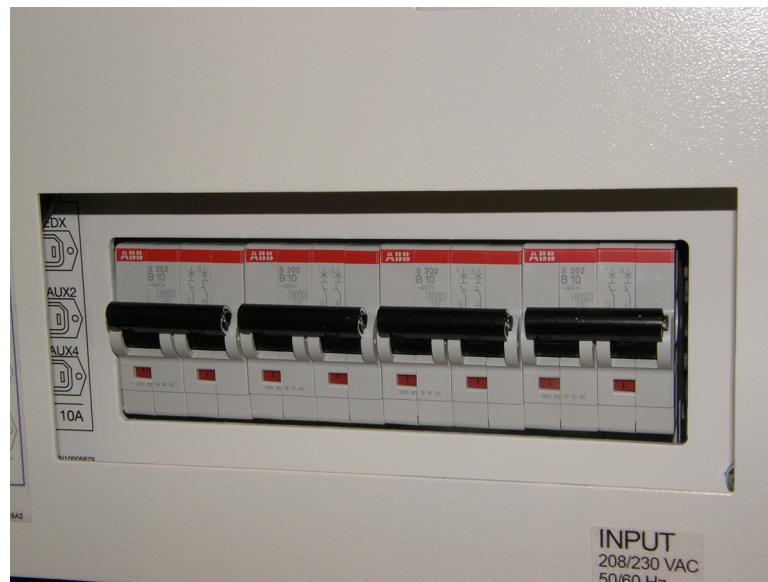


Figure 3-1: Miniature circuit breakers (MCBs)

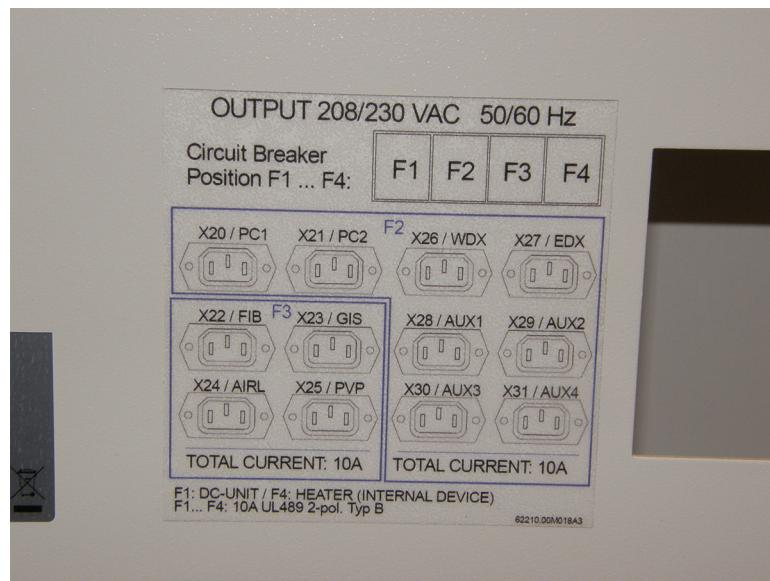


Figure 3-2: MCB and power output diagram

The ON / STANDBY / OFF buttons are at the front of the system.



Figure 3-3: ON / STANDBY / OFF buttons

3.4 System and electronics rack shield

The variation in laboratory temperature must comply with the site requirements.

The housing panels of the **eLINE Plus** should only be removed by service personnel who have completed the Raith Level 1 training course, in order to carry out service procedures. During the operation of the system, the shield panels must remain closed at all times.

The electronics are housed in an electronics rack. The rack shield must be closed during operation. The automated temperature regulation inside the shield is only maintained with the shield closed.



CAUTION

Service procedures inside the system shield, which do not form part of this manual and which require opening of the electronic units, may only be carried out by service personnel who have completed the Raith Level 1 training course.

3.5 Button panel

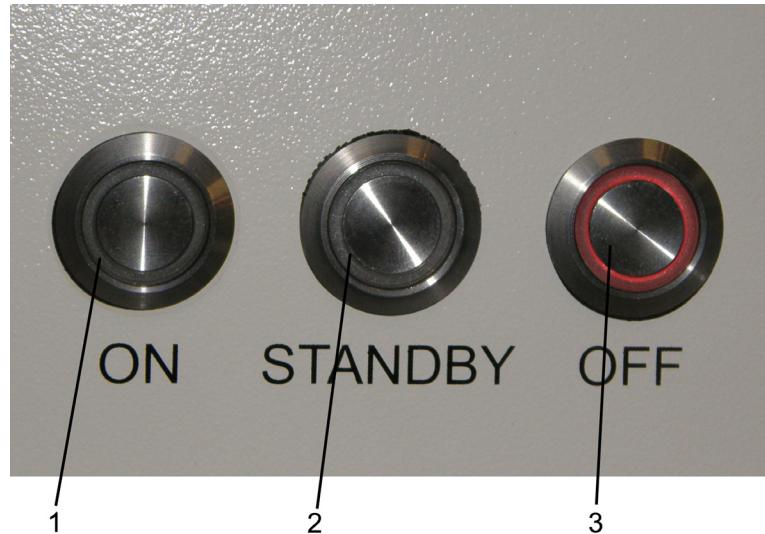


Figure 3-4: Button panel

Legend

- | | | | |
|----------|------------------------|----------|------------------------------|
| 1 | Green ON button | 2 | Yellow STANDBY button |
| 3 | Red OFF button | | |

Using the buttons in the button panel, the eLINE Plus can be either switched **ON**, **OFF** or put into **Standby** status. The buttons are illuminated and indicate the current status of the system. The **OFF** button will only switch off the main instrument, housed in the plinth. All electronics in the rack will remain on.

3.6 Load lock

Sample loading / unloading is performed quickly and easily by securing the samples directly onto sample holders. To minimize the time that the chamber is open, samples can be mounted off line onto sample holders.

The sample holders are equipped with sapphire inserts and are placed on a platform on the laser stage. The platform consists of three ceramic spheres, designed to match the positions of the sapphire inserts. This arrangement is designed for long-term stability and acts as a kinematic mount for the sample holder.

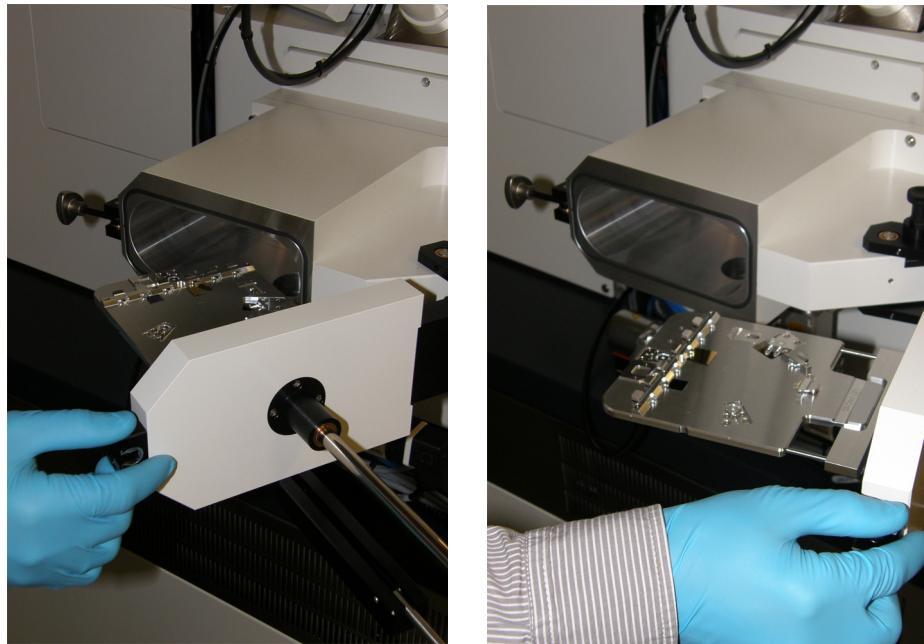


Figure 3-5: Fully opening the load lock door

3.7 Emergency OFF button

The eLINE Plus is equipped with one **Emergency OFF** button, which will interrupt the power supply to the system when pressed. The **Emergency OFF** button is situated on the right hand side of the system housing.

Only initiate the **Emergency OFF** button when either there is an immediate potential hazard to personnel or to prevent significant and imminent system damage, for example if there is danger of unavoidable water ingress to the system housing or significant water spillage in the installation area.

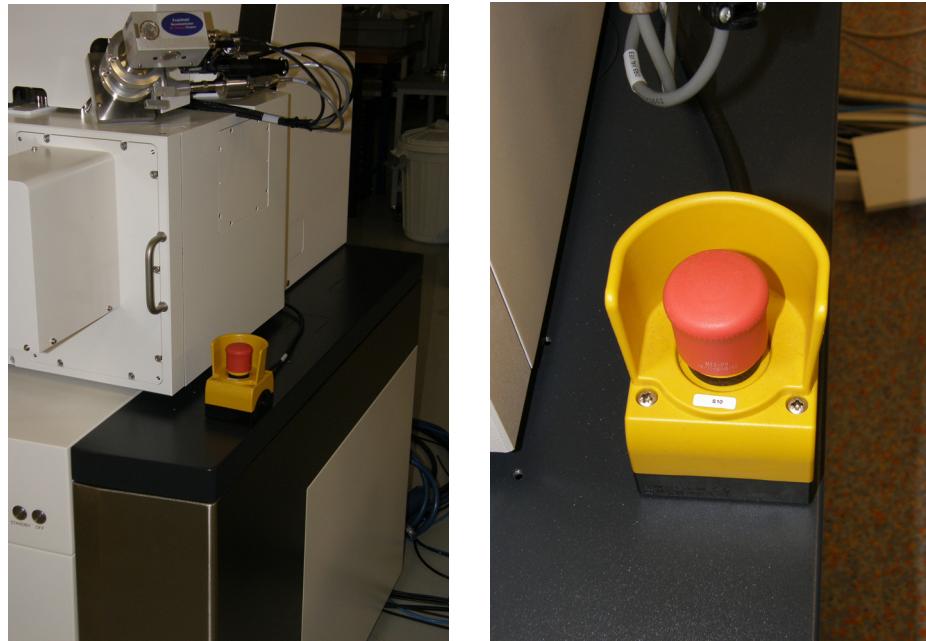


Figure 3-6: Emergency OFF button

3.8 Joystick



Figure 3-7: Joystick

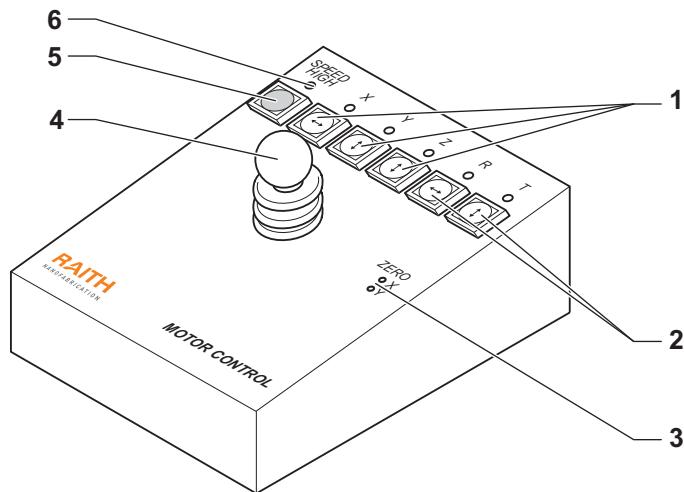


Figure 3-8: Joystick overview

Legend

- | | |
|--|--|
| 1 X, Y, Z- buttons to select the axis | 2 No function assigned for stage movement |
| 3 Potentiometer for fine adjustment of the joystick by Raith service personnel | 4 Control lever for moving the sample stage |
| 5 SPEED HIGH button to toggle between normal and high speed modes | 6 Green LEDs to indicate the currently selected mode |

Using the joystick, the sample stage can be moved in the X, Y and Z-axes. This is an alternative method to using the software commands. It is recommended to use the joystick when the sample stage has to be moved over large distances, for example to move a sample on the sample holder into the area of view, or when the coordinate system of the sample has not been defined.

The control lever (4) of the joystick has four movement directions with a step-less, continuous acceleration function in each direction:

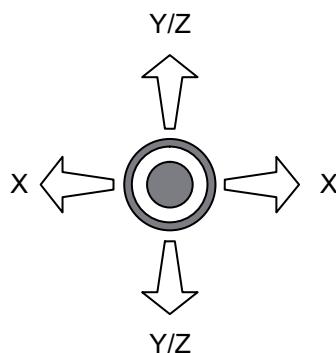


Figure 3-9: Movement directions and acceleration of the joystick

Pressing the X, Y or Z button (1) toggles between activation / deactivation of any axis, when moving the sample stage. LED (6) indicates which axis or axes are currently active.

The X and Y axes can be both selected at the same time and the sample stage will move simultaneous in both axes. As soon as the Z axis is activated, the X and Y axes are automatically disabled.

The joystick has two speed modes. The user can toggle between them via the SPEED HIGH-button (5). When the high speed mode is activated, the green LED above the SPEED HIGH-button will indicate that the high speed mode has been selected.

3.9 Electronics rack components

The 19" electronic units are placed into a rack. If a number of accessory options have been ordered, two electronics racks may be required. (⇒ *Electronics rack components* on page 3-10). The control panels of the individual units are described.



CAUTION

Crush hazard: There are sharp edges at the access doors, especially in the rack area, which may lead to injuries.

NOTICE

Only switch components on or off if directed to do so by Raith support.

To open the electronics rack shield door, follow these steps:



Figure 3-10: Opening the electronics rack door

- ▶ Slide the cover at the bottom of the door handle downwards
- ▶ Press the button behind the cover to release the door handle
- ▶ Turn the door handle counter-clockwise to open the shield door



Figure 3-11: Opening the electronics rack door

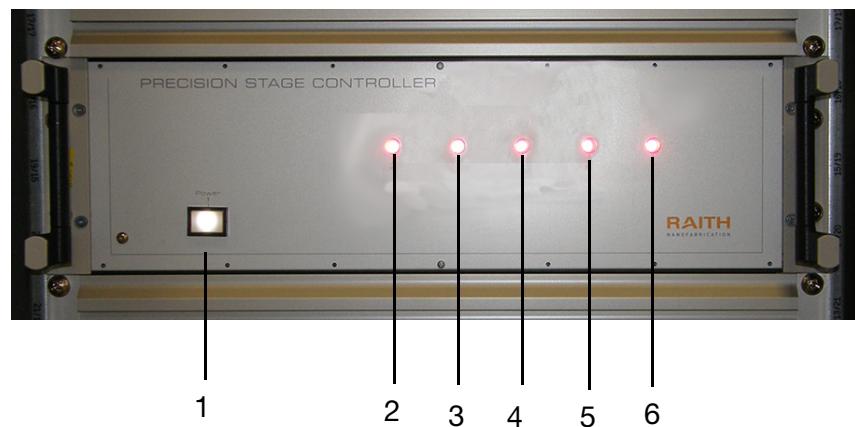


Figure 3-12: Stage control unit

Legend

- | | | | |
|----------|------------------------|----------|------------------------|
| 1 | Power switch | 2 | Control LED for X axis |
| 3 | Control LED for Y axis | 4 | Control LED for Z axis |
| 5 | No function assigned | 6 | No function assigned |

Control LEDs: Green = axis free, Yellow = axis moving, Red = axis locked



Figure 3-13: System computer closed



Figure 3-14: System computer

Legend

- | | | | |
|----------|--------------|----------|--------------|
| 1 | Reset button | 2 | Power switch |
| 3 | DVD drive | | |

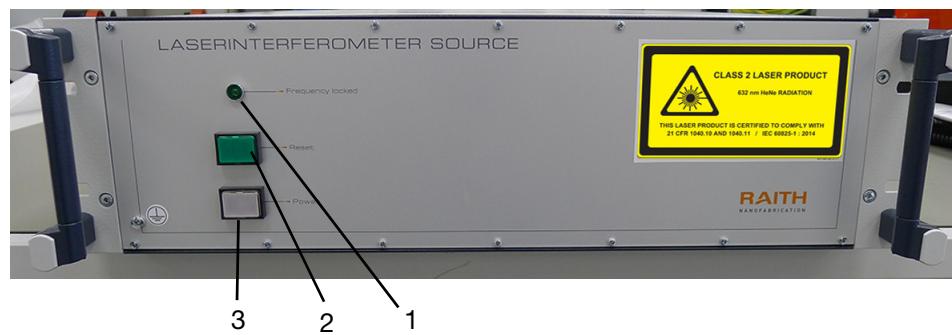


Figure 3-15: Laser interferometer source

Legend

- | | | | |
|----------|-----------------------------|----------|--------------|
| 1 | Frequency locked status LED | 2 | Reset button |
| 3 | Power switch | | |



Figure 3-16: Beam blanker

Legend

- | | | | |
|----------|----------|----------|--------------|
| 1 | Beam off | 2 | Reset button |
| 3 | 170 V on | | |

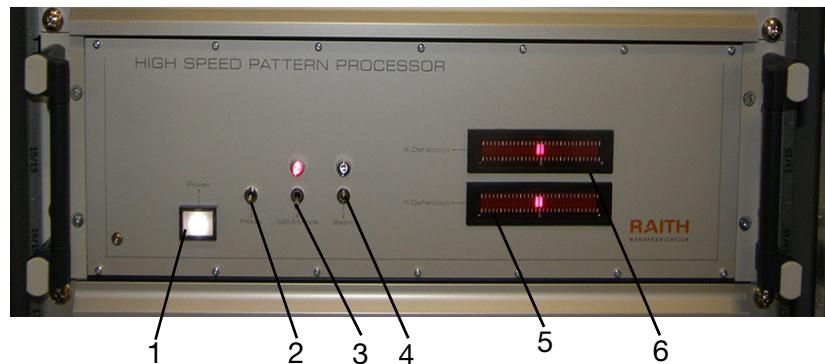


Figure 3-17: High speed patterning processor

Legend

- | | | | |
|----------|--------------|----------|--|
| 1 | Power switch | 2 | Reset button |
| 3 | SEM mode | 4 | Toggle between normal and inverted beam blanking |
| 5 | X-Deflection | 6 | Y-Deflection |

3.10 Computer and software

3.10.1 General

The eLINE Plus is equipped with a computer and a pattern generator controller running under the Microsoft Windows 7 operating system and two 23-inch wide screen flat panel monitors. The eLINE Plus can be entirely controlled by the user via the computer.

The control of the system is performed via the Raith **NanoSuite** software.
The following activities are carried out through the software:

- Load and unload sample procedures
 - Adjustment of the sample coordinate system
 - Design and composition of the structure layout
 - Optimization of the electron beam
 - Execution of patterning jobs
-



For further information about operation of the Raith **NanoSuite** software,
refer to the **NanoSuite Software Reference Manual** of the complete documentation package.

3.11 Basic principles of computer operation

Take particular note of the following basic principles, in order to ensure reliable functioning of the system computer and the display:

Operating system

- Only install Windows updates manually. Do not enable automatic updates.
- Do not update the Raith **NanoSuite** software if there are no serious reasons for it. In the case of software instabilities or software bugs that might be overcome by the latest service version, please contact Raith Support.
- Do not modify the following monitor parameters:
 - monitor resolution and refresh frequency for the images
 - the number of colors and the type of color palette
 - font type and size
- Do not activate a screen saver.

Hardware

- Do not install any additional hardware components.
- Do not connect any external hardware components that may affect the operation of the system. External data storage devices such as a USB memory stick or CD-drive are permitted.
- Do not connect any hardware components to connections which are used for the operation of the system.
- Do not adjust hardware components or the parameters for the corresponding driver.



For further information about the use of specific hardware components, contact Raith Support for advice.

Software

- Do not install any additional software.
If your network administrator requests additional software such as anti-virus program, consult with Raith support.
- Do not un-install any software.
- Do not adjust any driver settings.

3.12 Raith universal sample holder

3.12.1 General

For various samples, masks and wafers, which can be used for the **eLINE Plus**, Raith supplies specific sample holders. The design and construction of the sample holders are compatible with the high precision of the load lock and sample stage and to perform the required application functions. Specific sample holders are explained(⇒ Accessories on page 8-1)

The Raith sample holder is equipped with;

- Three sapphire kinematic mounts (⇒ Figure 3-18), for precise location of the sample holder on three ceramic spheres.
- Most sample holders have a Faraday cup to measure the electron beam current.

As standard, a universal sample holder is delivered with the system. There are also tools for fixing various types of samples.

3.12.2 Raith universal sample holder

The Raith universal sample holder can be used for various samples that can be fixed using the mounted tools.

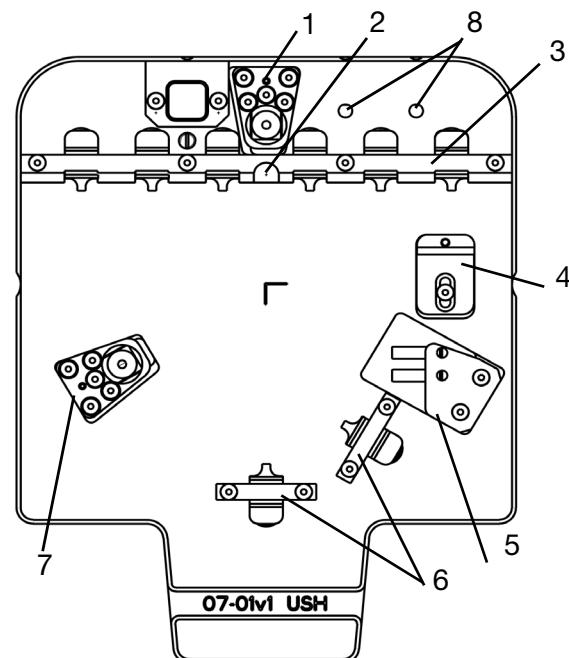


Figure 3-18: Universal sample holder with tools for fixing the samples

Legend

- | | | | |
|---|--|---|--|
| 1 | Adjustable kinematic mount no. 1 | 2 | Faraday cup for measuring the electron current |
| 3 | Clamps for wafer and wafer fragments up to 4 inch or 100 mm edge length. | 4 | Slide clamp to fix inclined samples at an angle of 45° or 90°. |
| 5 | Fixed kinematic mount no. 3 | 6 | Mounting clamps also for 2" wafers |
| 7 | Adjustable kinematic mount no. 2 | 8 | Holder for stubs |

Universal holder for small specimens up to 50 mm or 2".

- 13 mm stubs and other sample types.
- 45° sample mount for samples of 10 mm width and up to 10 mm height.
- 90° sample mount for samples of dimensions up to 10 mm x 7 mm.
- Sapphire inserts for improved position repeatability and long-term stability. Leveling not guaranteed.

Chapter 4 Safety

This chapter contains safety information, to which the user needs to pay particular attention when using the eLINE Plus.



⚠ CAUTION

Read this chapter in detail to avoid any injury to personnel and any instrument damage. Note all of the special safety hints before carrying out any actions described in the relevant chapters of this manual.



⚠ CAUTION

Users must be trained regularly by the system operator about emerging hazards (e.g. mechanical or electrical hazards, hazardous substances, noise, etc.).

The laser used in the eLINE Plus system is described as an embedded laser, in which the laser emission is not accessible to the user, so the system is classified as a **CLASS 2 LASER PRODUCT** ⇒ *Laser classification label* on page 4-9

4.1 Specific safety information

4.1.1 Installation of the eLINE Plus



The floor must have a sufficient load capacity ($> 1,000 \text{ kg/m}^2$ and $> 5 \text{ kg/cm}^2$) for transportation and installation of the system. The load capacity must be verified.

4.1.2 System shield



⚠ WARNING

Do not open the eLINE Plus system rack shield. Use only access doors when carrying out any required tasks.



Lockout / tag out required: If for any reason, access is required to any units or components behind the system shield, Lockout/ tag out procedures must be implemented before gaining access. (⇒ *Operation* on page 7-1)

4.1.3 High voltage hazards

High DC and AC voltages are present throughout various system components.



⚠ WARNING

High Voltage: Dangerous high voltages are present in the system. Only service personnel trained by Raith GmbH to Level 1 should perform any service or diagnostic tasks, which do not form part of this manual.

4.1.4 Magnetic fields



⚠ CAUTION

Magnetic field: Strong magnetic field intensities are emitted by the ion getter pump and vacuum gauges.

**DANGER**

Magnetic field: Persons with pacemakers or other implanted electronic devices must make themselves aware of the potential for magnetic field intensities emitted by the ion getter pump and vacuum gauges. The safety shield ensures that all personnel are at a safe working distance.

4.1.5 Ionizing radiation

**WARNING**

Ionizing radiation: X-rays are generated in the column and specimen chamber during operation. Observe local safety and X-ray protection regulations.

**WARNING**

Any modifications to the instrument, in particular those on the column, the specimen chamber, flanges, vacuum parts and the high voltage generator may reduce the radiation shielding.

It is important to check the dose rate around the instrument immediately after any such modifications. This should be done by an accredited testing agency and must comply with local regulator requirements.

X-rays are generated in the column and specimen chamber during operation of the electron beam lithography system. The system design limits the dose rate to less than $1\mu\text{Sv}/\text{h}$ at a distance of 0.1m from the surface of the electron beam lithography system.

Each instrument is rigorously tested for X-ray emissions by RAITH and the result is certified on the Test Certificate for each instrument. This Certificate is only valid for the delivered system configuration.

The user of this electron beam lithography system must observe the specific regulations of the country in which the system is installed.



For further information, refer to the *Technical Description* and the *Site Preparation Guide*.

4.1.6 Mechanical hazards



⚠ CAUTION

Crush hazard: Care is required when opening or moving access doors or the load lock lid, to prevent the risk of crush injuries.



⚠ CAUTION

Crush hazard: There are sharp edges at the access doors and inside the system shield (access via access doors), especially in the rack area, which can lead to injuries.



⚠ CAUTION

Trip hazard: Obstacles at floor level, such as cables or pipes may present a trip hazard.



⚠ CAUTION

Ensure that the Raith sample holder is not dropped during handling, to avoid foot injuries.



Wear suitable protective footwear (e.g. class S1 for 100 J), fulfilling any safety requirements described.

4.2 Ergonomic hazards



⚠ CAUTION

Some system components are heavy.

4.2.1 Noise

The noise level of the overall system is <70 dB(A)

4.2.2 High pressure

The eLINE Plus vacuum chamber is not a pressure vessel, within the meaning of the directive 97/23/EC. The user must ensure that the chamber is not used at pressures above 0.5 bar.

4.2.3 Chemical hazards

Cooling agent (water chillers)



⚠ CAUTION

Risk of cold burns or frostbites if exposed to refrigerant leaks.

Algicide (cooling water)



⚠ CAUTION

Irritant substance: Wear eye protection. Algicide may cause severe eye or skin irritation.

Gas injection system (optional)

The Gas injection system is used in conjunction with certain hazardous substances. Solid state substances are in a sealed reservoir. All reservoirs containing precursors are situated in the assembly within the vacuum housing region for the GIS. During operation, any precursor gases exiting will be pumped away by the system.

The precursors must be packed, labeled and transported corresponding to the legal provisions relating to hazardous goods (e.g. ADR, IATA).

The occupational exposure limit values of the hazardous substances (corresponding to your national legal provisions) must be met, especially if substances may potentially escape to atmosphere (e.g. exchanging the reservoirs).

Comply with local regulations for exposure limits in exhaust air regarding the specific hazardous substances.

In any case, the user should be aware of hazards related to any of these substances, in case of accidental release.



⚠ WARNING

Toxic substances: Exposure to toxic materials may cause immediate and serious, potentially fatal, toxic effects.



⚠ WARNING

Harmful or irritant substances: Exposure to harmful or irritant substances may cause irritation or inflammation to the eyes, skin or respiratory system.

**WARNING**

Corrosive substances: Contact exposure with either a gaseous, liquid or solid corrosive substance can cause permanent damage to human tissues, such as eyes, lungs and skin.



Wear suitable personal protection equipment (e.g. protective gloves, eye protection) during handling of hazardous substances. Use suitable skin cleanser and skin protection. A skin protection plan must be in place.



Extraction required: The exhaust of the pumping unit of the eLINE Plus must be connected via tubing to a suitable extraction system.



Environmental hazards: Comply with local regulations regarding release to the environment and disposal.



Follow all safety notes and hazard warnings provided with the reservoirs and the MSDS sheets, which are listed in the Appendix of the *G/S Manual*.



For more information, consult the *G/S Manual* and *Site Preparation Guide*.

4.2.4 Use of other hazardous substances



Hazardous substances: The user must declare all hazardous substances that have been used inside the system, before any maintenance tasks commence.

A list of all hazardous substances that are used with the system must be provided by the user.

4.3 Safety precautions for Class 2 laser operation

No special safety precautions are required to protect the eyes of users of a Class 2 laser beam. When the system is in its normal operating configuration, the laser beam should not normally be visible or otherwise accessible to the user. Even so, the beam, transmitted by fiber light guide, is defined as a Class 2 laser beam.

Only continuous wave visible wavelength (400 nm to 700 nm) lasers are placed in Class 2. This means that even if it is viewed accidentally, the blink reflex will limit the exposure to 0.25 seconds or less. To conform to Class 2, the laser output must be 1 mW or lower, when the beam is spatially coherent (for example when it emerges from the laser cavity). When it is transmitted along the fiber light guide, it loses its coherence and is even less hazardous.

The only way that injury can occur is if an individual would deliberately stare into the beam and intentionally overcome the blink reflex.

There are no special eye protection measures required for Class 2 laser operation, since accidental injury is not possible.



CAUTION

Do not look directly into the beam emerging from the fiber. The fiber should be directed towards a white surface during the cleaning of the fiber, described later in this manual.

The laser module and the optical assembly are enclosed in an interlocked protective housing, the LIS-1F laser interferometer source, during normal operation.

4.3.1 Laser classification label

The laser is classed as an embedded laser, in which the laser emission is not accessible to the user, so the system is classified as a **CLASS 2 LASER PRODUCT**. The certification label is positioned on the front panel of the laser power source.

Certification Labels:

The **CLASS 2 LASER PRODUCT** classification only applies to the laser system in its normal operating configuration. The following label is positioned on the outside of the protective housing and warns of the hazard that may occur when the housing is in place.



Figure 4-1: Protective housing laser hazard label

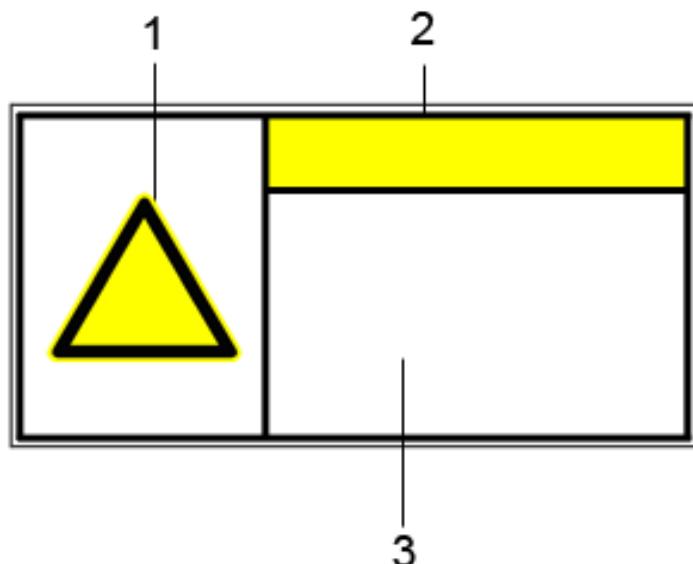
4.4 General safety information

4.4.1 Instrument safety notices

In addition to the warnings contained in this document, operators must also observe all warnings and instructions on all notices fixed to the instrument or its components.

SEMI Warning Label Structure

Warning labels are fixed to the instrument. The label includes a symbol that is specific to the hazard present and a signal word that indicates the severity of the consequences that may arise from the hazard. A description of the hazard and the possible personal injury risk, if any, are also included.



Label area 1. Specific hazard symbol

Label area 2. Signal word

Label area 3. Description of the nature of the hazard

4.4.2 Label positions on the eLINE Plus

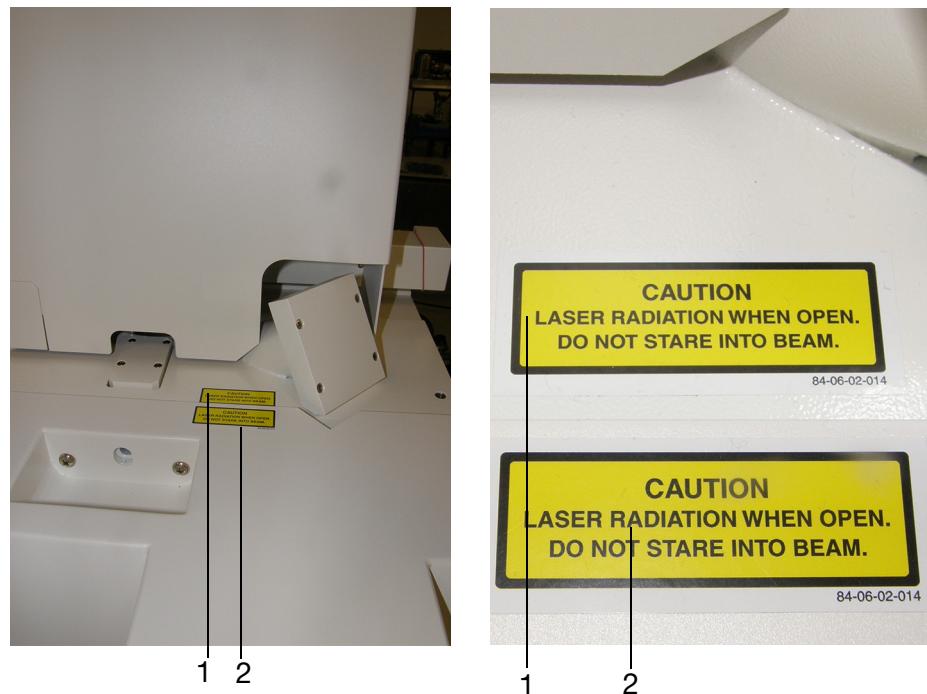


Figure 4-2: Caution labels on the front load lock door

Position 1, 2



CAUTION

Laser radiation when open. Do not stare into beam.

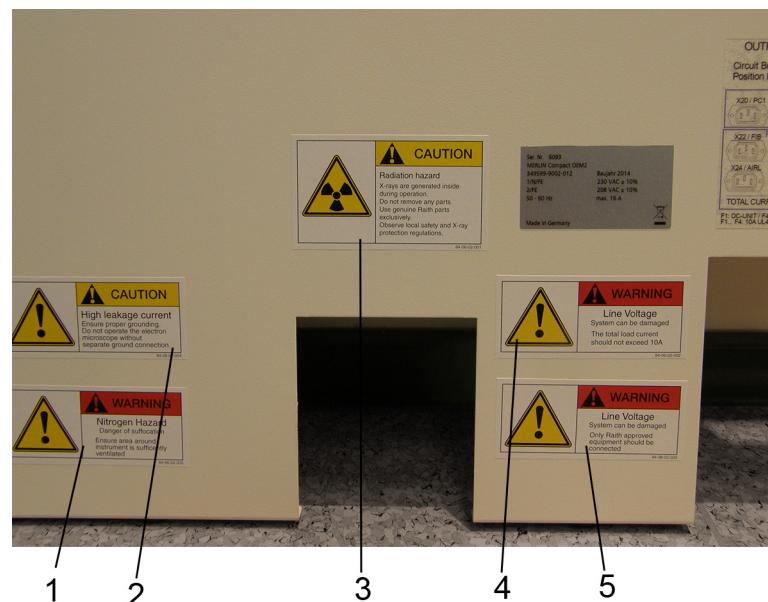


Figure 4-3: Label positions on the rear panel

Position 1



WARNING

Nitrogen hazard: Danger of suffocation. Ensure area around instrument is sufficiently ventilated.

Position 2



CAUTION

High leakage current: Ensure proper grounding. Do not operate the system without separate ground connection.

Position 3

**⚠ CAUTION**

Radiation hazard: X-rays are generated inside during operation. Do not remove any parts. Use genuine Raith parts exclusively. Observe local safety and X-ray protection regulations.

Position 4

**⚠ WARNING**

Line Voltage: System can be damaged. The total load current should not exceed 10A.

Position 5

**⚠ WARNING**

Line Voltage: System can be damaged. Only Raith approved equipment should be connected.



Figure 4-4: Label positions inside the electronics rack.

Position 1



⚠ CAUTION

Laser radiation: Class 2 laser radiation. The laser is embedded inside a housing and inaccessible to the user in normal operation.

4.4.3 Protective clothing



Wear protective clothing



Wear eye protection



Use protective gloves

Safety clothing appropriate to the general working environment must be worn at all times, particularly when handling components which may have been contaminated with irritant, corrosive or toxic materials.

4.4.4 Environment

The installation requirements and the environmental conditions required for the safe operation of the system are described in this document (⇒ *Environmental conditions* on page 1-3).

4.4.5 General maintenance



General maintenance tasks described in this manual should only be completed by fully trained operators. Use of the manual by other unqualified persons may lead to serious injury. This training requirement applies to all tasks described herein.

Only suitably qualified operators should perform the maintenance tasks described in this manual. Substituting parts or performing any unauthorized modification to the instrument may result in a safety hazard. Compliance with all local and national requirements for electrical and mechanical safety is required.

4.4.6 Preventive maintenance

The routine diagnostic and preventive maintenance procedures described in this manual must be conducted in accordance with the safety information provided herein. This instruction applies to maintenance tasks.

4.4.7 Use of chemical reagents and lubricants

Raith GmbH is not aware of any substance that is more hazardous, when used in conjunction or in contact with the system or its components, compared with its use when not in conjunction or contact with the system but this possibility is not precluded.

4.4.8 Hazardous waste material

The instrument user is responsible for the collection and safe disposal of any waste materials that may present a hazard to other operators or service engineers during diagnostic and service tasks. The instrument user should note that potentially hazardous waste materials must be properly disposed of, in accordance with national and local guidelines.

4.4.9 Cleaning and decontamination

It is the responsibility of the user to ensure the complete and appropriate decontamination of any hazardous material that has been used in the operation of the instrument, before any diagnostic or service tasks are carried out, to protect the service engineer from risk of exposure to this material.

This requirement includes, but is not limited to, risk of exposure to irritant, corrosive or toxic liquids, solids or gases that may present a risk of injury to the eyes, respiratory system, skin or any other tissues.

4.4.10 Return of components and materials

Raith GmbH must be notified if equipment being returned has been in contact with any hazardous substances. Raith GmbH will only accept delivery of equipment with a completed Return of Goods document. The equipment must be completely decontaminated, if it has been used in conjunction with hazardous substances, otherwise delivery can not be accepted.

4.4.11 Disposal

Safe disposal of all equipment and any decommissioned components must be in accordance with local and national safety and environmental requirements.

4.5 Electrical power, gases and cooling water requirements



All power, gas and cooling water input / output requirements are listed in the *Site Preparation Guide*.

The *Site Preparation Guide* document is specific to your region, particularly with respect to the electrical requirements and so this information is not specifically included in this manual.

The installation of the instrument can only proceed when the requirements of the Site Preparation Guide have been met.



After installation and acceptance of the instrument, any changes made to electrical, gas or cooling water supplies to the instrument must comply with the *Site Preparation Guide*.

4.6 Correct use

The eLINE Plus is used for structuring and measuring suitable samples, masks and wafers (all referred to as “samples”), of dimensions up to:

- 50 mm or 2”
- 10 mm height

It is only permitted to use Raith sample holders for each sample. The instructions that describe the fixing of the samples onto the sample holders must be followed. If improper usage results in damage or injury, no liability will be accepted by Raith.



For further information about suitable sample mounting, consult Raith support.

4.7 Emergency OFF button

The eLINE Plus is equipped with one **Emergency OFF** button. Press the **Emergency OFF** button in the event of any potential hazard to persons, or if serious damage to the system might occur.

Only press the **Emergency OFF** button in case of emergency. To turn off the system normally, refer to \Rightarrow *Switching off the system* on page 7-35.

4.8 Emergency shutdown

In the event of danger to personnel or to avoid serious damage to equipment, press the **Emergency OFF** button. (\Rightarrow *Emergency OFF button* on page 4-16).

In case of malfunction or breakdown, refer to \Rightarrow *Troubleshooting* on page 10-1. If problems persist, call your local Raith service partner or Raith support line.

After fault rectification, power failure or loss of the compressed air supply, the system needs to be reset, before switching the system back to normal operation.

4.9 Operation

Follow local regulations regarding protective clothing and the working instructions related to the class of cleanroom.

- Do not open the **eLINE Plus** rack shield, unless directed to do so by Raith support.
- Never carry out manual operation of the load lock or change any settings or parameters for the load lock unless directed to do so by Raith support. Always follow the instructions of the Raith support team carefully. When the load lock is operated manually, some safety measures or devices may be over-ridden or switched off. Errors in manual operation can lead to serious damage to the system.
- During operation, avoid any collision of the sample or the sample holder with the e-beam column. Any collision can damage the e-beam column, sample and sample holder.
- Only use materials which are suitable for operation in the **eLINE Plus**. Unsuitable materials can cause outgassing when used over prolonged periods, which may damage the electron column.
- Only use sample holders from Raith, as these have been specifically designed for use in the **eLINE Plus**, to ensure that they are compatible with the high precision of the load lock and sample stage and that they will perform the required application functions.
- Always ensure that the sample and sample holder fit together correctly and fix the samples according to the instructions. Samples which do not fit onto the chosen sample holder, or are not fixed properly, may move in an uncontrolled way, may fall off the sample holder or may collide with other parts of the system, which can lead to damage of the sample, sample holder or system.
- Keep the samples and sample holders dust-free and away from any dirt. Dust and dirt can outgas under the electron beam, leading to degradation of the vacuum system, which may take a few days to return to normal:
- Always use suitable rubber gloves when handling the sample and sample holder.
- Clean any contamination off the sample and sample holder before inserting it into the load lock.
- Avoid contact between any metallic objects and the samples or sample holder, to prevent damage to surfaces. Only use plastic tweezers when handling small samples.
- Always transport the Raith sample holders in the transport boxes supplied, to protect them from jarring and from falling over.
- Store the sample holders only in the transport boxes or in the sample holder chamber of the **eLINE Plus**, to protect them from dust and contamination and to store them safely.

4.10 Decommissioning and disposal

The decommission and disposal of the eLINE Plus and its individual components may only be carried out by Raith.

Chapter 5

Transport and storage

This chapter will give guidance on transporting and storing the **eLINE Plus** and its individual components.

5.1 eLINE Plus

The transport of the **eLINE Plus** and its individual components must be exclusively carried out by Raith and its authorized partners.

5.2 Raith sample holder

Each of the Raith sample holders is delivered in a specific transport box. If the transport box has a transport lock, the user must deactivate the transport lock first, before taking the sample holder out of the transport box.

Always transport the Raith sample holders inside their transport box with the transport lock activated, this will protect them from jarring and falling over.



Refer to the sample holder manual.

Chapter 6

Commissioning

The installation and commissioning of the eLINE Plus must be carried out exclusively by Raith or one of their authorized partners.



For detailed information about installation of the eLINE Plus, including the spatial requirements and the required technical supplies, consult the corresponding *Technical Description* and *Site Preparation Guide*.

Chapter 7

Operation

This chapter gives an overview of the basic operations required to carry out tasks on the eLINE Plus.

7.1 Switching on the system



Ensure that the electrical, gas and cooling water supplies are functioning before switching on the system. Ensure that the **Emergency OFF** button is enabled, with the stop button released (out). Ensure that power is supplied to the system.

- ▶ To avoid any electrical overload during switching on the system, open the rack doors and switch off all electronics rack components using the accessible power switches (⇒ *Electronics rack components* on page 3-10).

Turn the main switch at the rear of the instrument from OFF to the ON position by turning it 90 degrees clockwise. Then turn on the power supplies of the electronics rack(s), by pushing the green button, as shown below.

NOTICE

Power will now be supplied to the electronics rack.

- ▶ Ensure that all the breakers are switched on at the rear of the instrument.

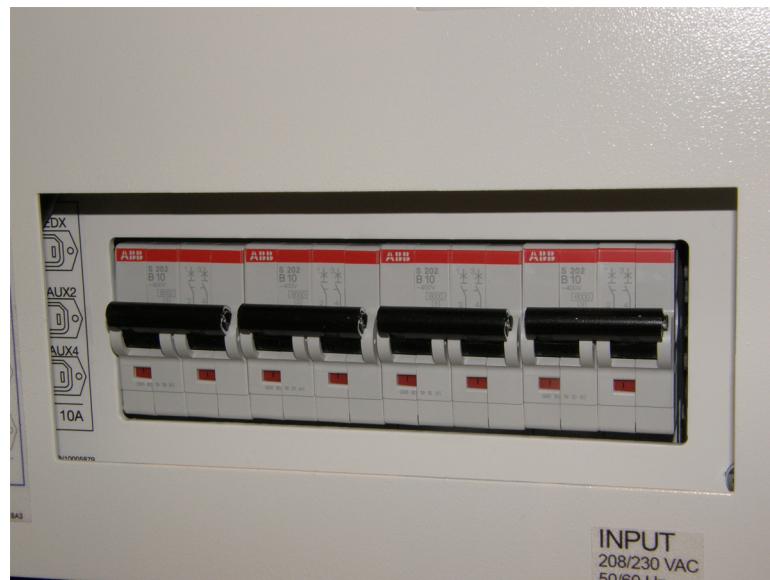


Figure 7-1: Breaker switches at the rear of the instrument

NOTICE

The instrument is now in **STANDBY** mode and the system is still pumping.

- At the front of the instrument, the **OFF** button is still active and illuminated in red.



Figure 7-2: ON/STANDBY/OFF buttons on the front panel

- Press the **ON** button. Once the instrument is fully switched on, the button will be illuminated in green.



Figure 7-3: ON button at front panel

When the **eLINE Plus** is ready:

- the Windows desktop will be displayed on the monitor



The computers are automatically started when the **eLINE Plus** is switched on. If a computer has been switched off inadvertently, it will need to be switched back on again.

Open the right rack door to gain access to the rack mounted computers.
Open the right door of the computer and press the start button.

- ▶ Switch on all electronics rack components.

7.1.1 Logging on to the Windows system

- ▶ The Login to the WindowsTM operating system occurs automatically.
- ▶ If automatic login does not occur, log in using personal login details or the default login.

7.1.2 Starting the Raith NanoSuite software

Start the Raith NanoSuite software with a double click on the icon  on the desktop.

The eLINE Plus Login dialog will open:

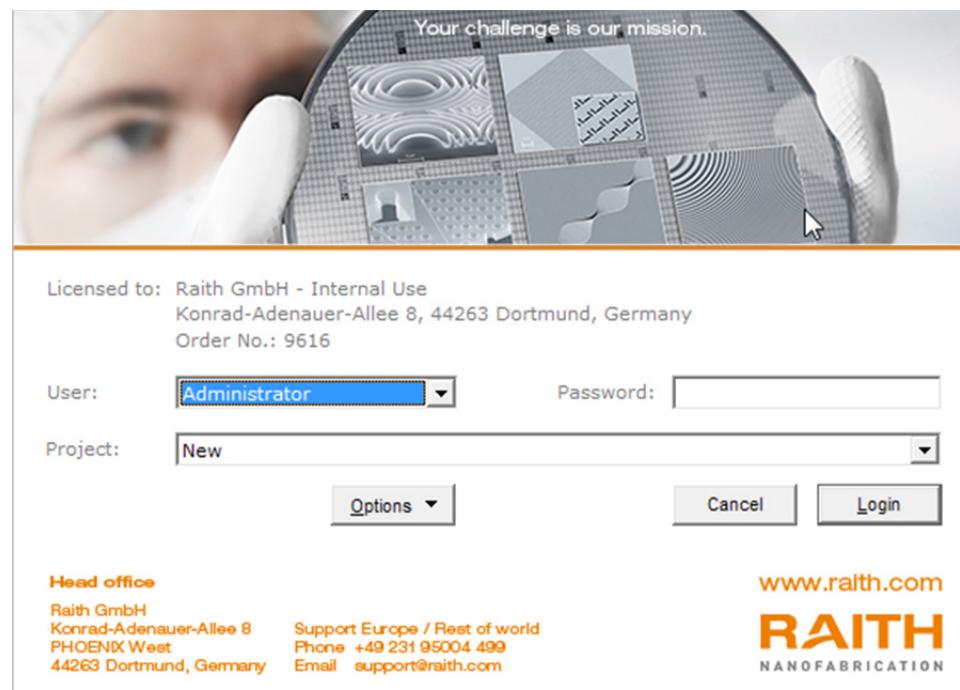


Figure 7-4: eLINE Plus Login dialog

- ▶ Enter personal login data or the default login **User: training, Password: training**.
- ▶ Go to **Project** and select **New** from the dropdown list to start a new project.
- ▶ Click on **Login**.

The Raith NanoSuite software will start, displaying the user interface.

7.2 Exchanging samples via the front door

The **Unload** and **Load** procedures will be explained in detailed steps.

7.2.1 Unload procedure via the front door

NOTICE

Exchanging samples is a manual procedure, so it is important to understand and follow the steps outlined very carefully, otherwise system damage may occur. The **Unload** and **Load** procedures are partly controlled by the software, but the opening and closing of the front door must be carried out by the user.

The software automatically drives the stage to the required positions for the exchange and controls the pump-down and vent procedures.

Whenever user intervention at the load lock is required, software prompts are displayed to guide the user through the next step.

The overall progress, as well as the initial steps, are displayed in an **Unload / Load via load lock** window.

STEP 1: Initiating Unload procedure

- ▶ Open the **Sample Exchange** window in the **NanoSuite** software. Go to **Sample exchange via front door** and press the **Unload Sample** button. This will initiate the unload sample procedure, which consists of a step by step process, in which the user is guided by software prompts to take certain manual actions for the manual sample exchange.
-



⚠ CAUTION

Crush Hazard: Do not touch the stage, unless it is required by a software prompt. Always ensure that the sample stage is stationary. Do not put your fingers between the mirror and the interferometer, otherwise your fingers may become trapped.

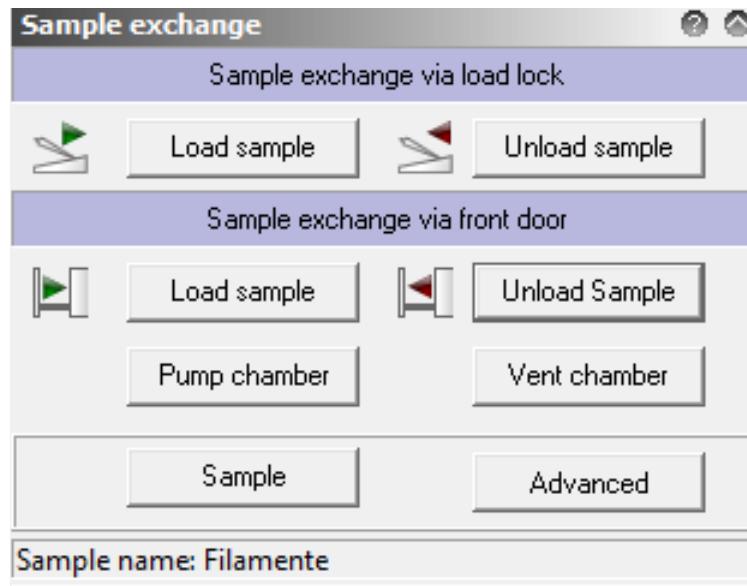


Figure 7-5: Initiating the Unload procedure via the front door

- A software prompt will be issued to inform the user that this procedure will take 10 minutes. Confirm with OK.

The **Unload via front door** window will open, showing the overall progress of the unload procedure. The first step to **Initialize** the procedure is performed by the software, which is to check that the column chamber valve is closed.

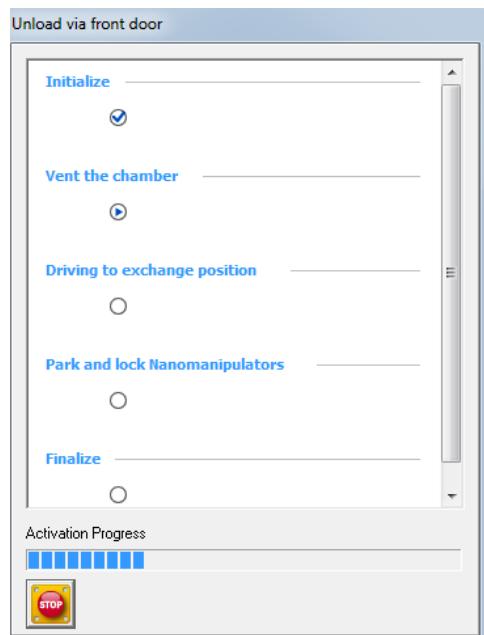


Figure 7-6: Unload progress initiated

- The software will now perform the automatic procedure to complete the Unload process, including closing the valve to the column, driving the stage into the exchange position and venting the stage chamber.

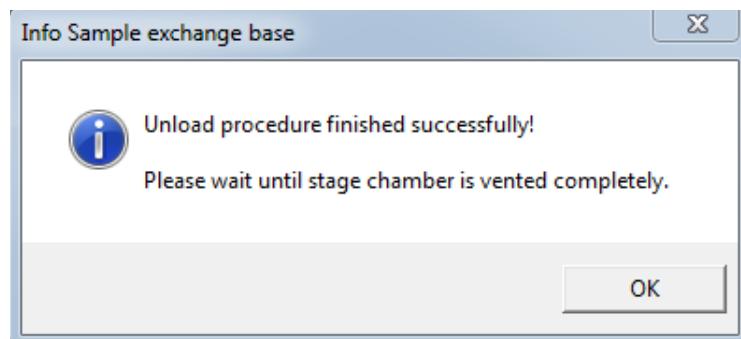


Figure 7-7: Unload procedure via front door completed

- Once the **Unload** procedure has been completed, the front door can be opened. Pull the front door towards you.

STEP 2: Opening the front door



⚠ CAUTION

The vacuum chamber is vented by nitrogen during the vent and unload procedure. When opening the vacuum chamber, be aware that breathing deeply at the open door can lead to dizziness or even unconsciousness. Keep your distance when opening the vacuum chamber and ensure that the room is well ventilated. Keep the front loading door open as briefly as possible. There is a 30 minute timeout for the nitrogen supply. Be aware that even without manually opening the front loading door, nitrogen might escape around the door when the chamber is vented, due to the gas pressure inside.

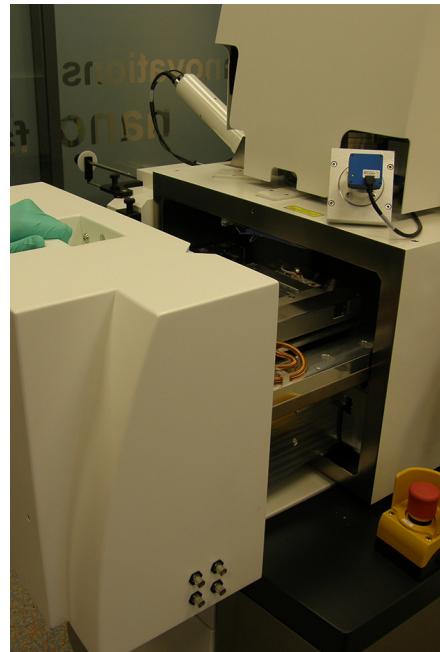
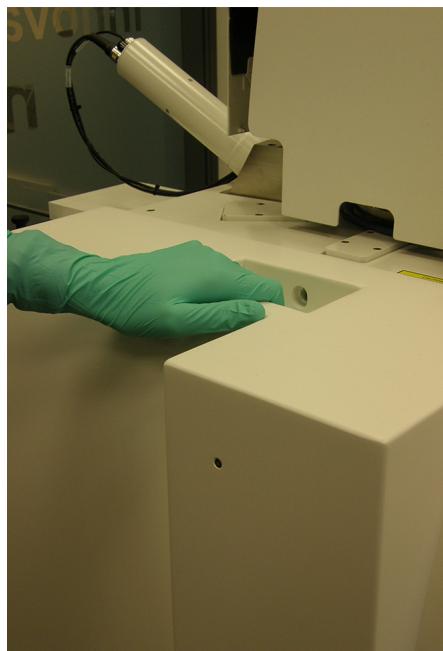


Figure 7-8: Opening the front door

- ▶ Take out the sample holder and place it into the sample holder carrier.
- ▶ Exchange the sample(s).

7.2.2 Load procedure via front door

- ▶ Always use a suitable sample holder to load samples into the system. After fixing the samples onto the sample holder, place it onto the stage.
- ▶ Close the door and keep one hand on the door, so that it does not slide open again.
- ▶ Click on **Load Sample via Front Door** in the **Sample Exchange** window. This will initiate the **Load** procedure.
- ▶ A software prompt will be issued that this **Load** procedure will take 30 minutes. Confirm with **OK**.

NOTICE

Press with one hand against the front door until some vacuum has been established, otherwise the front door may slide open again. Once a noise is heard, which is the valve opening between the turbo-molecular pump and the roughing pump, sufficient pre-vacuum has been established to keep the front door closed.

- At the end of the **Load** procedure, a software prompt will ask the user to enter a sample name.

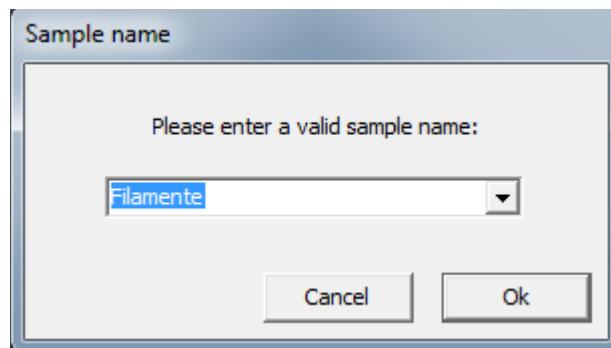


Figure 7-9: Entering a sample name

- At the end of the **Load** procedure, a software prompt asks the user if the most recent column parameters should be used again.

7.2.3 Other functionalities of Unload/Load via front door

- The **Unload/Load via front door** also enables other functions:

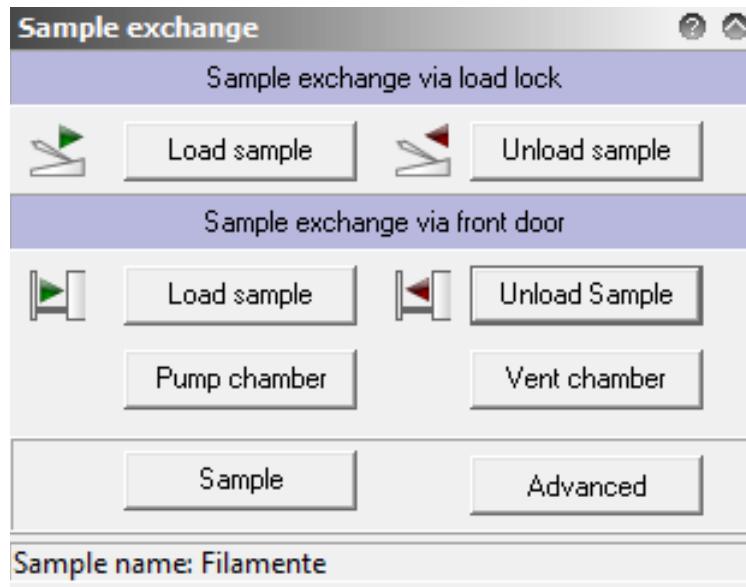


Figure 7-10: Overview of functionalities of the Sample exchange window

Sample exchange via front door

Button	Function
Load Sample	To load a sample via the front door. (\Rightarrow Load procedure via front door on page 7-8)
Unload Sample	To unload a sample via the front door. (\Rightarrow Unload procedure via the front door on page 7-5)
Pump chamber	To pump down the chamber without checking the stage position. Note: The user will be prompted to enter a sample name and will be asked if the last saved column parameters should be re-activated.
Vent chamber	To vent the chamber with nitrogen, without checking the stage position.
Sample	The sample name can also be entered directly by clicking on Sample .
Advanced	Only accessible for Administrators. The Administrator can perform single steps for the Load and Unload procedure. (\Rightarrow Troubleshooting on page 10-1)

NOTICE

Use **Pump chamber** with care. Ensure that the stage is still in the exchange position and the chamber is vented with nitrogen. The exchange position ensures that the stage is in a safe position where neither the interferometer mirror nor the sample holder can be damaged.

NOTICE

Use **Vent chamber** with care. This option is chosen to save time, as a significant part of the sample unload procedure time is taken to drive the stage to a safe position.

7.3 Exchanging samples via the load lock (optional)

The **Unload** and **Load** procedures will be explained in detailed steps.

NOTICE

Exchanging samples is a manual procedure, so it is important to understand and follow the steps outlined very carefully, otherwise system damage may occur. The Unload and Load procedures are partly controlled by the software, but the changes to the load lock, such as opening and closing the load lock, opening and closing the valve, moving the transfer rod, must be carried out by the user.

The software automatically drives the stage to the required positions for the exchange and controls the pump-down and vent procedures.

Whenever user intervention at the load lock is required, software prompts are displayed to guide the user through the next step.

The overall progress, as well as the initial steps, are displayed in an **Unload / Load via load lock** window.

7.3.1 Unload procedure via load lock



It is important to be familiar with Chapter 2, **Functional Principle**, particularly the load lock drawing and identification of all parts of the load lock.

STEP 1: Initiating Unload procedure

- ▶ Open the **Sample Exchange** window in the **NanoSuite** software. Go to **Sample exchange via load lock** and press the **Unload Sample** button. This will initiate the unload sample procedure, which consists of a step by step process, in which the user is guided by software prompts to take certain manual actions for the manual sample exchange.

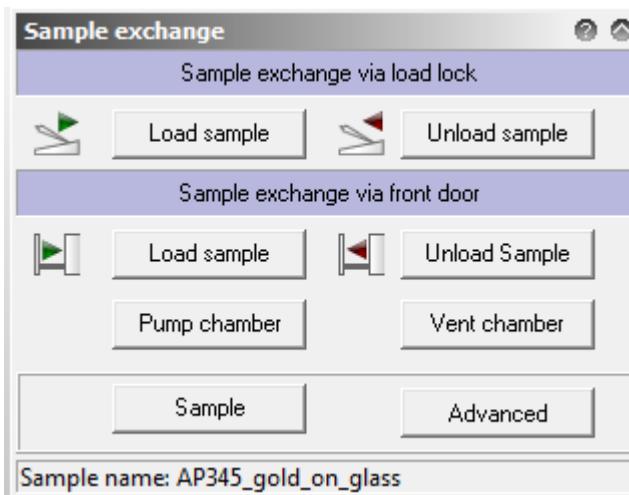


Figure 7-11: Sample exchange via load lock

- ▶ Click on **Unload sample**, which will initiate the unload procedure. The overall duration will be approximately 8 minutes. Confirm with **OK**.

NOTICE

Some parts of the procedure must be carried out manually by the user and some are carried out by the software. Throughout the full procedure, the software will display prompt messages, to guide the user through the process, which will need to be confirmed.

- ▶ The **Unload via load lock** window will open, showing the overall progress of the unload procedure. The first step to **Initialize** the procedure is performed by the software, which is to check that the upper column valve is closed.



Figure 7-12: Unload progress- Initialize

- ▶ Once the software has checked that the upper column valve is closed, the first software prompt to the user is displayed, directing the user to close the load lock door. It should normally be still closed from the last loading procedure, but it is safer to double check it. Turn the screw-knob, situated at the load lock, clockwise to close it.

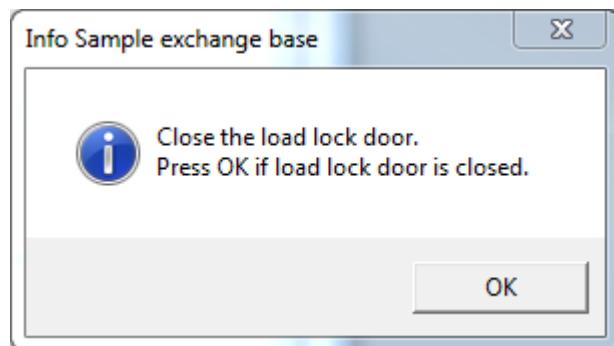


Figure 7-13: Software prompt to close the load lock door

NOTICE

Ensure that the screw-knob, situated at the load lock, is turned hand tight all the way in to lock the load lock door firmly. This will ensure that the seal of the door is firmly in place.

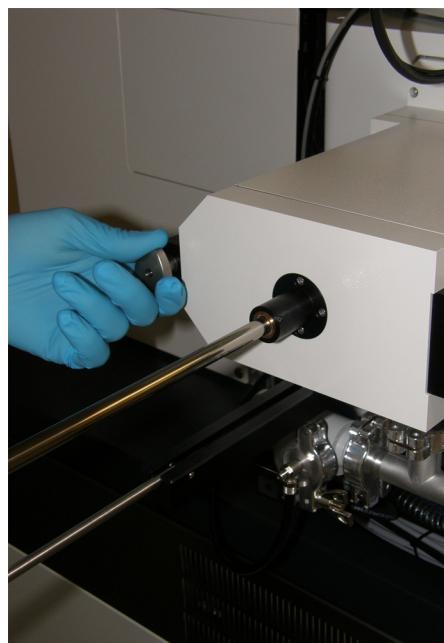


Figure 7-14: Checking that the load lock door is closed

- Once checked, confirm the software prompt with **OK**. The Column Stop will now be initiated by the Unload procedure.

STEP 2: Moving sample holder into the upper exchange position

- The stage is now moved to the upper exchange position in X/Y/Z. The Z stage is moved first, followed by the X/Y stage.

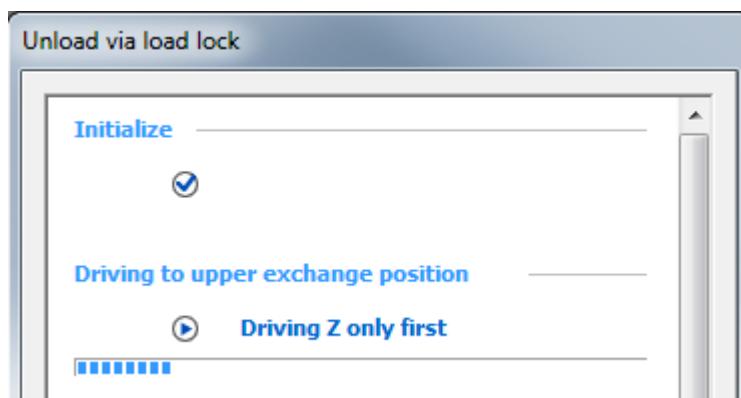


Figure 7-15: Unload progress - Z stage moving

- The current stage positions can be seen in the **Coordinates** window.

Coordinates			
● X:	42.750000 mm	U:	42.750000 mm
● Y:	-19.067000 mm	V:	-19.067000 mm
● Z:	21.840 mm	W:	11.660 mm

Figure 7-16: Moving down the Z axis to the transfer position

- The LED light for the Z axis is green, as it is currently moving downwards. The X and Y axis LED lights are red, as they are locked during this procedure in order to avoid any accidental movement via the joystick. It is important that the load lock transfer position is reached to enable the unload procedure via the transfer guide.
- As soon as the load lock transfer position is reached, all axes will be disabled and displayed with red LED lights.

Coordinates			
● X:	36.972000 mm	U:	36.972000 mm
● Y:	-0.797000 mm	V:	-0.797000 mm
● Z:	18.000 mm	W:	15.500 mm

Figure 7-17: Transfer position is reached and all axes are disabled

- The pump down of the load lock is automatically initiated by the software. A noise can be heard when the pumps are activated. The load lock is pumped to obtain a vacuum sufficient to open the load lock valve.

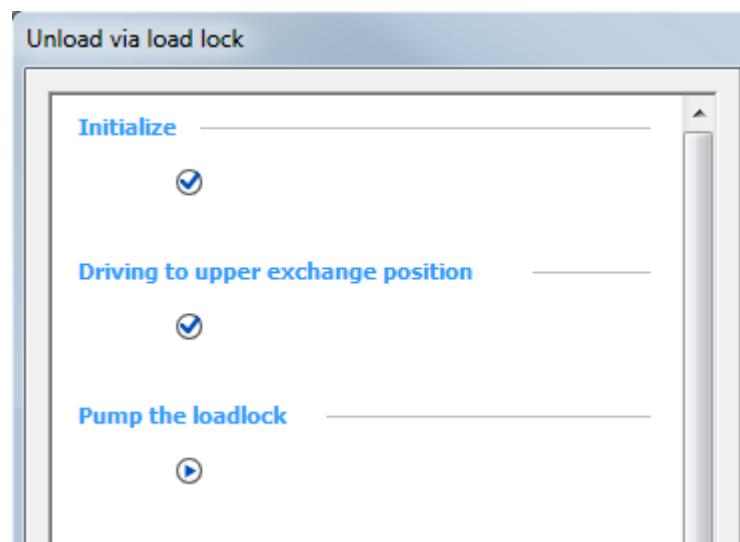


Figure 7-18: Unload progress - pumping the load lock

The icon indicates the currently active step, the icon indicates a completed step.

The Load procedure can be stopped at any time by pressing **STOP**.

STEP 3: Opening the load lock valve

- A software prompt will be displayed, indicating that the load lock is ready and the load lock valve can be opened manually.

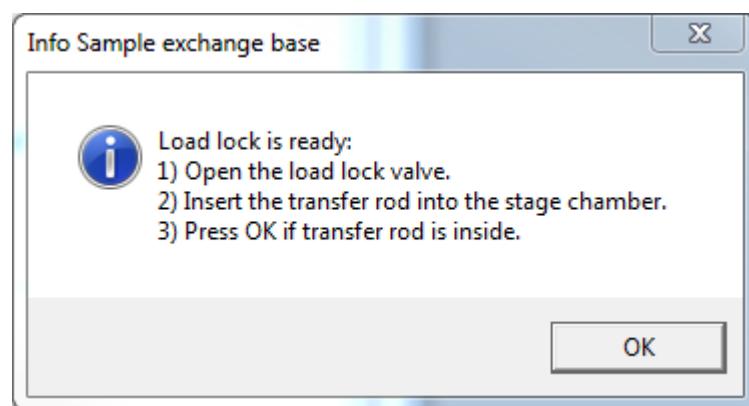


Figure 7-19: Software prompt to open the load lock valve and to insert the transfer rod

- The load lock valve can now be opened. Firstly, pull the knob upwards to allow the lever to be moved. Move the lever from **LOCKED** to **OPEN**.

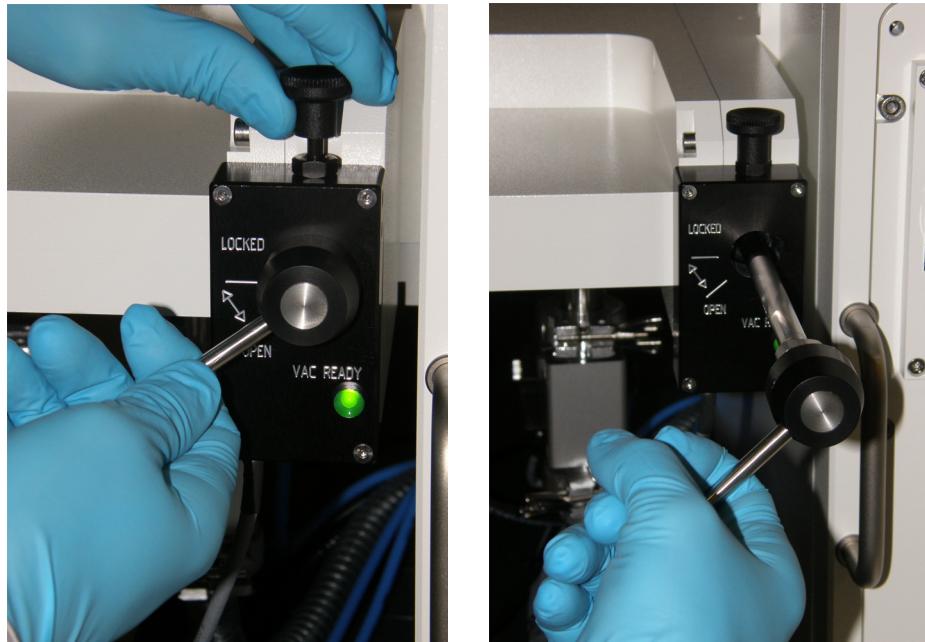


Figure 7-20: Moving the lever from **LOCKED** to **OPEN** position by pulling the knob upwards, then pulling the lever forward

- ▶ Once the lever is in the **OPEN** position, release the knob and pull the lever forward.
- ▶ Pull the lever all the way out to the mechanical end stop.

STEP 4: Pushing in the transfer rod

- ▶ Now the second part of the software prompt must be performed by the user, which is to push in the transfer rod so that its transfer guide will be situated underneath the sample holder. Push the transfer rod gently to the mechanical end stop.

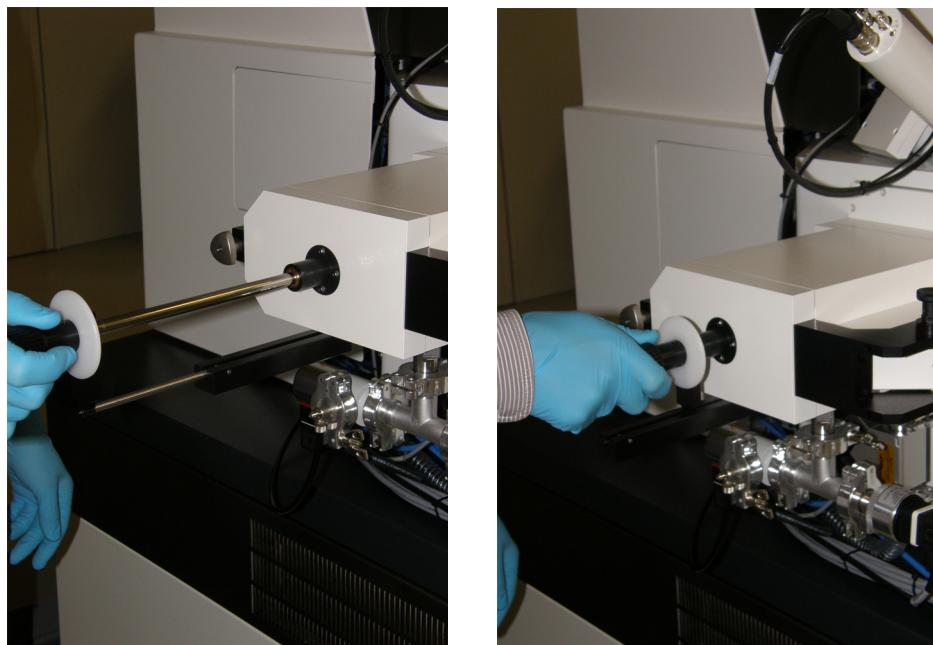


Figure 7-21: Pushing in the transfer rod

- ▶ Confirm the software prompt with **OK** when the transfer rod has been pushed in.

STEP 5: Sample holder transferred to transport guide

- ▶ Now the stage will be automatically moved downwards to the lower exchange position.

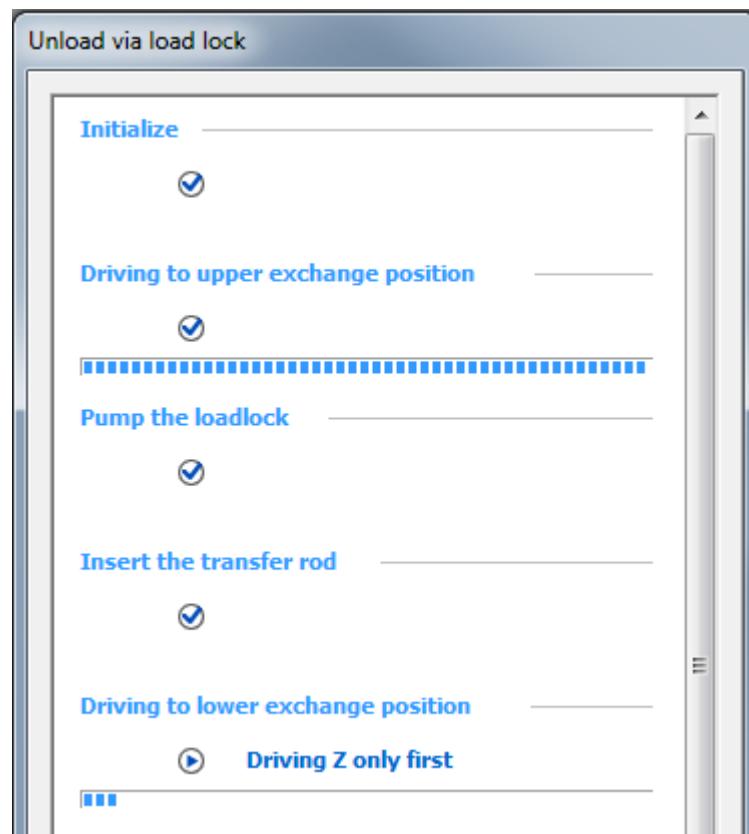


Figure 7-22: Unload progress - Z stage driving to lower exchange position

- In the load lock transfer position, there is a gap of a few mm between the stage and the sample holder. The sample holder is situated on the kinematic mount during this procedure step.
- Within this gap is the transport guide of the sample rod. The stage is moved downwards until the minimum Z stage position has been reached. This will now allow the sample holder to be positioned on the transport guide of the transfer rod. This process can be monitored via the TV camera.

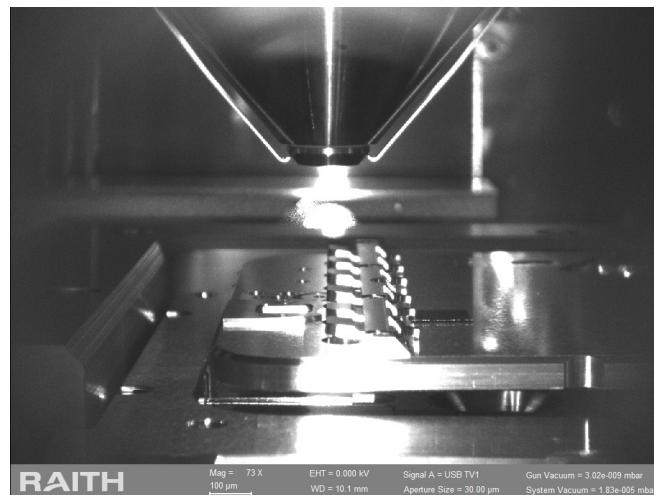


Figure 7-23: Camera image of sample holder in load lock exchange position

Coordinates	
● X:	36.972000 mm
● Y:	-0.797000 mm
● Z:	1.000 mm
U:	36.972000 mm
V:	-0.797000 mm
W:	32.500 mm

Figure 7-24: Z axis at minimum position of 1 mm

- It can now be observed that the sample holder is situated on the transfer guide of the transfer rod, and no longer on top of the stage. The transfer guide can not be seen with the TV camera, but the gap between the sample holder and the stage is clearly visible with the TV camera. The coordinates window shows that the Z stage is at its minimum position at 1 mm and all LEDs are red, since all axes are currently disabled.

STEP 6: Pulling out the transfer rod

- The next step is to pull out the transfer rod, this time with the sample holder. A software prompt will instruct the user to pull out the transfer rod and then to close the load lock valve.

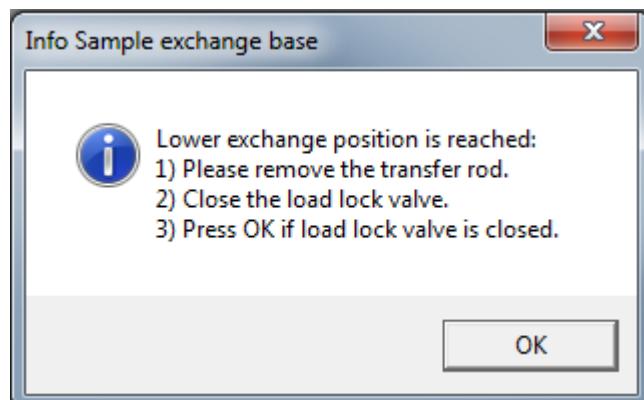


Figure 7-25: Software prompt to remove the transfer rod and to close the load lock valve

- Pull out the transfer rod.

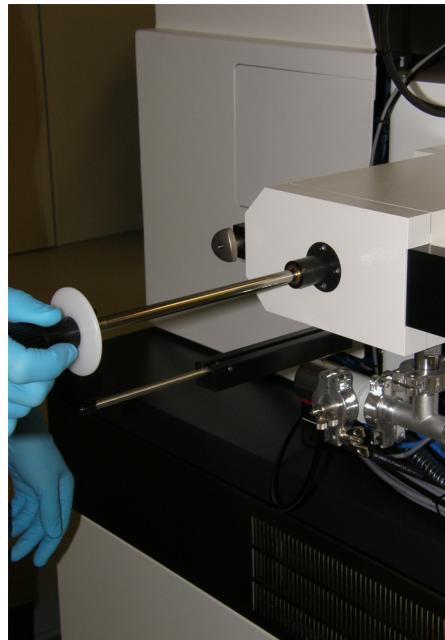


Figure 7-26: Transfer rod pulled fully out

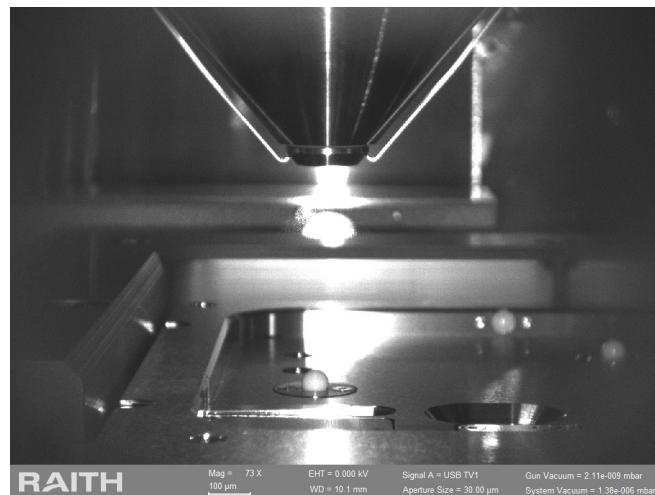


Figure 7-27: Camera image showing the empty chamber

- ▶ Using the TV camera image to monitor the sample holder, slowly pull back the transfer rod to its mechanical end stop. The sample chamber is shown without the sample holder and the sample.

STEP 7: Closing the load lock valve

- ▶ Now the second part of the software prompt must be performed by the user, which is to close the load lock valve. Push in and turn the lever back to the **LOCKED** position.
- ▶ Confirm in the software that the load lock valve is closed by pressing **OK** in the software prompt.
- ▶ The software will now automatically vent the load lock.

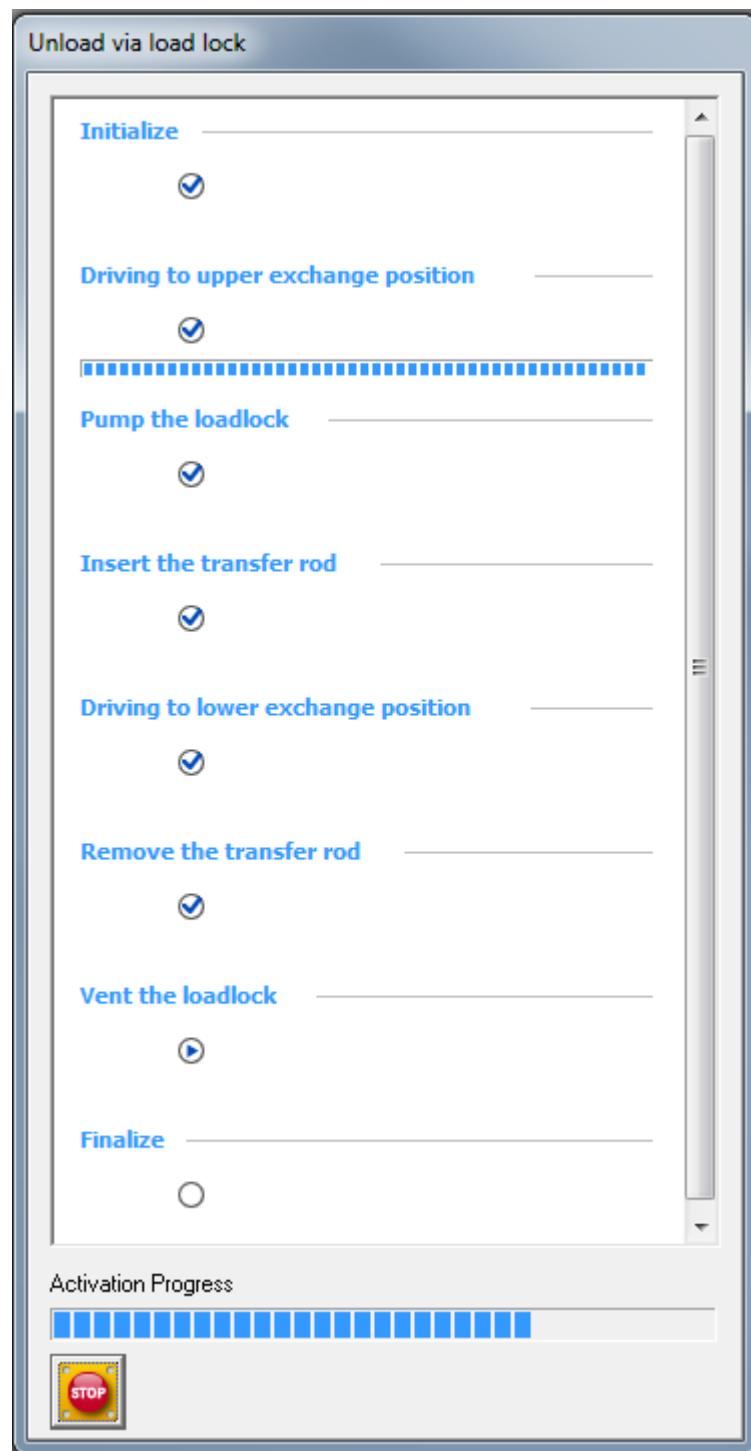


Figure 7-28: Unload progress - vent the load lock

The icon indicates the currently active step, the icon indicates a completed step.

The Unload procedure can be stopped at any time by pressing **STOP**.

The Unload procedure is completed and the sample holder can be removed.

NOTICE

The system vacuum can be degraded by dust or dirt from the load lock chamber. Remember to close the lid to the load lock chamber once the sample holder has been removed.

- ▶ The unloading procedure within the software is now complete. All axes are enabled, all stage axis LEDs are green. The load lock is vented. The Vacuum LED within the **Column Control** is green again as the system vacuum is within specifications with the load lock valve closed. Only the load lock is vented.

Coordinates			
● X:	36.972000 mm	U:	36.972000 mm
● Y:	-0.797000 mm	V:	-0.797000 mm
● Z:	1.000 mm	W:	32.500 mm

Figure 7-29: All axes enabled again

STEP 8: Opening the load lock door to exchange samples

- ▶ The next step is to open the load lock door to take out the sample with the sample holder. Loosen the knob and turn the lever next to the load lock door outwards to open the door.

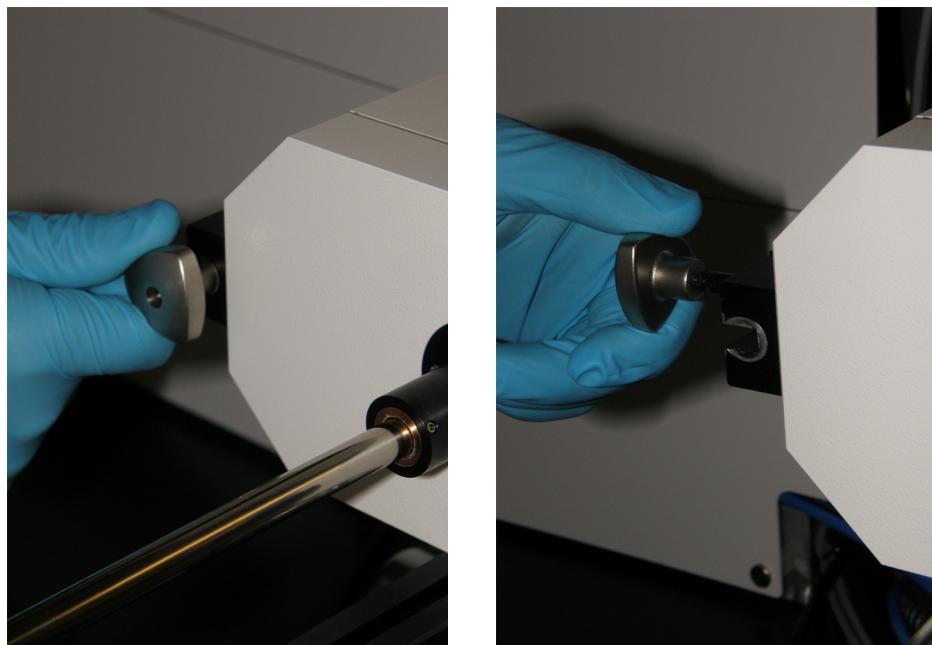


Figure 7-30: Loosen the knob on the load lock door, then pull to open it

- ▶ Open the load lock door fully.

NOTICE

The system vacuum can be degraded by dust and dirt in the sample chamber.

- Only handle the sample holder with suitable rubber gloves
- Only use plastic tweezers for samples

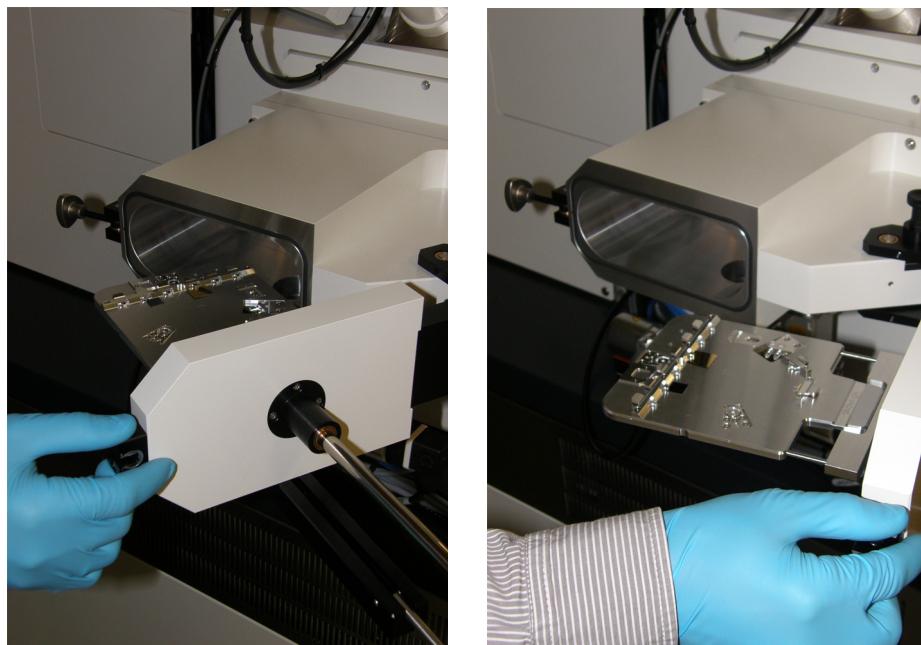


Figure 7-31: Fully opening the load lock door

- ▶ If the load lock door is swung fully open, a safety knob will engage, with an audible click, ensuring that the door stays open. This prevents accidental closing or swinging of the door while the user is working on the sample holder.
- ▶ Before touching the sample holder, always wear gloves. The sample and the sample holder can now be removed.

NOTICE

It is of vital importance to always store the sample holder in the transport box supplied when it is not mounted on the stage. Only ever change the samples with the sample holder in the transport box. Never attempt to change a sample while the sample holder is still on the stage, otherwise damage may be caused to the fine mechanism.

7.3.2 Load procedure via load lock

STEP 1: Placing the sample holder into the load lock

- ▶ Always load the sample onto the sample holder whilst it is in the dedicated transport box.

NOTICE

Only change the samples while the sample holder is in the transport box. Never attempt to change samples while the sample holder is mounted on the instrument. Never attempt to change a sample while the sample holder is still on the stage, otherwise damage may be caused to the fine mechanism.



Sample loading / unloading is performed quickly and easily by securing the samples directly onto sample holders. To minimize the time that the chamber is open, samples can be mounted offline onto sample holders.



Samples are placed directly onto a sample holder. The sample holders are equipped with sapphire inserts and are placed on a platform on the laser stage. The platform consists of three ceramic spheres, designed to match the positions of the sapphire inserts. This arrangement is designed for long-term stability and acts as a kinematic mount for the sample holder.

- ▶ To load the sample, the sample holder must be placed onto the load lock transfer guide of the transfer rod. One of the transfer guides is shorter than the other and a groove is situated between the two transfer guides, to ensure that the sample holder fits in snugly into its position. Place the sample holder onto the transfer guide.
- ▶ Ensure that the sample holder fits correctly onto the transfer guide. The figure below shows the pin on the transfer guide and the notch underneath the holder. Both ensure the correct positioning onto the transfer guide rod.



Figure 7-32: Pin and notch for correct placement of sample holder on the transport rod

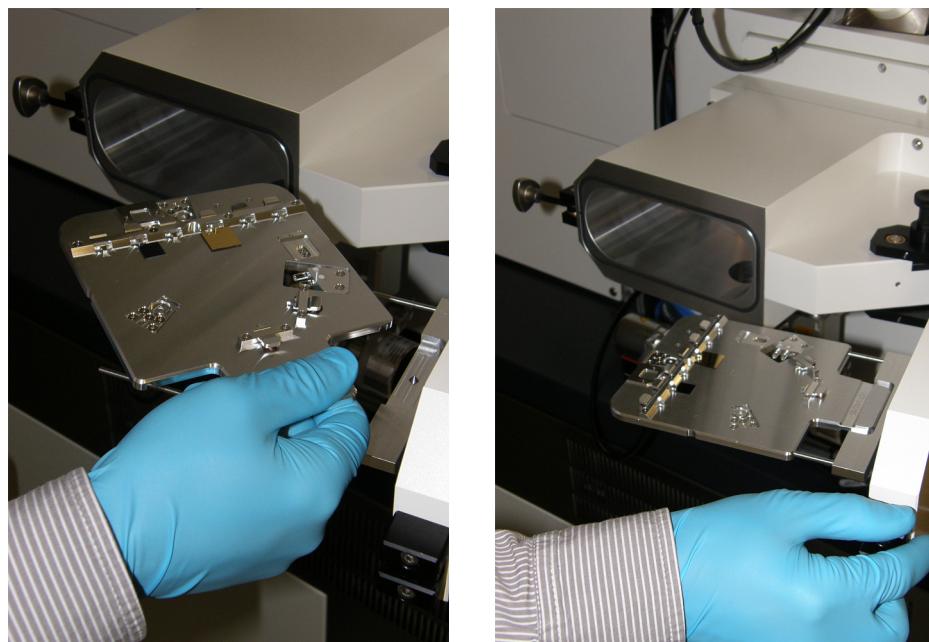


Figure 7-33: Placing the sample holder onto the transfer guide

- ▶ To close the load lock door, first release the locking device and then close the door, placing a hand on the door, not on the transfer rod. The transfer rod is a precise component and it moves freely. There is a risk that the rod may become slightly bent by putting sideways pressure on it.



Figure 7-34: Door safety knob

- Close the load lock door and lever.

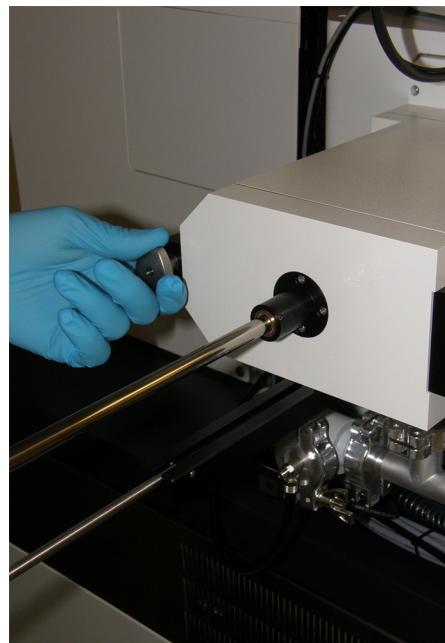
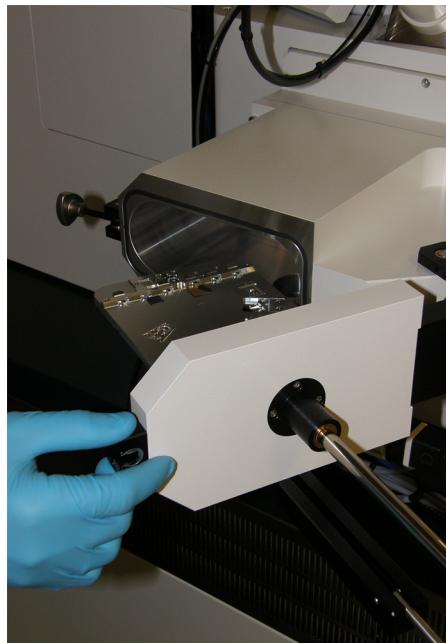


Figure 7-35: Closing the load lock door and tightening the knob to ensure a good seal

STEP 2: Pumping down the load lock

- Click on Load Sample in the software navigator. The loading procedure will take approximately eight minutes.

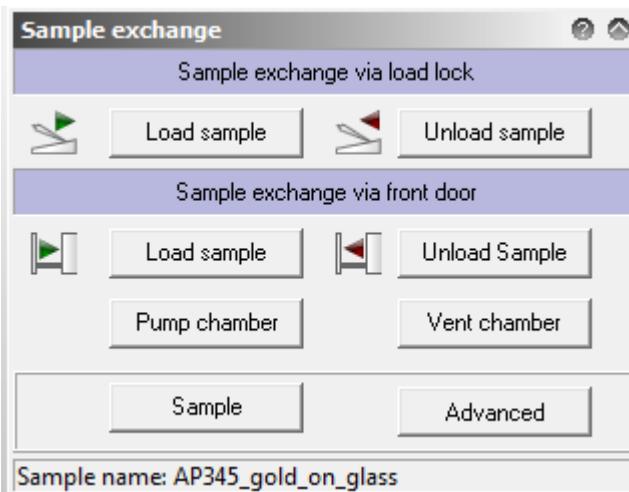


Figure 7-36: Sample exchange unload

- The Load procedure will now be initiated.
- The software will now prompt the user for confirmation that there is no sample holder in the chamber. This is an important question, as several sample holders may be in use.

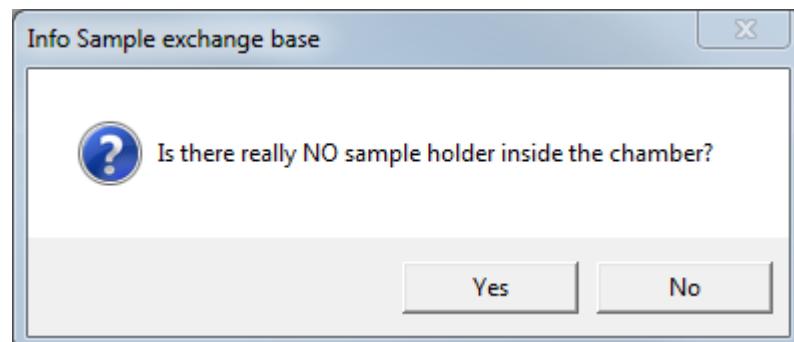


Figure 7-37: Software prompt to ensure that no sample is loaded

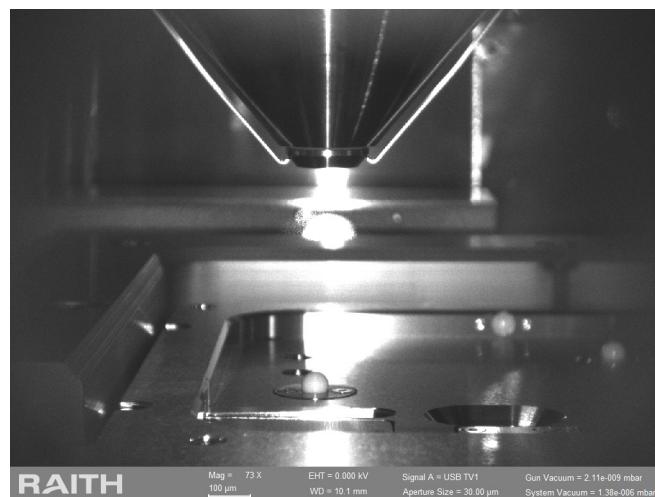


Figure 7-38: Camera image showing empty sample chamber

- ▶ If the sample chamber is empty, click **OK** to continue.
- ▶ The software will prompt the user to close the load lock door. Ensure that the knob next to the load lock door is turned, to ensure a tight seal.

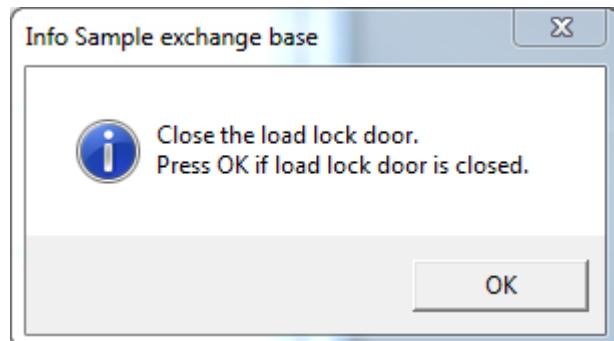


Figure 7-39: Software prompt to close the load lock door

- ▶ Check again that the load lock door is firmly closed. Confirm with **OK**.
- ▶ The software will now start the pump down of the load lock. All axes are disabled and the LEDs for X, Y and Z are shown in red. The load lock will be pumped.

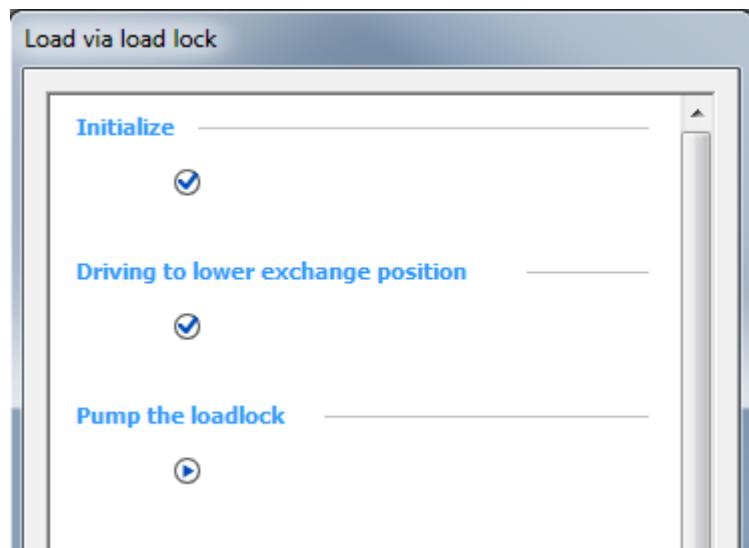


Figure 7-40: Load progress - pumping down the load lock

STEP 3: Opening the load lock valve

- ▶ Once the vacuum in the load lock has been reached, the load lock valve can be opened. The software will now prompt the user to open the load lock valve, the **Vac Ready** LED will be illuminated in green.

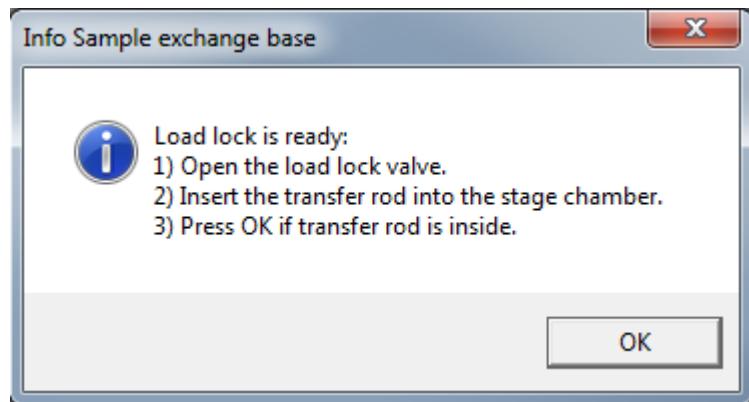


Figure 7-41: Software prompt to open the load lock valve and to insert the transfer rod

STEP 4: Transferring the sample holder into the chamber

- ▶ First, pull the knob upwards to allow the lever to be moved. Move the lever from **LOCKED** to **OPEN**. Once the lever is in the **OPEN** position, release the knob and pull the lever forward.
- ▶ Insert the transfer rod with the sample holder into the chamber.

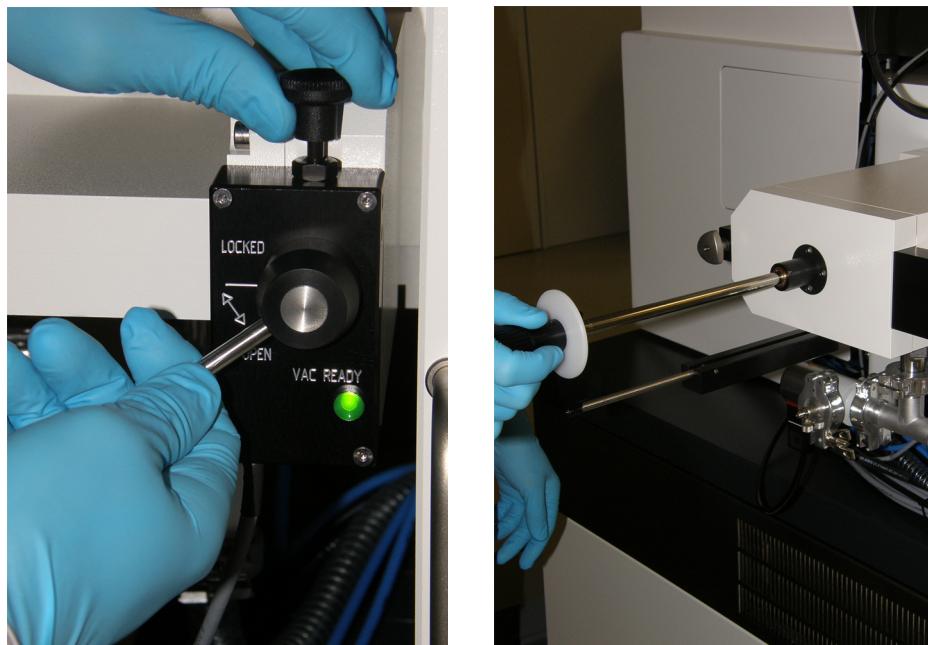


Figure 7-42: Inserting the transfer rod

- Watch the TV image to view the sample holder slowly being inserted, while pushing the transfer rod into the chamber.

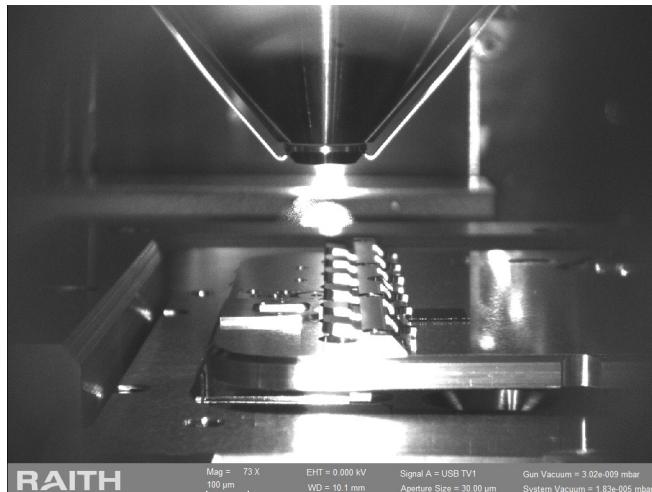


Figure 7-43: Camera image showing sample holder in the exchange position

NOTICE

It is important to push the transfer rod all the way to its mechanical end stop to ensure that the dedicated transfer position for the sample holder has been reached. When in the transfer position, the sample holder will be transferred from the transfer rod to the sample stage. Damage to the system can occur if this procedure is not followed.

- ▶ Once the exchange position is reached, confirm with **OK** in the software.

STEP 5: Pulling the transfer rod back

- ▶ The Z axis of the stage will now be driven upwards to the upper exchange position, to make contact with the sample holder and to lift it off the transfer guide.
- ▶ Once the upper exchange position is reached and the sample holder is now placed on the stage, a software prompt will ask the user to pull back the transfer rod, followed by closing the load lock valve. Once both tasks are complete, confirm with **OK**.
- ▶ Ensure that the transfer rod is pulled back to its mechanical end stop.

STEP 6: Closing the load lock valve

- ▶ Close the valve by pushing in the lever and turning it from **Open** to **Locked**. Ensure that the lever clicks into its position.
- ▶ Confirm the software prompt with **OK**.

STEP 7: Initiating Operating mode

- ▶ The **Vacuum LED** in **Column Control** will become green again, soon after the load lock valve is closed, since the chamber vacuum will be reached again. The CCV valve will open, once the chamber vacuum has been reached.
- ▶ The load lock will be vented under normal operating conditions.



If the software now displays an error message, indicating that it was not possible to open the valve, click on either **Retry** or **Cancel**. Normally, click on **Retry**, since this error message can be caused by the chamber vacuum not having been reached as quickly as the timer setting.

- Once the CCV valve has been opened, the software will then ask if the Coordinate system should be reset.

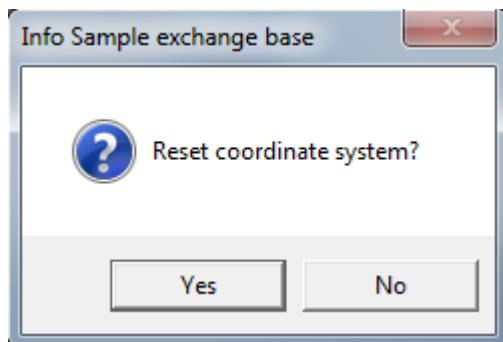


Figure 7-44: Software prompt to choose or decline reset of the coordinates



In most cases, it is recommended to click the **Yes** button. Reset is not required if, for example, a sample has been unloaded and then reloaded to continue work at the same position, if the position of the sample on the sample holder has remained unchanged. In this case, the UV adjustment does not need to be reset, as the correct coordinates will be reached. In all other circumstances, it is recommended to reset the UV adjustment.

- Now the software will display a prompt asking if the most recently used column parameter set should be used. The name of the parameter set is displayed.

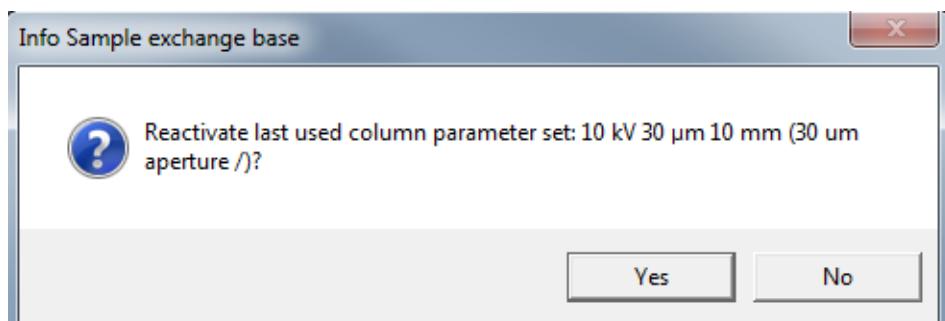


Figure 7-45: Software prompt to reactivate latest column parameters

- To use this parameter set, confirm with **Yes**. Select **No** to set the parameters manually afterwards.
- A prompt message will now be displayed that the **Load** procedure has been completed successfully.

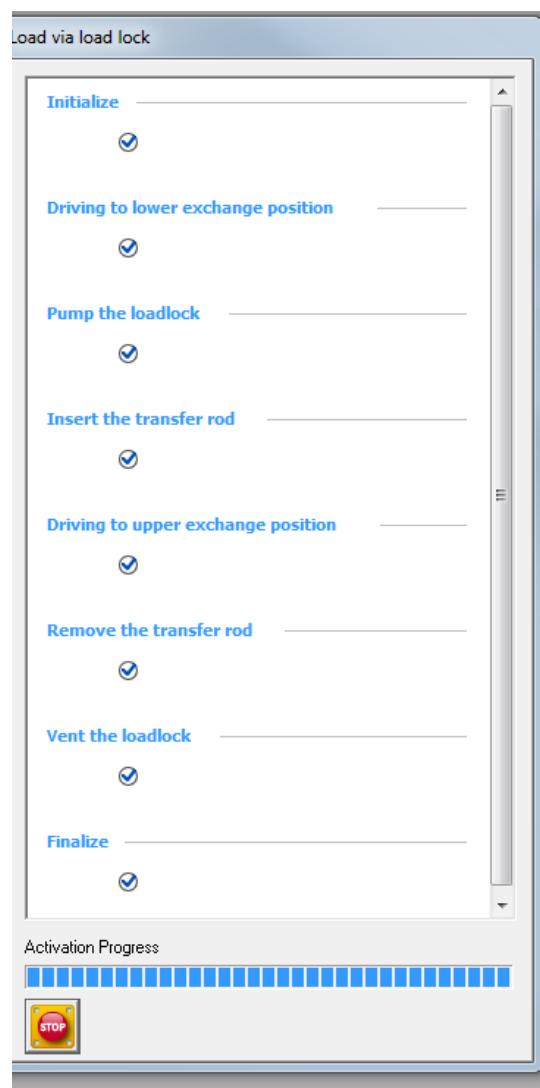


Figure 7-46: Load progress completed

- ▶ All the stage axis indications are now green and enabled.
- ▶ The system is now in **Operating** mode.

7.4 Switching off the system

The eLINE Plus should normally be permanently switched on. Only switch the system off either for significant technical reasons or if it will not be in use for a significant period of time.

STEP 1: Preparation

- ▶ Set **Column Stop** mode.

STEP 2: Turn off computers

- ▶ Close all windows and exit the software.
- ▶ Confirm with **OK** to save any changes.
- ▶ Go to the Windows start menu of the System Computer and select **Turn off Computer**.

STEP 3: System shutdown

The **eLINE Plus** should normally be permanently switched on. Only switch the system off either for significant technical reasons or if it will not be in use for a significant period of time.



Whenever the system is switched off, the Column Stop must be initiated. Depending on the column technology, repeatedly switching the gun off and on can cause instability of the electron beam current.

-
- ▶ Press the **Standby** button to initiate the standby mode.
-



Always put the **eLINE Plus** into Standby mode first and wait for 1 minute before switching it off completely. This avoids sudden power interruption in the subsystems and individual components. The system will switch itself off in a predefined sequence.

-
- ▶ Wait at least one minute, then press the **OFF** button to switch off the **eLINE Plus**. Once the **eLINE Plus** is switched off, the **OFF** button will be illuminated in red.
-



The **OFF** button will only switch off the main instrument, housed in the plinth. All electronics in the rack will remain on.



Figure 7-47: OFF button on the front of the **eLINE Plus**

- ▶ Go to the rear of the instrument and turn the main switch to the **OFF** position. All electronic units in the rack will now be switched off.



Figure 7-48: Switching off the power, turning the main switch to OFF

7.5 Lockout-tagout procedure



Always perform a lockout-tagout procedure before opening the shield.

STEP 1: System shutdown/lockout

- ▶ Perform a system shutdown (⇒ *Switching off the system* on page 7-35)

STEP 2: Lockout

During any maintenance or service activity on the eLINE Plus unit, the power supply to the unit must be interrupted. The client must ensure that the supply can not be reconnected.

This may be achieved by providing a lock-out device that prevents reconnection of the supply. The lock-out device must be under the control of the engineer.

- ▶ Alternatively, the power cable may be removed and placed under the control of the engineer.
- ▶ Attach a label at the main switch indicating that the power must not be switched on.
- ▶ Switch off the supplies for water, compressed air and nitrogen and ensure that they cannot be switched on again.

Chapter 8

Accessories

This chapter gives an overview of the available accessories and their components, with which the functionality of the eLINE Plus can be extended.

8.1 Starter kit

A starter kit is included in the delivery of the eLINE Plus. This will allow the first few steps with the system to be performed. If required, further starter kits can be requested from Raith.

8.2 Offline licenses

Operating software is installed with the eLINE Plus. One off-line license, for pre- or post-processing of the data is also included. Further optional licenses may be ordered.

8.3 Raith sample holder options

There is a range of specially designed sample holders available from Raith for a variety of samples, masks and wafers.



Refer to the sample holder manual for further information.



Consult Raith support for any special requirements for sample holders adapted to individual applications.

8.4 Semi-automated load lock

The semi-automated load lock is explained in detail (⇒ *System description* on page 2-1).

8.5 Gas Injection System (GIS) options

The Gas Injection System (GIS) includes up to 5 nozzles, for injection of gases for electron beam-induced deposition (EBID) and etching. An alternative efficient and cost-effective Mono-GIS has a single nozzle.

The Gas Injection System (GIS) is an option for the Raith systems **eLINE**, **ionLINE**, **ionLINE CE** and **RAITH150TWO**. It serves as an additional option for nano-structuring of samples, by adding a gaseous precursor to the electron or ion-beam. Introduction of these precursors makes it possible to perform local etching and deposition processes on suitable samples, in order to structure in the nanometer and micrometer regime.

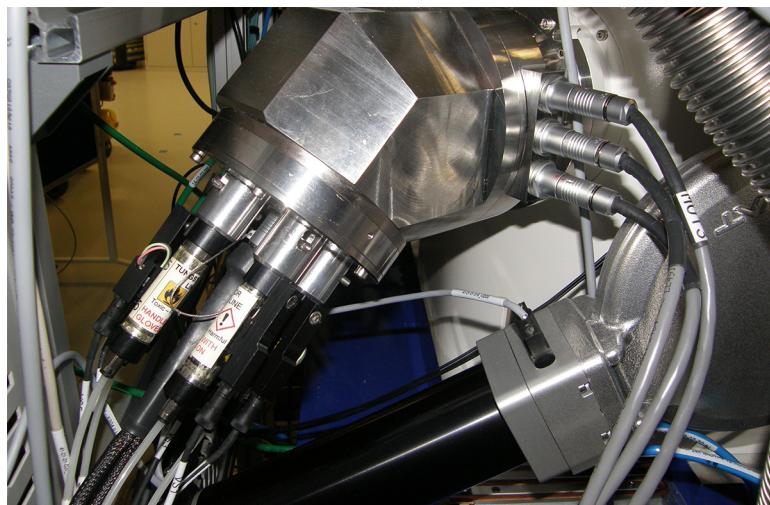


Figure 8-1: GIS attached to vacuum chamber (on the ionLINE CE)

The GIS consists of the following components:

- GIS hardware (GIS),
- Gas injection controller (GIS-Controller),
- GIS software module (GIS-Module).



Figure 8-2: GIS electronic unit

Control of the GIS is fully integrated into the **NanoSuite** Software of the Raith lithography systems and is exclusively carried out via software functions.



For further information about functionality, operation and safety of the GIS option, refer to the **GIS System Manual**.

8.6 Height sensing option

Automated focus control by laser height sensing.

- Automatic control of sample height to maintain focus after each stage movement.
 - Laser diode light source, 670 nm wavelength for use with III-V and II-VI semiconductors.
 - 1024 pixel line CCD camera detector.
 - 2 mm vertical detection range.
 - Reproducibility 1 µm.
-



Refer to the **Height Sensing** manual for further information.

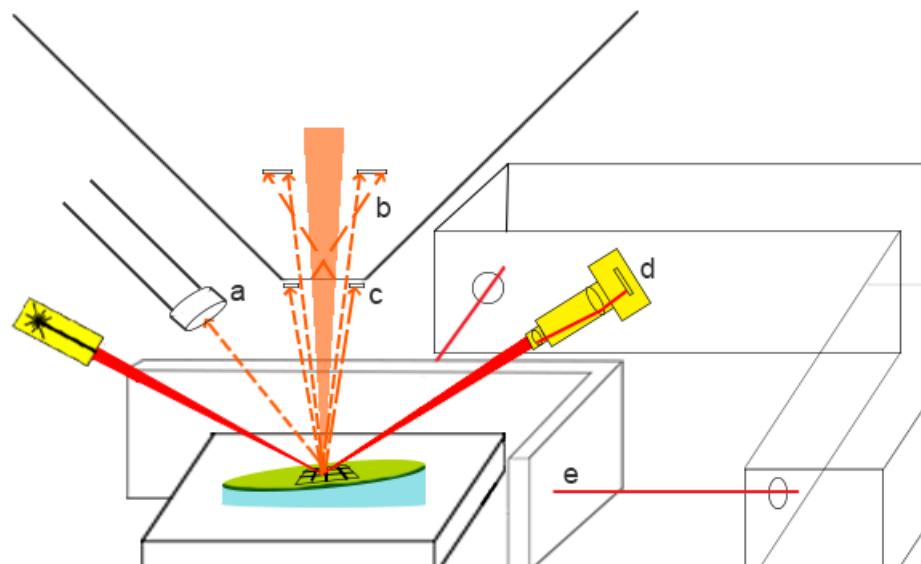


Figure 8-3: Schematic illustrating height sensing working principle on a sample with varying height (a) Everhart-Thornley secondary electron detector (SE). (b) In-lens detector for secondary and/or energy selective backscattered electrons (EsB). (c) Post-lens angular selective backscatter electron detector (AsB). (d) Height sensing apparatus which uses a laser beam to measure the sample height, keeping the sample in focus over large areas. (e) Laser interferometer stage that provides precise sample motion down to single nanometers.

8.7 Nanomanipulator option

- Up to 4 digitally controlled nanomanipulators provide, for example, electrical or mechanical nano-probing and profilometry. Each has closed loop position control with 2 nm resolution.



Refer to the **Nanomanipulator** manual for further information.



Figure 8-4: Nanomanipulator electronic unit

8.8 Advanced FEBIP supporting option

Advanced FEBIP supporting items include;

- Heating / cooling stage
- Anti-contaminator
- Residual gas analyzer
- Liquid nitrogen cooling trap

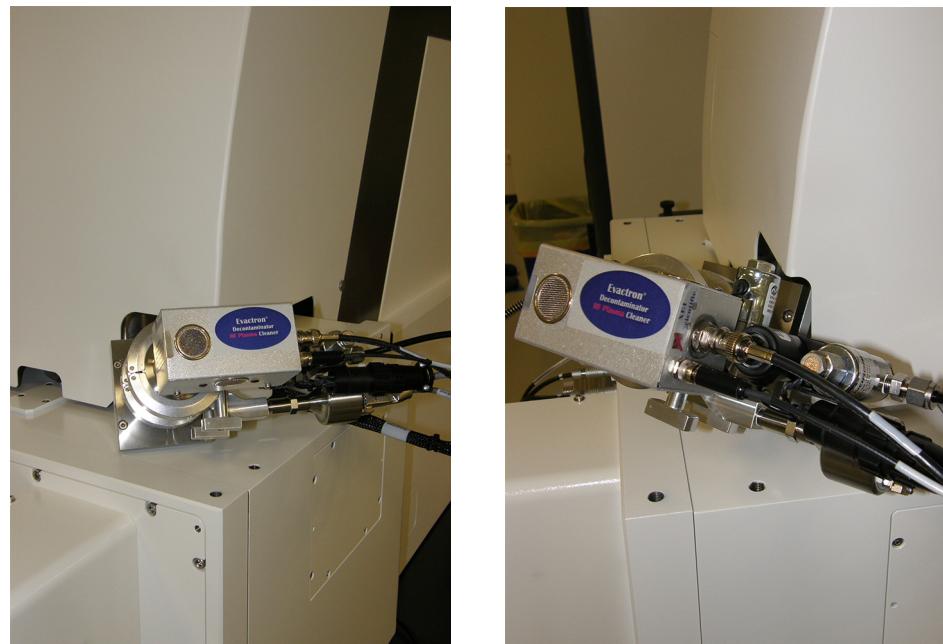


Figure 8-5: Anti-contaminator outside the eLINE Plus



Figure 8-6: Anti-contaminator electronic unit



Figure 8-7: Heating/cooling module

8.9 High efficiency detector options

- Multiple high efficiency detectors for surface, topographical, material, crystallographic or chemical information with ultra high resolution
- In-lens energy selective backscattered electron detector (EsB, combined with in-lens SE detector, alternative option to standard in-lens SE detector)
- Angle selective backscattered electron detector (AsB)
- Scanning transmission electron microscopy (STEM) detector
- Energy dispersive X-ray spectroscopy (EDX) system

8.10 Uninterruptible power supply (UPS)

The UPS maintains operation in the event of unexpected power failure. Depending on the typical duration of power failures, extra capacity can be added. The figure below shows the UPS control unit on the right, which also houses a set of batteries and on the left, a unit housing only batteries, for extended operation during power failure.



Figure 8-8: Uninterruptible power supply (UPS) units

Chapter 9 Maintenance

This chapter gives an overview of the maintenance procedures, which are required at regular intervals to ensure the optimum performance of the eLINE PLUS.



For further information regarding the maintenance procedures, contact Raith support.

9.1 Keeping the system clean



The system vacuum can be degraded by dust and dirt in the load lock or sample chamber.



Only use suitable rubber gloves when handling parts that are normally under vacuum.

9.1.1 Shield surfaces

Only clean the surfaces of the shield with a dry cloth, without cleaning agents or solvents.

9.1.2 Load lock

Only clean the outer surfaces of the load lock with a dry cloth, without cleaning agents or solvents. Only clean the outer surfaces, not the surfaces facing the vacuum.

9.1.3 Sample holder

The sample holders for the eLINE Plus must be free of dust and dirt when in use. Clean the Raith universal sample holders, masks and wafer holders using either of the following 2 methods:

- 1 Dust off with nitrogen.
- 2 Clean the holder with IPA or propanone (acetone) on a lint-free cloth, if required.

Use clean samples only.

Always keep the underside of the sample holder clean, particularly the kinematic holders.

9.2 Bakeout procedure



The bakeout procedure can only be carried out by users who have, as a minimum, Administrator rights and who have received dedicated administrator training by Raith.

The vacuum of the electron column must be checked at regular intervals, in order to keep the filament in good condition, with stable output. Carrying out the bakeout procedure too often or too intensively, can reduce the lifetime of the filament. Only perform the bakeout procedure when the gun vacuum is worse than 5×10^{-9} mbar.

There are several bakeout procedures available, during which the electron column is heated for a defined period of time and then is locked for a certain period of time to allow it to cool down again.

In the event of drift problems, contact Raith Support.

NOTICE

The filament might be damaged by carrying out bakeout procedures too often or too intensively. Before carrying out the bakeout procedure for the first time, please consult Raith service to obtain advice regarding the time intervals and the intensity of the bakeout procedure.

Conditions

The vacuum is considered to be insufficient when it is worse than 5×10^{-9} mBar. The system will register when there is insufficient vacuum and will prompt the user to perform a bakeout. Before starting the bakeout procedure, ensure that the gun vacuum is above this value, to make sure that the bakeout procedure is required.

Performing the Bakeout procedure

A bakeout will be carried out by service personnel after the filament has been exchanged. The user may also wish to perform a bakeout if the system was left in an unpumped state for a significant period of time. Raith may also advise the user to carry out a bakeout for other reasons.

It is recommended to carry out the bakeout overnight.



CAUTION

Hot surface: Danger of burn injury. During the bakeout procedure, the electron column will become very hot. Avoid contact with the electron column.

Do not place flammable objects onto the protective grid behind the electron column.

STEP 1: Preparation

- ▶ Turn off the EHT.
- ▶ Turn off the gun.
- ▶ Open the CCV.

STEP 2: Carry out the bakeout procedure

- ▶ Go to the **Electron Optics** software.
- ▶ Go to the menu bar and select **Tools \ Go To Panel \ Bakeout**.

The Bakeout dialog will open:

- Select the required bakeout procedure from the dropdown list of the Bakeout field:

Bakeout-Procedure	Time
Quick	2 hours heating / 1 hour cooling
Overnight	8 hours heating / 2 hours cooling
Weekend	40 hours heating / 3 hours cooling. The bakeout procedure Weekend is only required after changing the filament and will be carried out by Raith Service personnel.
User	To set individual timings for the bakeout procedure: -double left click on Bakeout Heat . Enter a time for the heating between 1 hour and 200 hours. -double left click on Bakeout Cool and enter a time for the cooling between 1 hour and 5 hours

- Click on **Bakeout Start**, to initiate the bakeout procedure.

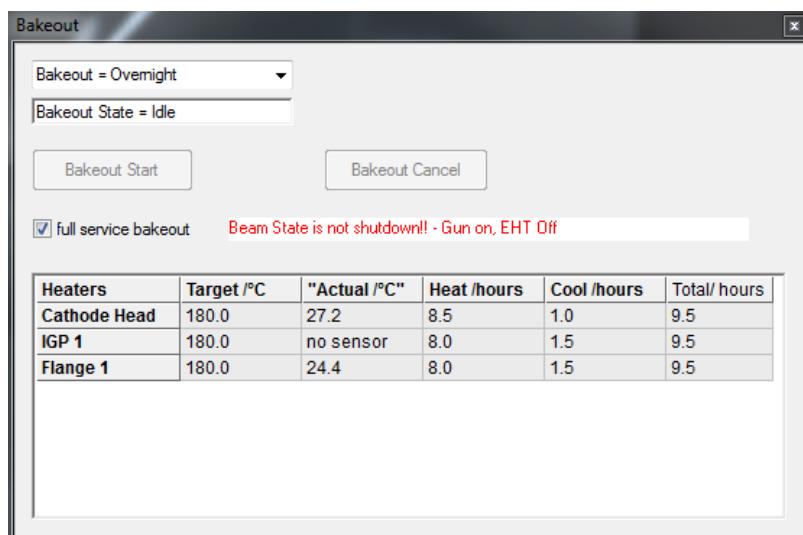


Figure 9-1: Bakeout dialog A

The **Bakeout** dialog will give a progress time, displaying the total required time and the remaining time. The completion time of the bakeout will also be indicated.

NOTICE

It is important that the total bakeout time is the same for the Cathode Head, IGP 1 and Flange 1. In this example, the time is 9.5 hours. The **Heat** and **Cool** times can be different, as long as the total time is the same. The total hours are automatically calculated by adding the heating and cooling time. The temperatures for all regions should be set to 180°C.

9.2.1 Lifetime of the filament

The lifetime of the filament can be increased by leaving the gun on permanently when the eLINE Plus is in normal operating condition. This ensures that the electron beam current remains stable. Only switch off the gun if the system is not going to be in use for more than 1 week or if there is some reason that the system should be switched off.

The EHT has no influence on the lifetime of the filament and can therefore be left switched on permanently while the gun is in operation. After the gun and the EHT have been switched on, it will take a few hours until the extractor and electron beam current are stabilized.

Performing the filament stability test

The filament stability test is used to measure the electron beam current at defined time intervals and to statistically evaluate the measured data. This can give an early identification of any malfunction of the filament. The lifetime of the filament can be increased if it is operating under optimum conditions.

NOTICE

An unstable electron beam current does not necessarily mean that the filament has to be replaced. There are a number of factors which might lead to an unstable electron beam current, such as:

- problems with the earthing of the sample
- aperture condition
- dirt inside the electron column

Contact Raith support to discuss possible causes.

Perform the stability test every four weeks, as follows:

STEP 1: Preparation

- ▶ Ensure that the room temperature does not vary by more than ± 0.5 °C.
- ▶ Go to the Raith EO software.
- ▶ Set the high voltage to 10 kV and select the 30 μm aperture.
- ▶ Move the stage so that the Faraday cup of the sample holder is in the center of the viewing area.
- ▶ Move the stage to WD = 5 mm and focus the electron beam, using the edge of the Faraday cup.

Use the Spot mode.

The beam current should be around 200 pA, but can vary by ± 50 pA, depending on the age of the filament.

NOTICE

Refer to the Raith NanoSuite Software Reference Manual for detailed information on performing the individual preparation steps.

STEP 2: Measuring using the Gun Monitor Utility

Using the program **Gun Monitor Utility**, it is possible to measure certain parameters of the electron column at defined time intervals, to display the results graphically and to save them in a separate data file.

NOTICE

Refer to the Raith EO Software Manual for more information about use of the program **Gun Monitor Utility**.

- ▶ Go to the Windows Start menu **All Programs \ Smart SEM Service \ Gun Monitor Utility**.

The dialog **Gun Monitor - Untitled** will open:

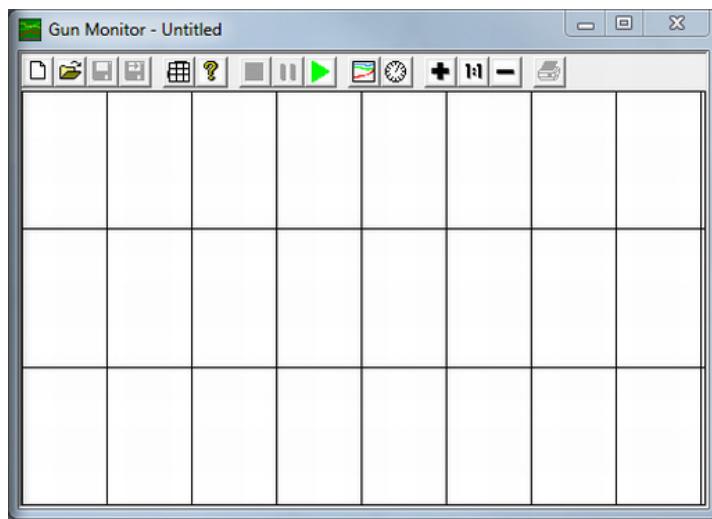


Figure 9-2: Gun Monitor - Untitled dialog

- ▶ Click on the button to open the Parameter Setup dialog.

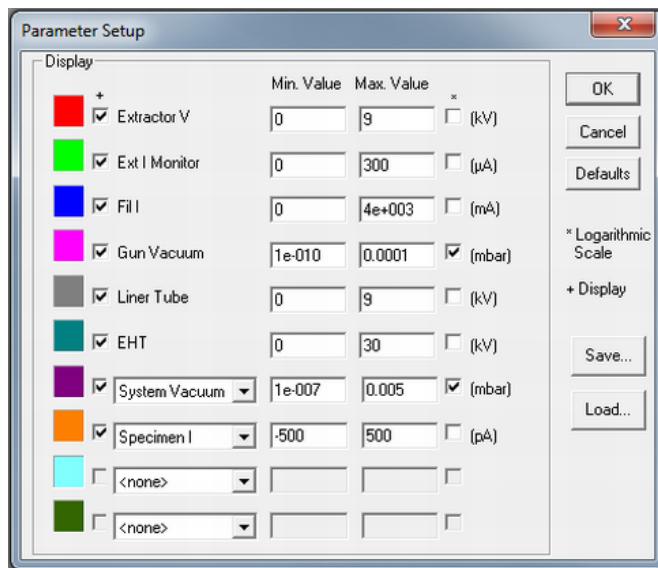


Figure 9-3: Parameter Setup dialog

Within the **Display** area, the following options can be set:

- the measurement parameters that will be displayed during the measurement
- the value range for the display of the individual parameters.

- ▶ Check the checkboxes of the parameters to display during the measurement.
- ▶ Enter the upper and lower limits in the corresponding **Min. Value** and **Max. Value** columns. The selected parameters will only be displayed if the values are between these limits.

- ▶ Confirm with **OK**.

NOTICE

In the **Display** dialog, only the parameters to be displayed are set in the **Untitled - Gun Monitor** window, along with the range of values to be displayed. Parameters that have not been selected will not be displayed, but they will still be measured and saved.

- ▶ Click on the  button to open the **Set Interval** dialog:

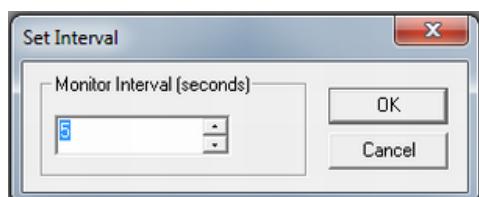


Figure 9-4: **Set Interval** dialog

- ▶ In the **Monitor Interval (seconds)** dialog box, the time interval can be set for the update of the display and acquisition of the values.
- ▶ Enter a time interval of 1 second.
- ▶ Click on the  button to start the measurement.

The measurement will be carried out and the measured values for the parameters which have been chosen in the **Display Options** dialog will be displayed as colored graph lines:

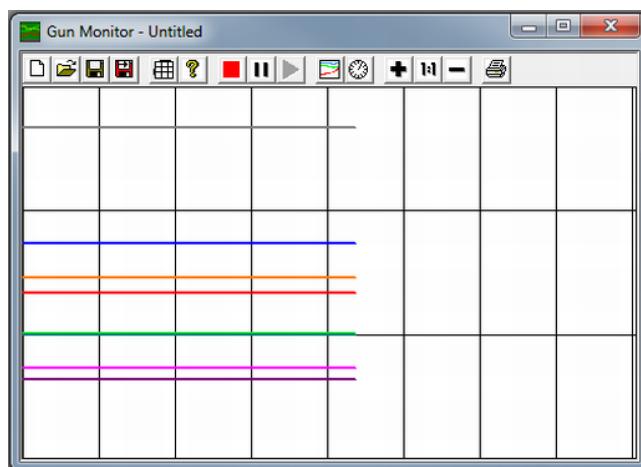


Figure 9-5: **Gun Monitor - Untitled** dialog

- ▶ Click on the  button to stop the measurement.

Click on the  button to save the measured values. Use a meaningful data file name.

9.2.2 Measuring the laser interferometer stage

The laser interferometer source and the motor controller require no maintenance.

Measuring the signal voltage, as well as cleaning the fiber, should be performed every month.

Measuring signal voltage

A digital voltmeter (DVM), BNC adapter and BNC cables are required.

a) Measuring the signal voltage using a digital voltmeter

- Connect the DVM to BNC X1 (20 V DC range).



Figure 9-6: BNC connectors

Legend

X1	BNC connector for laser signal measurement	X2	BNC connector for laser signal measurement
Y1	BNC connector for laser signal measurement	Y2	BNC connector for laser signal measurement

- Move the stage in 10 nm steps in the X-direction, using the software, until the reading on the DVM reaches a maximum.
- Note the measured value.

- ▶ Repeat the steps above with the BNC connector X2, Y1 and Y2.
-



If the measured voltage is below 5 V, the fiber should be cleaned.

b) Measuring the signal voltage using an oscilloscope

An oscilloscope and a BNC cable are required.

- ▶ Connect channel A of the oscilloscope to X1 and channel B to X2.
 - ▶ Switch the oscilloscope to X/Y mode, 2 V per division.
 - ▶ Move the stage over the whole travel range. The observed signal on the oscilloscope should form a circle.
 - ▶ Note the maximum and minimum values for X1 and X2 (peak to peak values).
 - ▶ Connect channel A to Y1 and channel B to Y2.
 - ▶ Repeat the measurement with the Y axis.
-



If the measured voltage is below 5 V, the fiber should be cleaned.

9.3 Fiber cleaning

During operation, the end of the laser fiber can become contaminated, resulting in a gradual decrease of the laser signal.



This is a well known effect called "optical tweezers", caused by the strong electrical field induced by the laser signal at the end of the fiber. Particles are attracted towards and collect at the end of the fiber.

If laser mode can not be selected, or the system automatically drops back to encoder mode, this indicates that the laser signal has fallen below a threshold value. If this happens, proceed as follows:

- ▶ Switch off the motor controller and the laser interferometer source.
- ▶ Vent the system.

- ▶ Pull out the stage.
- ▶ Locate the fiber mount and unscrew the head nut that keeps the fiber in place.

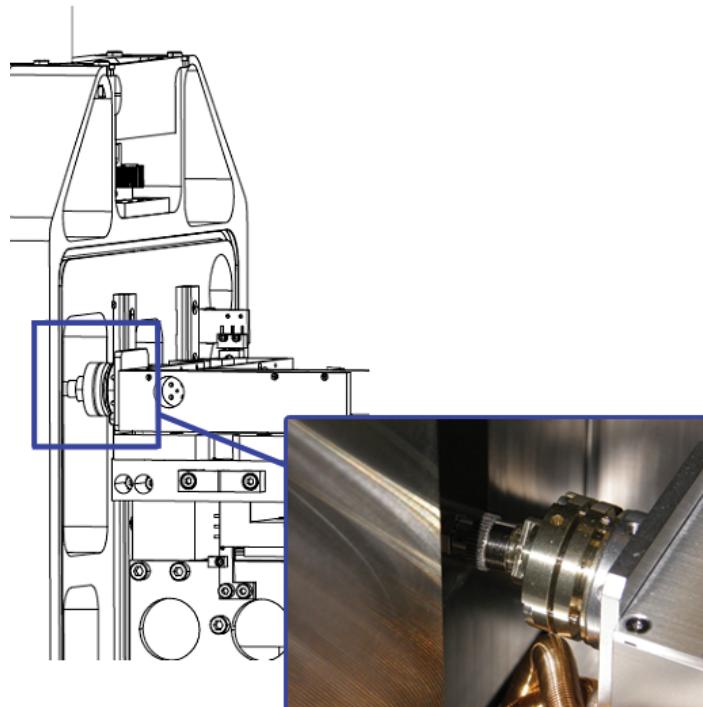


Figure 9-7: Fiber mount (front view) on the back of the front door

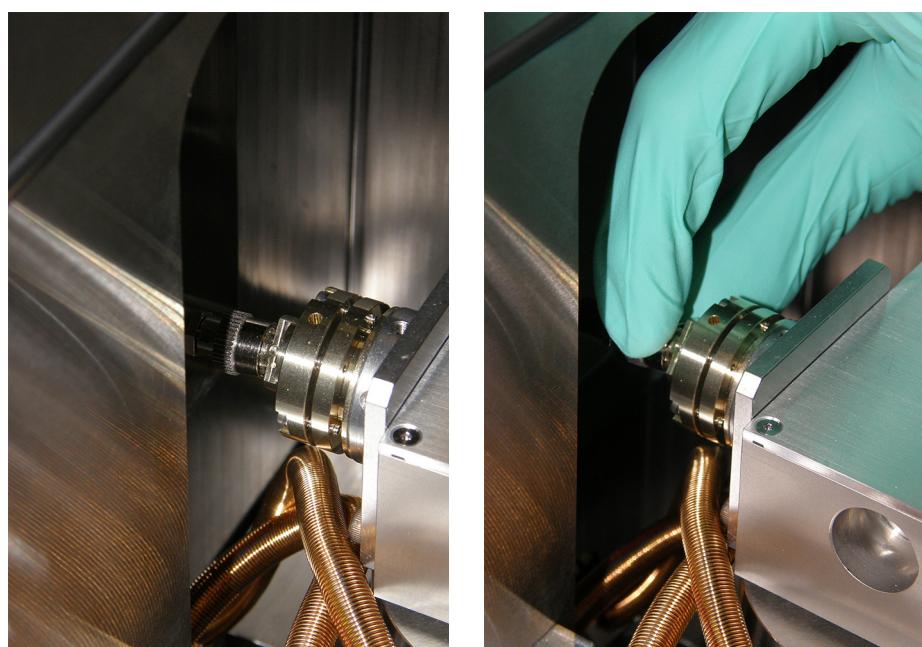


Figure 9-8: Disconnecting the fiber mount

- ▶ Disconnect the fiber.

NOTICE

Handle the fiber with great care.
Do not apply excessive force to the fiber.
Ensure that the fiber always has a bend radius of greater than 5 cm.

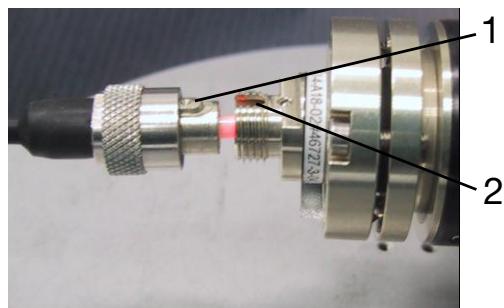


Figure 9-9: Opening the fiber mount

Legend

1 Latch

2 Notch

**CAUTION**

Laser emission: Do not look directly into the beam emerging from the fiber. The fiber should be directed towards a white surface during the following steps.

- ▶ Wipe the fiber end with a soft tissue moistened with propan-2-ol (also known as isopropyl alcohol, or IPA).
- ▶ When the fiber has dried, switch on the laser source in the electronics rack. Hold the end at a distance of 5 cm from a white surface and check that the visible spot has an apparent Gaussian distribution.



Figure 9-10: Laser spot on a surface at 5 cm from the fiber end. Diameter approximately 1 to 2 cm

- ▶ Insert the fiber into the mount. To ensure the correct orientation, the fiber has a latch that fits into a notch on the mount.
- ▶ Screw on the head nut, finger tight.
- ▶ Switch the laser interferometer source **ON** and wait until the green light indicates that the frequency is locked.
- ▶ Switch on the motor controller.
- ▶ Make sure laser mode is selected.
- ▶ Measure laser signal as described above.
- ▶ Move the stage across the whole travel range using the joystick.
- ▶ Close the stage door and evacuate the chamber, following the guidelines of the system manufacturer.

9.4 Maintenance of the accessories



Training requirement: The maintenance of the accessories can only be carried out by users with Administrator rights or by local system specialists.

9.4.1 Water chiller

The system has one water chiller, which can be located away from the eLINE Plus in an adjacent room (refer to *Technical Description* and *Site Preparation Guide*):

- The water chiller cools several components, such as the electron optics, the objective lens, the main psu and the turbo-molecular pump.

NOTICE

Using an unsuitable chiller solution can lead to deposits and malfunction in the cooling system. Only fill the water chiller with a mixture containing 70% deionized water and 30% (by volume) tap water. To each 1dm³ (liter) of this mixture, add 1ml of ThermoClean-DC. Do not use more than this. Crystalline deposits of ThermoClean-DC can harm system seals.

Check the water level in the chiller regularly, in order to avoid blockage of the filters. Take note of the following target value and maintenance intervals:

Table 9-1: Target value and maintenance intervals for the water chiller

Parameter	Target value	Maintenance interval
Water level	4 liters	The water top up interval depends on the humidity in the laboratory. Check the water level of the water chiller every 3 to 4 weeks after the commissioning of the system, until you become familiar with the water consumption that is specific to the laboratory environment. Determine the control intervals and top up the distilled water accordingly.

If it is necessary to refill large amounts of water, the algal suppressant (ThermoClean-DC) will need to be replenished. ThermoClean-DC has a blue color indicator. When the blue color disappears, the product is ineffective and needs to be replenished. Add 4 cm³ of ThermoClean and ensure that the chiller is topped up with water. See Appendix for further information

**WARNING**

Toxic and irritant substance: ThermoClean-DC is toxic when swallowed and irritant on skin contact. Refer to Safety Datasheet Operating instructions on page A-1. Wear suitable rubber gloves and eye protection. Avoid skin contact.

9.4.2 Roughing pump

The standard roughing pump is a Vacuubrand MV 10 NT VARIO. There is no need for preventive maintenance by the user.

9.5 Nitrogen and compressed air

The eLINE Plus uses:

- ▶ Nitrogen (N_2) for venting the sample chamber and load lock
- ▶ Compressed air to operate the pneumatic valves and the integrated damping platform

Check the pressure of nitrogen (N_2) and air regularly. Take note of the following target values and maintenance intervals:

Table 9-2: Target values and maintenance intervals for nitrogen and air

Gas	Target value	Maintenance interval
Nitrogen (N_2)	3 to 3.5 bar	Check and adjust the pre-set pressure on a monthly basis.
Air	6 to 8 bar	Check and adjust the pre-set pressure on a monthly basis.

9.6 Supply lines and pipes

Check the power supply, nitrogen (N_2) and air supplies and water pipes regularly for damage or signs of aging.

9.7 UPS battery life



CAUTION

Harmful gases and corrosive liquids: Irritant gaseous emission (hydrogen sulfide) and corrosive leaks may emerge from aging UPS battery systems. Ensure that the batteries are replaced at the recommended intervals.

The lifetime of the UPS batteries is approximately 2 years, after which time they need to be replaced. This is an important requirement for such sealed valve-regulated lead-acid batteries, otherwise corrosive leaks or hazardous odorous outgassing may occur. Contact Raith Service and Support for further information.

Lifetime can be reduced still further if the UPS system operates in environments with a temperature above 25 degrees Celsius.

9.8 Operating system

Carry out the following tasks to maintain a stable operating system and to avoid any loss of data:

- ▶ Defragmentation
- ▶ Data backup: Backup data at regular intervals onto an external data storage device, otherwise in the event of a hard drive crash, any customer-specific parameters and user data may be lost. Raith can, in such circumstances, only provide the standard parameters and standard system data.
- ▶ Anti-virus protection: Install an anti-virus protection software and a firewall on your computer, either when connecting to the internet or when exchanging data between computers.

Raith does not give any specific recommendation regarding the choice of anti-virus protection and firewall software. Industry-standard software products have been proven to be reliable.



For further guidance about the selection of suitable anti-virus and firewall software, consult either your IT department or Raith support.

Chapter 10

Troubleshooting

This chapter gives an overview of possible system errors and interruptions to the operation of the eLINE Plus. Some possible solutions are also outlined.

NOTICE

If a problem causes particular concern or if the user is not very familiar with the system, refer to your local system specialist trained by Raith, or contact Raith service.

10.1 Raith NanoSuite not responding

If the Raith NanoSuite software interface is unresponsive, close and restart it.

- If the Raith NanoSuite software can be closed without any error messages, it can simply be restarted.



If these steps are not successful, contact Raith support.

10.2 Noisy monitor display

If noise problems occur in one or both monitor displays, or if they are not visible at all, the monitor parameters may have inadvertently been changed or perhaps the monitor is in sleep mode.

- Reset the monitor parameters and restart the computer.

10.3 Computer not responding

If the computer is completely unresponsive, it must be restarted:

STEP 1: Restart the computer

- ▶ Close all windows and exit the software.
 - ▶ Confirm with **OK**, to save any changes.
 - ▶ Go to the Windows start menu and select **Restart**
-



If these steps are not successful, contact Raith support.

10.4 System error during loading

The sample holders are loaded and unloaded into the sample chamber by semi-automated **Load** and **Unload** procedures. During these procedures, various mechanical switches are monitored and software checks are carried out to ensure that all functions are performed without errors. During the Load and Unload procedure, the system is in its most error-sensitive state.

In the event of any kind of error indication, the system will initiate its own routine to deal with the errors and will display appropriate prompts on the monitor. If this occurs, follow the instructions. The system will reset itself into a safe state.

The system is in a safe state when:

- the transfer rod is pulled out of the chamber
 - the load lock door is closed
 - the valve between the roughing pump and the load lock is closed so that the load lock can not be pumped.
-

NOTICE

If the system's own troubleshooting procedure is not successful, contact Raith support.

10.4.1 Advanced button for sample exchange

When experiencing any problems during the **Sample exchange** procedure, the Administrator can go to the **Advanced** button of the **Sample exchange** panel to perform single commands.



Note that the **Advanced** button is only accessible when the **Administrator** has logged in. The **Advanced** button cannot be used by **Users**.

NOTICE

The **Advanced** button enables the **Administrator** to perform individual checks or single steps during the **Sample exchange** procedure. This button should only be used when a problem was encountered during the **Sample exchange** procedure.

Three modules are available to perform single commands.

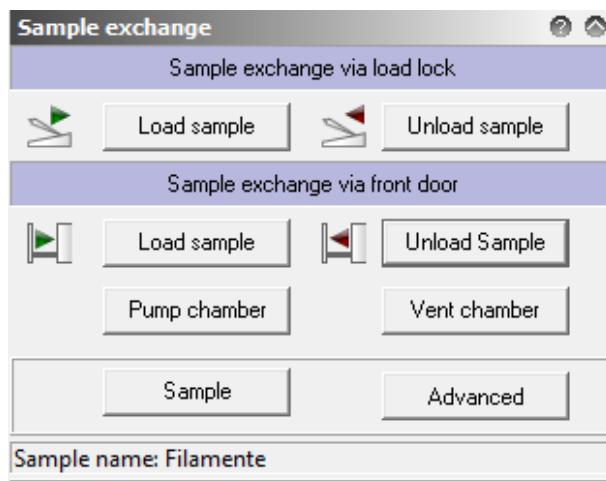


Figure 10-1: Sample exchange dialog

Clicking on the **Advanced** button opens the **Advanced load lock** dialog with three sub-panes, **Error**, **Settings** and **Single Steps**, which will be explained in detail.

10.4.2 Error panel in Advanced Sample exchange

The **Error** dialog lists the individual errors that have occurred.

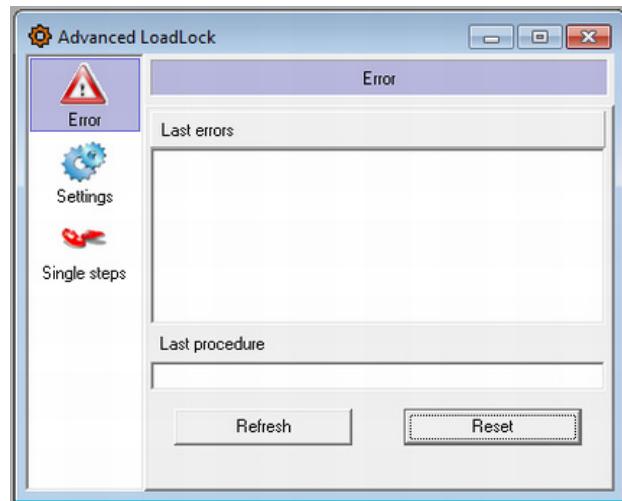


Figure 10-2: Error dialog

Error panel in Advanced Sample exchange

Control Element	Function
Last errors	Displays a list of the latest errors.
Last procedure	Displays the last procedure used.
Refresh	The status will be checked again. The error may no longer be active and will disappear from the list.
Reset	This will acknowledge and reset the error message.

10.4.3 Settings panel in Advanced Sample exchange

Settings is divided into four subsets:

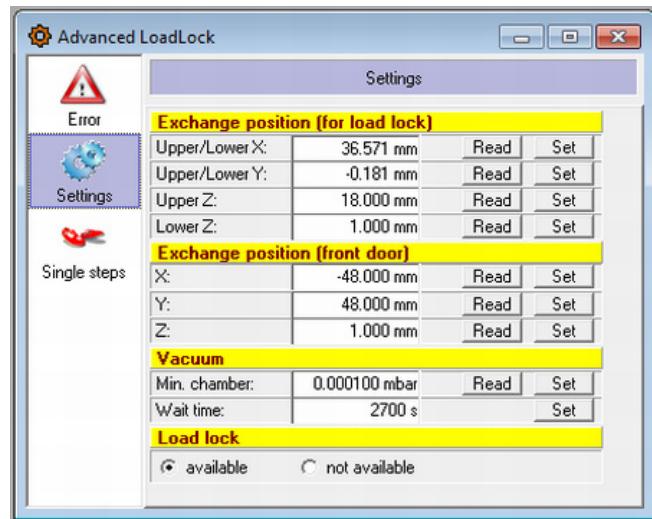


Figure 10-3: Advanced Settings panel

Control element	Function
Exchange position (for load lock) subset:	
Upper/Lower X	To Read the current position and to Set a new exchange position. Pressing Set will activate the new value.
Upper/Lower Y	To Read the current position and to Set a new exchange position. Pressing Set will activate the new value.
Upper Z	To Read the current position and to Set a new exchange position. Pressing Set will activate the new value.
Lower Z	To Read the current position and to Set a new exchange position. Pressing Set will activate the new value.
Exchange position (front door) subset:	
X	To Read the current position and to Set a new exchange position. Pressing Set will activate the new value.
Y	To Read the current position and to Set a new exchange position. Pressing Set will activate the new value.
Z	To Read the current position and to Set a new exchange position. Pressing Set will activate the new value.

Control element	Function
Vacuum subset:	
Min chamber	To Read the current vacuum reading and to Set the required vacuum, measured in mBar.
Wait time	The required waiting time in seconds can be set. Pressing Set will activate the new value.
load lock subset:	
available	Select if the load lock option is installed on the system.
not available	Select if the load lock option is not installed on the system. The load lock interface will not be visible to the user and sample exchange will be performed via the front door.



When the sample is exchanged via the load lock, an upper and lower exchange position must be defined to transfer the sample from the transfer rod onto the sample holder and vice versa.

10.4.4 Single step panel in Advanced Sample exchange

The single step module is divided six subsets, which will be described below.

It is possible to give single commands, which are normally done automatically during a semi-automated **Sample exchange** procedure, e.g. move to the upper exchange position, move to the lower exchange position etc. The stage can be moved to a defined position and the X/Y/Z motors can be released.

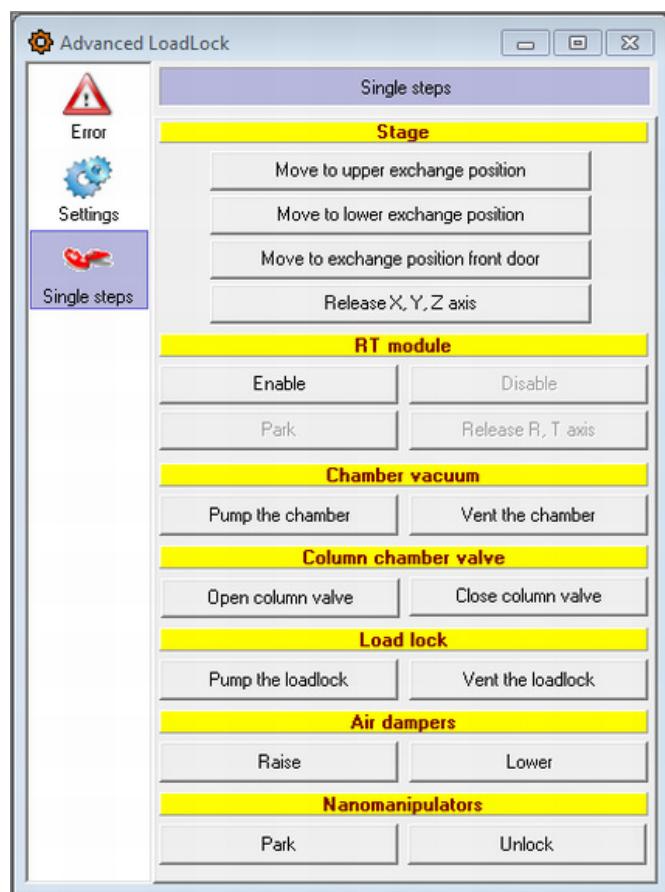


Figure 10-4: Single step panel

Control element	Function
Stage subset:	
Move to upper exchange position	Pressing this button will initiate the stage movement to the required position.
Move to lower exchange position	Pressing this button will initiate the stage movement to the required position.
Move to exchange position front door	Pressing this button will initiate the stage movement to the required position.
Release XYZ axes	Releases the X/Y/Z axes. The LEDs in the Coordinates window will change from red to green. Stage movements can be carried out again.
RT module subset:	

Control element	Function
Enable	To enable the RT module if installed. This will initiate the software communication to the RT module.
Disable	To disable the RT module. It is recommended to disable the RT module when not in use.
Park	To park the RT module in a safe position
Release RT axes	To release the RT axes. The LEDs in the Coordinates window will change from red to green. Stage moves can be carried out again.
Chamber vacuum subset:	
Pump chamber	To pump the vacuum chamber. Note: Take great care that the front door is firmly closed.
Vent chamber	To vent the vacuum chamber. Note: Take great care that the stage is in the exchange position, to avoid system damage.
Chamber vacuum valve subset:	
Open column valve	To open the column vacuum valve. Note: Take great care that the required vacuum has been reached to avoid system damage. Note: If required, the column can be vented for service tasks by Raith level 1 trained operators. Contact Raith for advice.
Close column valve	To close the column vacuum valve.
load lock subset:	
Pump the load lock	To pump the load lock. Note: Ensure that the load lock is firmly closed.
Vent the load lock	To vent the load lock.
Air dampers subset:	
Raise	To raise the air dampers.
Lower	To lower the air dampers.
Nanomanipulators subset:	
Park	To park the nanomanipulators in a safe position.

Control element	Function
Unlock	To unlock the nanomanipulators.



⚠️ WARNING

Crush hazard: Driving the stage while the vacuum chamber is open can cause serious hand injuries.



During the semi-automated **Sample exchange** procedure, the stage is locked to user intervention while the stage is driving to its defined exchange positions. The LEDs in the Coordinates window will be red while the stage is locked.

If, for example, the sample was loaded using single commands, the X/Y/Z stage must be released again when the **Sample exchange** procedure has been completed, so that the stage can be driven again by the user. While the stage is locked and the LEDs are red in the Coordinates window, no drive commands can be carried out. When the sample loading procedure has been completed successful, the stage will be enabled again in X/Y/Z and the LEDs in the **Coordinates** window will be green again. This command can also be carried out as a single command.



A troubleshooting scenario example: If the **Administrator** wishes to check if the stage is driving smoothly, a test can be carried out whilst the stage outside the vacuum chamber. After an **Unload** procedure has been completed and the stage is pulled out, the X/Y/Z stage must be released via a single command to allow movement of the stage outside the vacuum chamber.



When stage moves are carried out as single commands, a software prompt will be issued, to double-check that the **Administrator** is sure that this move should be performed.

NOTICE

Take great care when performing single commands, as the stage or the sample can be damaged by any unexpected impact.

10.5 Inaccurate stage movement

If the sample stage moves inaccurately at high magnification, the frequency of the laser interferometer may not be stable, or the stage may be running in Encoder mode. This can happen if the laser interferometer source has only recently been switched on. If this is the case, wait for approximately 20 minutes. When the frequency has stabilized, change the sample stage to laser mode via the **Laser Stage Control** dialog. Click on the **Laser** button.

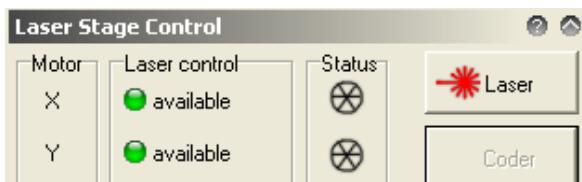


Figure 10-5: **Laser Stage Control** dialog – Encoder-Mode

10.6 Laser interferometer LED blinking

If the temperature in the room is varying above the specified limit, the laser interferometer might not function precisely. This can lead to unstable positioning of the stage and blinking of the interferometer LED. If the permitted temperature tolerance value is exceeded, the **LED Frequency Locked** LED will be blinking on the laser interferometer source unit.

The Laser Frequency Locked LED can indicate eight different statuses. These are summarized below.

Green LED off		Laser is off, shutter is closed (Power OFF)
● Green LED on	—	Laser is locked, shutter is open
● Green LED rapid blinking	— — — — — — —	Laser is unlocked, shutter is open
● Green LED slow blinking	— — — — — — —	Laser is locked, was unlocked before, shutter is open
● Yellow/ red LED rapid blinking	— — — — — — —	Laser is unlocked, shutter is closed
Yellow/ red LED slow blinking	— — — — — — —	Laser is locked, shutter is closed
● Yellow LED	— — — — — — —	Laser is unlocked, shutter is closed
● Red LED		Laser is off, shutter is closed

Figure 10-6: Laser statuses indicated by the Frequency Locked LED

- Go to the laser interferometer source unit situated in the rack and press the **Reset** button.



If, after pressing the **Reset** button, the problem persists, contact Raith support.

Chapter 11

Chemical Safety Data Sheets

This chapter describes the safe handling, use and storage of hazardous substances that are related to the working with the **eLINE Plus**. The information is intended as a template, to be adapted for your laboratory environment and to comply with your laboratory guidelines and regulations.

Operating instructions

in accordance with § 14 GEFSTOFFV, in association
with GHS (regulation (EG) Nr.1272/2008)

RAITH
NANO FABRICATION

Working area:

Room: _____

Date: _____ Signature: _____

Hazardous material name

2- Propanol

$(\text{CH}_3)_2\text{CHOH}$, Isopropyl alcohol, propan-2-ol,
colorless liquid with characteristic (alcohol-like) odour.

Hazards for personnel and environment



Danger

Flammable Liquid, Category 2/ H225

(Index-No. 603-117-00-0)

Eye irritation, Category 2/ H319

Specific Organ Toxicity (single exposure), Category 3/ H336

Hazard statements:

H225: Highly flammable liquid and vapour.

H319: Causes serious eye irritation.

H336: May cause drowsiness or dizziness.

Protective measures and safety precautions



P210: Keep away from heat / sparks / naked flames / hot surfaces. No smoking.

P233: Keep container tightly closed.

P305+P351+P338: AFTER EYE CONTACT: Rinse thoroughly with water for several minutes.

Where reasonably practicable, remove contact lenses and continue rinsing.



Work under hood. Do not inhale substance. Avoid generation of vapours / aerosols.

Vapours may form explosive mixture with air.

Take precautionary measures against static discharge.



Keep away from heat and sources of ignition. Store in a tightly closed container in a dry and well-ventilated place.

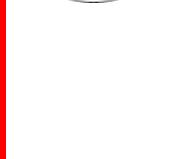
Store at +5°C to +30°C (+41°F to +86°F).



Eye / face protection: Safety glasses.



Hand protection: Full contact: Nitrile rubber, Glove thickness: 0.40 mm



Splash contact: Polychloroprene (Neoprene), Glove thickness 0.65 mm

Monitored work place limit (AGW): 200ppm (500 mg/m³).

Hygiene measures:

Change contaminated clothing. Preventive skin protection recommended. Wash hands after working with substance.

Respiratory protection: Required when vapours / aerosols are generated.

Recommended Filter type: Filter A (conforming to DIN 3181) for organic compound vapors.

Please turn over

Emergency Procedures

Emergency call:

112



Avoid substance contact. Do not inhale vapours, aerosols.

Ensure adequate ventilation. Evacuate the danger area.

For small spillages and leaks, including on soil, allow to evaporate, otherwise use chemical absorbents (universal chemical binder, e.g. Chemisorb). Dispose of appropriately.



Suitable extinguishing media: Carbon dioxide (CO₂), Foam, Dry Powder.

Accumulation of hazardous combustion gases or vapours possible in the event of fire.

Do not empty into drains. Risk of explosion.

Escape route: Leave the danger zone by nearest stairway or escape door. Do not use elevators!

First Aid

Emergency call: 112



At any first aid measure: Protect yourself and inform a physician.



After skin contact: Rinse with plenty of water. Remove contaminated clothing.

After eye contact: Rinse the eye(s) with plenty of water. Immediately call ophthalmologist.

After inhalation: Fresh air. Consult doctor if feeling unwell.

After swallowing: Caution if victim vomits. Risk of inhalation! Keep airways free. Pulmonary failure possible after inhalation of vomit. Call Emergency 112 immediately.

After clothing contact: Remove contaminated clothes immediately with product. Seek medical advice with any symptoms.

First aid : _____, phone _____

Appropriate Disposal

Disposal in accordance with local regulations. Store separately in suitable containers (the original container if possible). Store for disposal in the hazardous materials cupboard (cool, dry and away from sunlight). Pay particular attention to clear and correct labelling for identification.

Status: _____

Operating Instructions

In accordance with § 14 GEFSTOFFV in conjunction with GHS (Regulation (EC)1272/2008)

Workplace, scope and activity:

Room: _____

Date: _____

Signature: _____

RAITH
NANO FABRICATION

Identification of the hazard

Acetone

C_3H_6O ; 2-propanone, propanone, dimethyl ketone.
Colorless liquid, characteristic smell.

Dangers for man and environment

GHS classification:

Flammable liquid, Category 2,

H225: Highly flammable liquid and vapor.

Eye irritation, Category 2,

H319: Causes severe eye irritation.

Specific organ toxicity (single exposure), Category 3,

H336: May cause drowsiness or dizziness.

Additional Information:

EUH066 Repeated exposure may cause skin dryness or cracking.

Has narcotic effects.

DO NOT allow contact with alkali (hydroxides), halogens, halocarbons / halogenated halogen compounds, oxidizing agents (e.g., CrO_3 , peroxides, nitric acid, nitrating compounds), halogen oxides, alkali metals, nitrosyl compounds, metals and ethanolamine (2-aminoethanol). Hazardous decomposition products are peroxides (light-sensitive and sensitive to air).

Forms explosive mixtures with air.

Occupational exposure limit (OEL): 1200 mg / m³, 500 ml / m³.

Possible hazardous reactions

Risk of ignition or formation of dangerous gases or vapors with:

Activated carbon, chromic acid, ethanolamine (2-aminoethanol), strong oxidizing agents, strong reducing agents, nitric acid, chromium (IV) oxide.

Explosion with: nonmetallic, halogen-halogen compounds

Chloroform, nitrating acid, nitrosyl compounds, hydrogen peroxide

Exothermic reaction with: bromine, alkali metals, and halogenated hydrocarbons.



DANGER

Do not empty into drains, waste water or soil.

Protective measures and rules



Preventive measures:

P210 Keep away from sources of heat, hot surfaces, sparks, naked flames and other ignition sources.

No smoking.

P305 + P351 + P338 IN THE EVENT OF EYE CONTACT: Rinse thoroughly for several minutes with water.

Remove contact lenses, if practicable. Continue rinsing.

P403 + P233 Keep container tightly closed and in a well-ventilated place.

All chemicals are potentially dangerous. Therefore only adequately trained personnel should handle the substance, with due diligence.

Do not inhale vapors and aerosols. Avoid skin and eye contact. Wear safety goggles.

Work only in fume cupboard. Protect from direct sunlight.

Take precautionary measures against static discharges.

Wear suitable protective gloves.

General protective and hygienic measures:

When using do not eat, drink or smoke.

Keep away from food and beverages.

Avoid contact with eyes.

Not inhale gases / vapors / aerosols.

Wash hands before breaks and at the end of the workday.

Preventive skin protection skin protection cream.

Protective Gloves: for example, Butyl rubber, thickness: 0.7 mm

For light splash protection, latex, nitrile or neoprene gloves more suitable.

Respiratory protection: Filter AX (color code: brown). Required when aerosol, vapors or mist are formed when ventilation is inadequate.

Eye protection: Wear tightly fitting goggles or face shield.

Skin protection: Protective clothing

Storage: Store in sealed containers in a cool, dry, well ventilated place, protected from light, at +15 ° C to +25 ° C.

Emergency Procedures

Dial Emergency: 112



Absorb spillages in liquid-binding material (sand, diatomite, No. 1710.1).

Collect material according to local regulations, with adequate ventilation.

Do not empty into drains.

Suitable fire extinguisher: Powder, Foam, Carbon dioxide.

Specific hazards: Combustible. Forms explosive mixtures with air at ambient temperature.

Vapors heavier than air. In case of fire, hazardous combustion gases or vapors.

Small spillages or leaks can be allowed to evaporate, otherwise use absorbent material (Universal chemical binder).

Dispose of the absorbent material as hazardous waste.

Escape route: Nearest staircase or emergency exit.

Do not use elevators!



At any first aid measure: Protect yourself and inform a physician.



Skin contact: Immediately wash with water.

Eye contact: Rinse eye(s), held open, with plenty of running water (eye shower!). Rinse for at least 10 minutes. Seek medical advice.

Inhalation: Remove to fresh air. In the event of symptoms, seek medical treatment.

Ingestion: Inhalation hazard! Rinse out mouth and drink water. Do not induce vomiting. Seek medical advice immediately and show this container or label.

Contact with clothing: Immediately remove any contaminated clothing

First Aider: _____, phone: _____

Hand this sheet to the doctor!

Appropriate disposal

Dispose in accordance with local regulations. Store in suitable containers for flammable, halogen-free, organic solvents. Store for disposal in safety cabinet in a cool dry place, away from direct sunlight.

Ensure that the container is clearly and accurately labelled!!

Status: _____

Operating Instructions

In accordance to § 20 GEFSTOFFV

Workplace, scope and activity:

Equipment installation

Room _____

Date: _____ Signature: _____



Identification of the hazard

Magnesium Sulphate Heptahydrate

Synonyms: Epsom salts, kieserite, Mg vitriol.

$\text{MgSO}_4 \times 7 \text{ H}_2\text{O}$, colorless, odorless solid

Hazards for personnel and environment

No
Hazard
symbol
assigned

Avoid generation of dust. Do not inhale dust.

Do not dispose of into drains.

Hazardous thermal decomposition products (gaseous sulfur oxides).

The product should be handled using normal chemical handling precautions.

Toxic effects only at very high doses.

R-phrases: not assigned

Protective measures and code of practice



With proper handling, very low hazards

Avoid heating the substance

Specific safety instructions: not assigned



Emergency Procedure

Dial Emergency: 112



Escape route: Leave danger zone by nearest escape door or exit windows.
Do not use elevators!



Firefighting measures: Use suitable extinguisher appropriate to surrounding area. In the event of fire, toxic gases or vapors possible (sulfur oxides). Stay out of immediate area unless wearing self-contained breathing apparatus.
Prevent fire-fighting water from entering surface water.



At any first aid measure: Protect yourself and inform a physician.

After eye contact: Irrigate the eye with plenty of water with the eyelid held open - (min. 15 minutes). Seek medical advice.

After skin contact: Wash with plenty of water. Remove contaminated clothing.



After inhalation: Supply fresh air.

After swallowing (large amounts): Rinse mouth. Consult a physician.

First Aider: _____, Tel.: _____

Appropriate Disposal

Collect separately in suitable, tightly closed containers. Clearly identify as a material designated as special waste. Identification must be accurate and clearly visible.

Status: _____

Operating Instructions

In accordance with § 14 GEFSTOFFV, in conjunction with GHS (Regulation (EC)1272/2008)

Workplace, scope and activity: Signature:

Raith cleanroom laboratory

Date: 19.11.2015



Identification of the hazard

Tungsten hexacarbonyl

Molecular Formula: W(CO)₆

Appearance: colorless to pale yellow solid

Hazards for personnel and the environment

EU-GHS / CLP classification:

Acute toxicity, Oral (Category 3)

H301: Toxic if swallowed

Acute toxicity, skin (Category 3)

H311: Toxic in contact with skin. Toxic by absorption through the skin.



Acute toxicity, inhalation (category 3)

H331: Toxic if inhaled. May cause eye irritation.

DANGER

Special hazards arising from the substance: Carbon monoxide, tungsten oxide. Carbonyl compounds are toxic due to the carbon monoxide released during decomposition.

The chemical, physical and toxicological properties of this substance have not been fully investigated.

Occupational Exposure Limits (OEL): no data available

Storage: Do not store with flammable substances and / or oxidizing agents.

Ecological information: Extremely hazardous in aquatic environments (class 3).

Do not empty into drains, waste water or soil.

Protective measures and rules



Prevention:

P61 + P280: Avoid breathing dust / fume / gas / mist / vapors / spray.
Wear protective gloves / protective clothing / eye protection / face protection:



P301 + P310: IF SWALLOWED: Immediately call a POISON CENTER or doctor.

P311: Immediately call a POISON CENTER or doctor.



Handling and Storage: Avoid contact with eyes, skin and clothing. Avoid breathing dust, fumes, mist and vapor. Ensure adequate ventilation. Do not empty into drains. Keep in a cool place. Keep container tightly closed in a dry, ventilated place.

Eye protection: Use face shield and / or goggles. Only use eye protection equipment complying with appropriate standards, such as **NIOSH (US)** or **EN 166 (EU)**.

Hand protection: Handle with gloves. Use protective gloves (full contact) certified to **DIN EN 374** (butyl rubber, layer thickness: 0.7 mm). Wash hands before breaks and at end of work. Use suitable skin protection products (see skin protection plan). Gloves must be checked for leaks. Only use disposable nitrile rubber or neoprene gloves as a splash guard.

Respiratory protection: In case of insufficient ventilation, use full-face particle type **N99 (US)** or filter type **P3 (EN 143)**, in addition to other technical measures.

Skin protection: The type of protective equipment used at the working area must be selected according to the concentration and amount of the specific hazardous substance (possibly a protective suit).

Emergency Procedures

Dial Emergency: 112



Spillages: Wear respiratory protection. Absorb spillages or leaks absorb dust-free absorbent. Dispose of according to local safety regulations. Do not inhale vapors / aerosols. Ensure adequate ventilation. Remove affected persons to safety. Avoid breathing contaminated dust.

Wear personal protective equipment. Keep in suitable, closed containers for disposal. Discharge into the environment must be avoided. Do not discharge into groundwater or the sewerage system.



Fire-fighting measures: Extinguishing media: Use water spray, foam, dry chemical or carbon dioxide. In case of fire, if necessary, wear self-contained breathing apparatus. Hazardous carbon oxides can occur.

Remove contaminated clothing.

Escape route: Leave affected area by nearest exit / staircase. Do not use elevators.

With all first aid measures: protect yourself and contact a doctor.

Remove the victim from exposure, lay the victim down.

Skin contact: Remove contaminated clothing and shoes immediately.

Wash off with soap and plenty of water. Take victim immediately to hospital. Rinse eyes with water as a precaution. Consult a doctor.



Eye contact: Rinse eyes with plenty of water. Consult a doctor.



Inhalation: Remove person to fresh air. If breathing has stopped, artificial respiration. Consult a doctor.

After swallowing: Never give an unconscious person anything by mouth. Rinse the mouth with water. Consult a doctor.

First Aider: Axel Rudzinski, Tel: -115 or Ulrich Barth, Tel: -. 111

Give this safety data sheet to the doctor

Appropriate disposal

This material (residues and / or non-recyclable solutions) may only be disposed of by an approved waste disposal specialist.

This substance should be dissolved in a flammable solvent. Mixtures containing the material must be disposed of in a chemical incinerator equipped with afterburner and scrubber. Disposal according to local regulations.

Contaminated packaging must be disposed of in the same way as the unused product. Arrange appropriate, separate collection and intermediate storage for disposal in a labelled poison cupboard. Keep container tightly sealed and store upright.

Ensure that the container is clearly and accurately labelled.

Status: 11/2015

Operating Instructions

In accordance with § 14 GEFSTOFFV, in conjunction with GHS (Regulation (EC)1272/2008)

Workplace, scope and activity: Signature:

Raith cleanroom laboratory

Date: 19.11.2015

RAITH
NANO FABRICATION

Identification of the hazard

(Trimethyl) methylcyclopentadienyl platinum (IV)

Molecular Formula: C₉H₁₆Pt

Appearance: off-white solid

Hazards for personnel and the environment

EU-GHS / CLP classification:

Acute toxicity, Oral (Category 1),

H300: Fatal if swallowed.

Acute toxicity, skin (Category 2)

H310: Fatal in contact with skin.



Skin sensitization (Category 1),

H317: May cause an allergic skin reaction.

Acute aquatic toxicity (Category 1),

H400: Very toxic to aquatic organisms.

DANGER

Highly toxic in contact with skin. Potentially fatal if swallowed and by skin absorption. The in-vitro test (Ames test) positive, indicating substance potentially carcinogenic (No cell mutagenicity).

May cause eye irritation.

Other chemical, physical and toxicological properties of this substance have not been thoroughly investigated.

Occupational Exposure Limits (OEL): No data available

Materials / Conditions to be avoided: Strong oxidizing agents and air exposure.

Ecological information: Extremely hazardous in aquatic environments (class 3).

Do not empty into drains, waste water or soil.

Protective measures and rules



Prevention:

P64: Wash hands thoroughly after handling.

P73: Avoid release to the environment.

P280: Wear protective gloves / protective clothing / eye protection / face protection:

P301 + P310: Immediately call a POISON CENTER or doctor, if swallowed.

P302 + P350: Wash with soap and water in case of contact with the skin.



Handling and Storage: Avoid contact with eyes, skin and clothing. Avoid dust and aerosols. Ensure adequate ventilation. Do not allow to enter drains. Keep in a cool place. Keep container tightly closed in a dry, well-ventilated place. Air-sensitive material, handle and store under inert gas.

Eye protection: Use face shield and / or goggles. Only use eye protection equipment complying with appropriate standards, such as **NIOSH (US)** or **EN 166 (EU)**.

Hand protection: Handle with gloves. Use protective gloves (full contact) certified to **DIN EN 374** (butyl rubber, layer thickness: 0.7 mm). Wash hands before breaks and at end of work. Use suitable skin protection products (see skin protection plan). Gloves must be checked for leaks. Only use disposable nitrile rubber or neoprene gloves as a splash guard.

Respiratory protection: In case of insufficient ventilation, use full-face particle type **N100 (US)** or filter type **P3 (EN 143)**, in addition to other technical measures.

Skin protection: The type of protective equipment used at the working area must be selected according to the concentration and amount of the specific hazardous substance (possibly a protective suit).

Emergency Procedures

Dial Emergency: 112



Spillages: Wear respiratory protection. Absorb spillages or leaks absorb dust-free absorbent. Dispose of according to local safety regulations. Do not inhale vapors / aerosols. Ensure adequate ventilation. Remove affected persons to safety. Avoid breathing contaminated dust.

Wear personal protective equipment. Keep in suitable, closed containers for disposal. Discharge into the environment must be avoided. Do not discharge into groundwater or the sewerage system.



Fire-fighting measures: Extinguishing media: Use water spray, foam, dry chemical or carbon dioxide. In case of fire, if necessary, wear self-contained breathing apparatus. Hazardous carbon oxides can occur.

Remove contaminated clothing.

Escape route: Leave affected area by nearest exit / staircase. Do not use elevators.

With all first aid measures: protect yourself and contact a doctor.

Remove the victim from exposure, lay the victim down.

Skin contact: Remove contaminated clothing and shoes immediately.

Wash off with soap and plenty of water. Take victim immediately to hospital. Rinse eyes with water as a precaution. Consult a doctor.



Eye contact: Rinse eyes with plenty of water. Consult a doctor.

Inhalation: Remove person to fresh air. If breathing has stopped, artificial respiration. Consult a doctor.

After swallowing: Never give an unconscious person anything by mouth. Rinse the mouth with water. Consult a doctor.

First Aider: Axel Rudzinski, Tel: -115 or Ulrich Barth, Tel: -. 111

Give this safety data sheet to the doctor

Appropriate disposal

This material (residues and / or non-recyclable solutions) may only be disposed of by an approved waste disposal specialist.

This substance should be dissolved in a flammable solvent. Mixtures containing the material must be disposed of in a chemical incinerator equipped with afterburner and scrubber. Disposal according to local regulations.

Contaminated packaging must be disposed of in the same way as the unused product. Arrange appropriate, separate collection and intermediate storage for disposal in a labelled poison cupboard. Keep container tightly sealed and store upright.

Ensure that the container is clearly and accurately labelled.

Operating Instructions

In accordance with § 14 GEfStoffV in conjunction with GHS,
Regulation (EC) No 1272/2008 [EU-GHS / CLP]

Workplace, scope and activity:

RAITH
NANO FABRICATION

Room: _____

Date: _____ Signature: _____

Identification of the hazard

Phenanthrene

(in 1.8 ml of GIS precursor as a carbon source)

Appearance: Colorless, white to yellowish crystalline solid

Hazards for personnel and environment



EU-GHS / CLP classifications:

Acute toxicity, Category 4, oral

H302: Harmful if swallowed.

Acute aquatic toxicity, Category 1,

H400: Very toxic to aquatic organisms.

Chronic aquatic toxicity,

H410: Very toxic to aquatic life with long lasting effects.

Polycyclic aromatic hydrocarbon (PAH).

(Environmentally hazardous substance)

Reduced labeling ($\leq 125 \text{ ml}$)

Hazardous substances without occupational exposure limit (OEL).

Hazardous reactions: Violent reaction on contact with oxidizing agents.

Attention

Protective measures and code of practice

Prevention (precautions):

P262: Avoid eye contact, skin contact, or clothing contamination.

P272: Contaminated work clothing should not be allowed out of the workplace.

Do not empty into drains.

Technical measures and the application of suitable work practices have priority over the use of personal protective equipment.



Handling and Storage: Keep in sealed containers in a dry place at + 15 ° C to + 25 ° C.

Eye protection: Close contact goggles.

Hand and Skin Care:

Hand and Skin Care:

Hygiene measures: Change contaminated clothing immediately.

Preventive skin protection: Wash hands before breaks and immediately after handling the product. After work, wash hands and face.

Nitrile or neoprene disposable gloves should be used only as a splash protection. Use protective gloves (full contact) according to DIN EN 374 (butyl rubber, Layer thickness: 0,11mm). Use suitable skin protection products (see skin protection plan).

Skin Protection: Wear appropriate impervious protective clothing.

Respiratory protection: Required when dusts are generated. Recommended Filter type: P2.

Emergency Procedure

Dial Emergency: 112



Collect product residues and seal in packaging as hazardous waste and dispose of appropriately. Avoid contact with substance, and dust. Use personal protective equipment. Do not inhale dust. Do not discharge into groundwater drains. Evacuate personnel to safety. Ensure adequate ventilation. Combustible material. Vapors are heavier than air and may spread along floors.

Caution: In the event of fire, hazardous combustion gases or vapors possible.



Fire extinguishers: Use water, foam, dry chemical or carbon dioxide fire extinguisher.

In case of fire, if necessary, wear self-contained breathing apparatus (SCBA)

Remove contaminated clothing.

Explosive mixtures with air.

Do not discharge water into surface water or groundwater system.



Escape route: Leave danger area by the nearest exit or staircase. Do not use elevators.

First Aid

Dial Emergency: 112



At any first aid measure: Protect yourself and inform a physician.

Remove the affected person from exposure and lay the person down. Place and transport in the recovery position. When breathing is irregular or arrested, administer artificial respiration. Remove contaminated clothing immediately.

Skin Contact: Remove contaminated clothing and shoes immediately.

Wash off with soap and plenty of water.

Eye Contact: Rinse the eye(s) with plenty of water with eyelids held open.

Inhalation: Remove person to fresh air.

After swallowing: make affected person drink water (maximum of 2 glasses). Seek medical advice.



First Aider: _____, Phone: _____

Show this material safety sheet to the attending physician!

Appropriate Disposal

Product residues should be disposed of in compliance with the 2008/98 / EC Waste Directive.

Collect small quantities in containers for solid organic residues.

Collection containers must be clearly labeled with the systematic description of their contents and the correct hazard pictograms. Keep containers in a well-ventilated place.

Follow the national regulations for waste disposal.

Contaminated packaging to be disposed of in the same way as the unused product.

Status: _____

Operating Instructions

In accordance to § 14 GEfStoffV in conjunction with GHS,
Regulation (EC) No 1272/2008 [EU-GHS / CLP]

Workplace, measuring range, Activity:

Room: _____

RAITH
NANO FABRICATION

Date: _____ Signature: _____

Identification of hazard

2,4,6,8,10-Pentamethyl-cyclopentasiloxane (PCMS in 1,4ml GIS Insulator precursor)

Appearance: Colorless liquid

Synonyms: 2,4,6,8,10-pentamethyl-cyclopentasiloxane; Pentamethylcyclopentasiloxane; 2,4,6,8,10-pentamethylcyclopentasiloxane; Cyclopentasiloxane, 2,4,6,8,10-pentamethyl-; Pentamethylcyclopentasiloxane; 1,3,5,7,9-Pentamethylcyclopentasiloxane; 2,4,6,8,10-pentamethyl-1,3,5,7,9,2,4,6,8,10-pentaoxapentasilecane; 2,4,6,8,10-PENTAMETHYLCYCLOPENTASILOXAN

Hazards for Personnel and Environment



EU-GHS / CLP classifications:
Flammable liquid (category 3)

H226: Flammable liquid and vapor.

Irritant to skin, (category 2),

H315: Causes skin irritation.

Eye irritation (Category 2)

H319: Causes severe eye irritation.

Specific organ toxicity-single exposure (Category 3),

H335: May cause respiratory irritation.

Potential health effects: May be harmful if inhaled. Causes respiratory tract irritation.

Hazardous substances without occupational exposure limit (OEL).

ATTENTION

Protective measures and code of practice

Prevention (precautions):

P261: Avoid breathing dust / fume / gas / mist / vapor / spray.

P305 + P351 + P338: Rinse thoroughly with water for several minutes: In case of contact with eyes. Remove contact lenses, if practicable. Continue rinsing.

Keep away from sources of ignition. No smoking. Take precautionary measures against static discharges.



Handling and Storage: Store under inert gas. Moisture-sensitive. Store in a cool place. Keep container tightly closed in a dry and well-ventilated place. When opened, container must be carefully resealed and kept upright to prevent leakage.

Eye Protection: Use close-fitting safety goggles or face shield eye protection. Only use eye protection equipment tested, approved and conforming to appropriate regulatory standards. [NIOSH (US) or EN 166].

Hand and Skin Care: Work with hand protection. Gloves must be inspected prior to use. Wash hands before breaks and immediately after handling the product and after work. Nitrile or neoprene disposable gloves should be used only as a splash protection. For full contact, use protective gloves (full contact) in accordance with DIN EN 374 (butyl rubber, Layer thickness: 0.7 mm). Use suitable skin protection products (see skin protection plan).

Skin protection: suitable impervious protective clothing (if applicable, flame retardant antistatic protective clothing). The type of protective equipment must be selected according to the concentration and the quantity of the dangerous substance.

Respiratory Protection: If an air-purifying respirator is required under the risk assessment, use a full-face particle respirator type N100 (US) or type P3 (EN 143) in addition to other technical measures. Respirators and components must be tested and approved under appropriate regulatory standards [(US) or CEN (EU) NIOSH].

Emergency Procedure

Dial Emergency: 112



Collect product residues or fluid leaks with suitable amounts of chemical sorbents and seal in packaging as hazardous waste and dispose of appropriately. Do not inhale vapors / mist / gas. Use personal protective equipment. Remove all sources of ignition. Do not discharge to groundwater drains. Evacuate personnel to safety. Ensure adequate ventilation. Vapors may accumulate in low areas.

Caution: In case of fire, toxic fumes, e.g. Carbon dioxide and carbon monoxide.



Use normal fire-fighting measures: For small developing fire, use foam, dry chemical or carbon dioxide. For large fire use water spray. Cool all affected containers with water.

In case of fire, if necessary, wear self-contained breathing apparatus (SCBA).

Remove contaminated clothing.



Escape route: Leave danger area by the nearest staircase or exit door. Do not use elevators.

**At any first aid measure: Protect yourself and inform a physician.**

Remove the affected person from exposure, lay the person down. Place and transport the affected person in the recovery position. When breathing is irregular or arrested, administer artificial respiration.

Remove contaminated clothing immediately.

Skin Contact: Remove contaminated clothing and shoes immediately. Wash off with soap and plenty of water. Seek medical advice.

Eye Contact: Rinse the opened eye(s) thoroughly under running water for at least 15 minutes and seek medical advice.

Inhalation: Remove affected person to fresh air. If not breathing, give artificial respiration. Seek medical advice.

Swallowing: Do not induce vomiting. Never give an unconscious person anything by mouth. Rinse mouth with water. Seek medical advice.

According to current knowledge, the chemical, physical, and toxicological properties have not been thoroughly investigated.

First Aider: _____ Phone: _____

Show this material safety sheet to the attending physician!

Appropriate Disposal

Pay attention to common storage prohibitions. Keep container tightly closed and upright. Ensure absolutely accurate labeling (including hazard pictograms).

Offer surplus and non-recyclable solutions to a licensed disposal company for burning in a chemical incinerator, equipped with an afterburner and scrubber. Extra care in igniting, as this material is highly flammable.

Contaminated packaging to be disposed of in the same way as the unused product.

Status: _____

Operating Instructions

In accordance with § 14 GEFSTOFFV in conjunction with GHS,
Regulation (EC) No 1272/2008 [EU-GHS / CLP]

Workplace, scope and activity:

Room: _____

Date: _____ Signature: _____

RAITH
NANO FABRICATION

Identification of the Hazard

Xenon difluoride (XeF_2)

(in 1.8 ml of GIS etching precursor to Si / SiO_2 or W)

Appearance: Colorless crystalline solid

Hazards to Personnel and Environment

EU-GHS / CLP classifications:

Oxidizing solid, Category 2,

H272: May intensify fire; oxidant

Acute toxicity, Oral (Category 3)

H301 Toxic if swallowed.

Skin corrosion, Category 1B,

H314: Causes severe skin burns and eye damage.

Risk of skin burns and serious eye damage, loss of sight.

Oxidizing, corrosive, highly destructive to tissues and fabric.

Acute toxicity, inhalation (category 2)

H330 Fatal if inhaled.

Potential health effects:

Inhalation: May be fatal if inhaled. Material is extremely destructive to tissue to mucous membranes and upper respiratory tract.

Ingestion: Toxic if swallowed. Causes burns.

Skin: May be harmful if absorbed through the skin. Causes skin burns.

Eyes: Causes eye burns.

Occupational exposure limit (OEL): 1 mg / m³

Possibility of hazardous reactions: Reducing agents

Further hazardous properties cannot be excluded.

DANGER



Protective measures and code of practice



Prevention (precautions):

P220: Store and keep away from clothing / combustible materials.

P280: Wear protective gloves, protective clothing, eye protection, face protection.

P284 Wear respiratory protection.

P301 + 330 + 331: If swallowed, rinse mouth. Do not induce vomiting.

P305 + 351 + 338: Eye Contact. Rinse thoroughly with water for several minutes

Remove contact lenses, if practicable, continue rinsing.

P309 + 310: Immediately call a POISON CENTER or doctor: If exposed or if you feel unwell.

Do not inhale substance. Do not empty into drains.

Technical measures and the application of suitable work procedures have priority over the use of personal protective equipment. **Work under fume hood.**

Handling and Storage: Keep in a tightly sealed container. Do not store near combustible materials. Store away from ignition and heat sources, dry, at + 2 ° C to + 8 ° C.

Eye protection: Close fitting goggles.

Hand and Skin Care:

Hygiene measures: Change contaminated clothing immediately. Preventive skin protection.

Wash hands before breaks and immediately after handling the product.

After work, wash hands and face.

Butyl rubber or neoprene disposable gloves should be used only as a splash protection. Use protective gloves (full contact) according to DIN EN 374 (butyl rubber, Layer thickness: 0,11mm). Use suitable skin protection products (see skin protection plan).

Skin Protection: Wear appropriate impervious protective clothing.

Respiratory Protection: If an air-purifying respirator is required under the risk assessment, a full-face particle respirator type N100 (US) or type P3 (EN 143) must be used, in addition to other technical measures. If the respirator is the sole means of protection, breathing apparatus should be used with full face mask. Respirators and components must be (US) or CEN (EU) tested and approved under appropriate regulatory standards such as NIOSH.

Emergency Procedure

Dial Emergency: 112



Recover residues (e.g. with Chemizorb). Seal waste in packaging labelled as hazardous waste and dispose of appropriately. Avoid contact with substance, and dust. Use personal protective equipment. Do not breathe dust or fumes. Do not discharge to groundwater drains. Evacuate personnel to safety. Ensure adequate ventilation.



Caution: In the event of fire, hazardous combustion gases or vapors possible (e.g. hydrogen fluoride). Expert assistance required.

Fire extinguishers: For this substance, there are no limitations on extinguishing agents.

Use extinguishing measures that suit the immediate environment.

Do not stay in dangerous area without self-contained breathing apparatus!

Remove contaminated clothing.



Escape route: Leave danger area by the nearest staircase or exit door. Do not use elevators.

**At any first aid measure: Protect yourself and inform a physician.**

Remove the affected person from exposure, lay the person down. Place and transport the affected person in the recovery position. When breathing is irregular or arrested, administer artificial respiration.

Remove contaminated clothing immediately.

Skin Contact: Remove contaminated clothing and shoes immediately.

Wash with plenty of water. Dab affected skin area with polyethylene glycol 400. Immediately seek medical attention.

Eye Contact: Rinse with plenty of water with eyelids held open. Remove contaminated clothing.

Inhalation: Supply fresh air. Move exposed person to fresh air. Consult a physician.

After swallowing: make affected person drink water (maximum of 2 drinking glasses). Avoid vomiting (perforation). Call a physician immediately. No neutralization tests.

First Aider: _____, Phone: _____

Show this safety data sheet to the attending physician.

INFORMATION CENTER against POISONING: Tel: _____

Appropriate Disposal

Product residues should be disposed of in compliance with the 2008/98 / EC Waste Directive.

Possible residues should be left in the original container.

Do not mix with other waste.

If necessary, use separate collection containers, clearly marked with the systematic description of their contents and the correct hazard pictograms.

Keep containers in a well-ventilated place.

Follow the appropriate national regulations for waste disposal.

This material may only be removed by a licensed waste disposal contractor.

Contaminated packaging to be disposed of in the same way as the unused product.

Status: _____

Operating Instructions

In accordance with § 14 GEFSTOFFV in conjunction with GHS,
Regulation (EC) No 1272/2008 [EU-GHS / CLP]

Workplace, scope and activity:

RAITH
NANO FABRICATION

Room: _____

Date: _____ Signature: _____

Identification of the hazard

1,1,1,2-Tetrafluoroethane (R 143a), liquified

Synonyms: R-134a, Forane 134a, Genetron 134a, Florasol 134a, Suva 134a or HFC-134a, also known as norflurane
Refrigerant gas R134a Category: fluoroalkanes
Appearance: Colorless, non-flammable gas; Smell: ethereal
Application: refrigerant

Hazards for personnel and environment

EU-GHS / CLP classifications:

Gases under pressure, liquefied gas,

H280: **Contains gas under pressure; may explode if heated.**



Potential health effects:

At high concentrations, risk of suffocation. Vapors are heavier than air.

Contact with liquid may cause chill burns / cause frostbite.

Major mechanisms of acute injury:

The main route of 1,1,1,2-tetrafluoroethane (R-134a) proceeds via the respiratory tract.

At low concentrations, narcotic effects (dizziness, headache, nausea) can occur.

After exposure to high concentrations of vapors or aerosols:

- Minor irritation to mucous membranes,
- Cardiovascular disorders
- Loss of mobility and consciousness.



Hazardous substances with **occupational exposure limit (OEL)**: 1000 ppm; 4200 mg / m³

Special hazards arising from the substance or mixtures:

During thermal decomposition / in a fire, hazardous fumes, toxic and corrosive decomposition products such as carbon monoxide, carbonyl fluoride, hydrogen fluoride or Fluorophosgene.

Hazardous reactions / Incompatible materials:

Keep away from moisture and heat. Avoid strong oxidizing agents.

Can react violently with alkali and alkaline earth metals, resulting in toxic metal fumes.

Ecological information:

Product must be handled in a closed system. Prevent any substance release.

Waste containing residues or refrigerant must not be allowed to enter sewers / drains.

Global warming potential for refrigerant R143a: 1430 (> 150)

Global Warming Potential (GWP) of fluorinated greenhouse gases (see the Kyoto Protocol)

Banned as a coolant in vehicles since 2011 (see EU Directive). All sales banned from 2017. Substitute material is urgently required.

Protective measures and code of practice



Prevention (precautions):

P403: Store in a well-ventilated place.

P410 + P403: Protect from sunlight in a well-ventilated place.

Handling and Storage: Do not keep storage bottles in the working area.

Do not use force to open valves. Always leak check changeover valves of filled and empty bottles. Filling and transfer in storage rooms is prohibited.

Secure bottles in the upright position. Prevent ingress of water into the gas tank. Prevent backflow into the gas tank. Use low pressure gas tight apparatus with suction, for filling and transferring. The gas to be filled must be dry, i.e., the dew point must be <-10 ° C. Only fill into dry containers.

Transport usually takes place in high pressure containers. For transport, use suitable equipment and containers.

Containers must be clearly and permanently marked.

Keep container in a well-ventilated place.

Secure in an upright position, to prevent toppling.

Protect from direct sunlight.

Do not store in escape routes and work spaces and in their immediate vicinity.

When transporting, storing, preparing, draining and maintaining compressed gas cylinders / aerosols, the detailed provisions of TRG 280 bzw. TRG 300 must be observed.

Beim Hantieren mit Druckgasflaschen sind Schutzschuhe zu tragen



When handling compressed gas cylinder, protective footwear must be worn

Eye protection: Adequate eye protection should be worn.

When dealing with compressed gas, as a minimum, framed glasses with side protection are required. When dealing with liquefied gas, wear chemical goggles in addition to a face shield.

Hand and Skin Protection: Use leather gloves when handling compressed gas cylinders to protect against injury and frostbite by rapidly decompressing gas.

Skin Protection: Wear appropriate impervious protective clothing. The type of protective equipment must be selected according to the concentration and quantity of the dangerous substance at the specific workplace.

Respiratory protection: In an emergency (eg unintentional release of substance, occupational exposure limit is exceeded) wearing of respiratory protection is required.

Observe respiratory equipment time limitations. Respiratory protection: SCBA

Do not use filter devices.

Emergency Procedure

Dial Emergency: 112



Use normal fire-fighting measures: Non-combustible gas. Use extinguishing measures appropriate to the environment. In the event of fire, draw to the attention of the Emergency Services the presence of pressurized vessels. Use breathing apparatus (SCBA) according to EN137.

Cool containers with water spray.

If possible, remove containers from the danger zone.

Pressure rise and explosion can occur when heated.

Risk of frostbite in the event of liquid contact.



Escape route: Leave danger area by the nearest exit or staircase. Do not use elevators.



After any first aid measure: Protect yourself and inform a physician.

Remove affected person from the hazardous area (fresh air) and lay down. At high concentrations, self-contained breathing apparatus (SCBA) must be worn. Place and transport the affected person in the recovery position. When breathing is irregular or arrested, administer artificial respiration. Consult a physician. Remove contaminated clothing immediately.



Skin Contact: Wash affected skin areas thoroughly with soap under running water. Remove contaminated clothing, while protecting yourself. Keep injured personnel calm, protect against hypothermia. After contact with the liquid, treat supercooled skin surfaces (frostbite) continuously with warm (not hot) water. Call a physician.



Eye Contact: Rinse eye(s) for 10 minutes under running water with eyelids held open. Seek medical treatment.



Inhalation: Move the affected person, using self-protection, from the danger zone to fresh air. Ensure exposure to fresh air or air enriched with oxygen.

If unconscious but breathing, place in the recovery position. Keep injured person calm, protect against hypothermia. Provide first aid and seek medical treatment.

Occurrence of contact with fumes or thermal decomposition products:

Repeated deep inhalation of glucocorticoid aerosol dose.

Ingestion: Due to the low boiling point of the liquid, oral ingestion of toxicologically relevant quantities under real conditions is not possible.

First Aider: _____, Phone: _____

Seek medical assistance. Show this safety data sheet to the attending physician!

Appropriate Disposal

Do not discharge into the atmosphere. Do not discharge into drains, cellars, working pits and similar places where accumulations of escaped gas could be dangerous. Compressed gas cylinders are usually returned to the supplier. Pressurized cans are disposable containers and must be discarded appropriately. Pressurized gas tanks are not empty until the total pressure equalization with atmosphere. Empty containers should be clearly labeled to avoid confusion. Do not release residual gas into the atmosphere. Returned to the distributor. Ensure absolutely correct labeling (including hazard pictograms).

Status: _____



LAB

bioanalytic GmbH

GB

ThermoClean - DC

**Stabilizing double-concentrate for waterbaths
only 1ml ThermoClean-DC for 1l water**

2511 / 2512

100ml dropping bottle, 500ml, 5l

Characteristics:

ThermoClean-DC is generally used to prevent the growth of mold fungus, alga and bacteria in water bath and its belonging parts. Therefore all odors, clogging in the tempering system and the often change of water will be avoided.

ThermoClean-DC gives you better analysis results!

ThermoClean-DC without indicator is specially qualified for water bath where color impairs the sight.

ThermoClean-DC is recommended by leading producers of thermostates and laboratory equipments!

Qualities:

- High concentrate: 0.1% = only 1ml ThermoClean-DC for 1l water!
- Prevents positively the growth of mold fungus, alga and bacteria in water bath for several months.
- Therefore clogging in tubes and tempering systems as well as „cold sections“ in the temperature controlled cellholder will be prevented.
- Tubes and implements will last longer.
- Saves time, due to less water changes!
- Prevents annoying odors!
- Contains no aggressive phosphates, acids, alkalines, is absolutely free of organic solvents and leaves no residues; - dissolves in water 100%.
- Produces no foam, even at high rotation!
- Qualified for all thermostates and turnover pumps made of waterresistant metals or metallic compounds, glass, or any plastics. Also qualified for enclosed tempering systems.

Product information • Update: 2003-01-10

Application:

Only 0.1% = 1ml ThermoClean-DC for 1l water (demineralized) added to the clean water bath.

Temperature-range 0...65°C, short-time up to 80°C possible.

Do not use as an alga suppressent in an aquarium!

Guarantee:

ThermoClean does not include toxic salts or other compounds with mercury (quicksilver) or with other heavy metals.

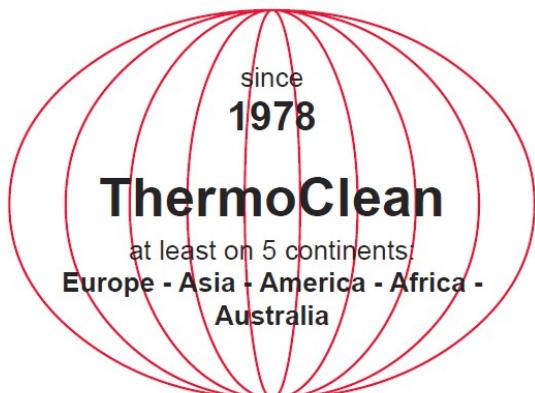
Indication for order:

ThermoClean-DC - (Double-Concentrate)
colorless (without indicator)
No. 2511 -100ml, -500ml, -5l

ThermoClean-DC - (Double-Concentrate)
with methylenblue-indicator
No. 2511 -100ml, -500ml, -5l

ThermoClean is also available as single-concentrate
(application 2ml/l):

ThermoClean - with methylenblue-indicator
No. 2522 -100ml, -500ml, -5l

**bioanalytic** GmbH

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