User Operation Manual

FEI™

NOVA NANOSEM 650

NOVA NANOSEM

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Technical Writer

Martin Dufek

TABLE OF CONTENTS

Chapter 4 Alignments

Chapter 5 Operating Procedures

Chapter 6 Maintenance

Chapter 7 System Options

FEI Limited Rights Data

1 | SYSTEM OVERVIEW

User Manuals

FEI MICROSCOPE SYSTEMS SAFETY MANUAL

It provides important information required during operation and maintenance for a product and personal safety.

Be sure to read at least this manual which is delivered as the printout.

USER OPERATION MANUAL

The User Manual is delivered in the electronic PDF file only. However, it is possible to print parts of the manual if this is desired.

It is recommended to read the appropriate User Manual section before operating any of the microscope function. Most importantly, you should locate the topics necessary to operate the microscope in the proper way to safely achieve the best results.

The manual is divided into the following chapters:

1. **System Overview (this chapter)**
   gives overview of the user manuals and system capabilities.
2. **System Control**
   describes the system hardware (interface elements, vacuum system, system states, Equipment).
3. **Software Control**
   describes the interface that sets and controls system operation, giving the function of each tool, menu item and control page.
4. **Alignments**
   explains how to align the equipment to achieve the optimal performance.
5. **Operating Procedures**
   gives procedures for how to use the system features.
6. **Maintenance**
   gives allowed step by step cleaning and maintenance procedures.
7. **System Options**
   explains relevant options that are integrated into or accessory to the system.

In the PDF file, you can take advantage of the searching and navigation possibilities. The following conventions are observed:

- Some software functions use shortcuts, which are given beside the heading in the brackets (for instance: **Save (Ctrl + S)**) and in the **Help** menu / **Keyboard Shortcuts…** (see Chapter 3).
- A reference to the specific software element is highlighted in bold. For instance: "Clear the **Stage** module / **Coordinates** tab / **Z** coordinate check box."

System Capabilities

The Nova NanoSEM Scanning Electron Microscope (SEM) produces enlarged images of a variety of specimens, achieving magnifications of over 500 000× providing ultra high resolution imaging in a digital format. This important and widely used analytical tool provides exceptional depth of field, minimal specimen preparation, and the ability to combine the technique with X-ray microanalysis.

SYSTEM PERFORMANCE

The main instrument components used for imaging of the samples are:

- **Electron source**
  The electron beam is emitted within a small spatial volume with a small angular spread and selectable energy.
- **Lens system**
  The beam enters the lens system consisting of several electromagnetic or electrostatic lenses and exits to hit the specimen surface.
- **Scan unit**
  The scan generator signal, fed to the deflection systems, moves the beam in a raster pattern over the specimen area. The electrical voltage changes as it rasters. This signal, modulated by the detection system signal produces the onscreen imaging of the specimen surface.
- **Detection unit**
  Electrons striking the specimen react with its surface producing three basic types of signal: backscatter electrons, secondary electrons and X-rays. The detection system picks up these signals, converts them into a digital signal which is then sent to the control PC and displayed on the monitor.

FIGURE 1-1   COLUMN SCHEMATIC OVERVIEW
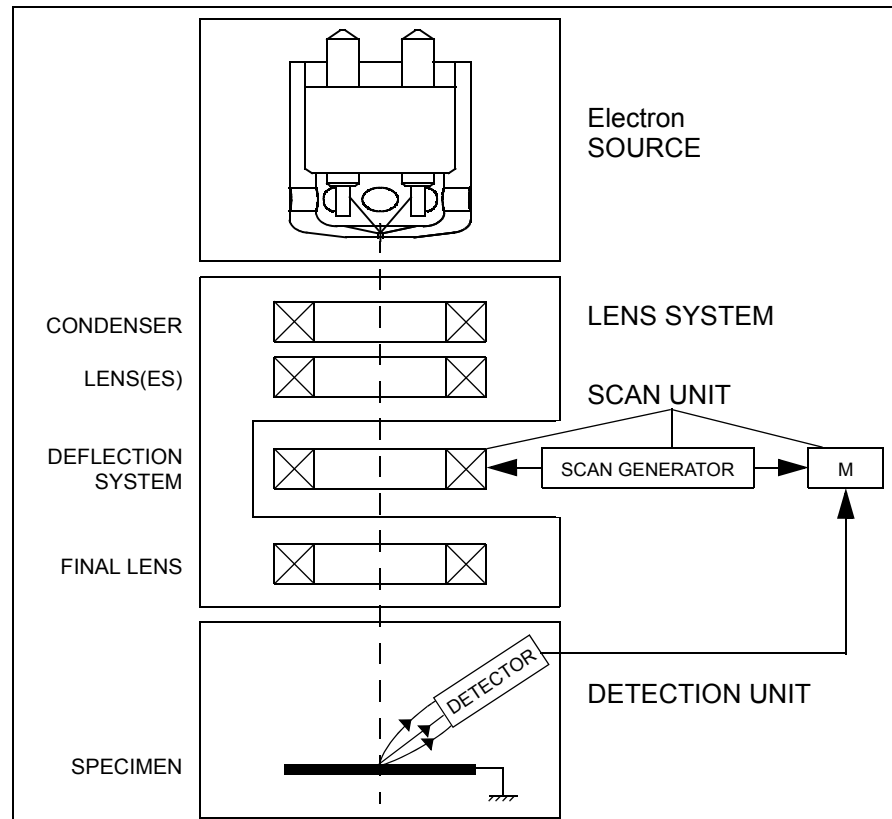
Computer Control

The xT microscope Server and xT microscope Control (User Interface) software integrate SEM functionality within a Windows 7™ operating environment.

These software consist of programs defining specific instrument settings for particular applications, ensuring reproducibility of complex procedures (for instance imaging, management of image capture, storage, and data output devices etc.). They also control instrument hardware (the column, detector(s), stage, EDX, vacuum functions etc.).

Vacuum System

The entire electron path from gun to specimen must be under vacuum so that the particles do not collide with air molecules. Various levels of vacuum are necessary, so a Turbo Molecular Pump (TMP) backed by a scroll pre-vacuum pump (PVP), obtains the necessary specimen chamber pressure. The Nova NanoSEM has the following operating vacuum modes to deal with different sample types.

High Vacuum (HiVac)

This is the conventional operating mode associated with all scanning electron microscopes.

Low Vacuum (LoVac)

In the gaseous mode the electron column is under lower pressure than the specimen chamber. This mode can use water vapours from a built-in water reservoir, or an auxiliary gas which is supplied by a user and connected to the gas inlet provided for this purpose. Observation of outgassing or highly charging materials can be made using this mode without the need to metal coat the sample, which would be necessary for conventional HiVac mode.

Stage

The Nova NanoSEM 450 / 650 has a computer-controlled high-accuracy five-axis stage. It offers precision specimen computer controlled manipulation and automation of all axes for overall spatial orientation on highly repetitive or extremely irregular samples.

Specimen exchanges take place through a chamber door which exposes the specimen stage when opened. The exchange takes a few minutes. Software and interlocks protect the system against a damage and users against an injury.

The Nova NanoSEM 650 chamber, stage, and wafer holder accommodate wafers up to 6", or other devices, in a high-vacuum environment.

Image Viewing and Capture

Because the amplified detector signal is displayed synchronously with the beam scanning, there is a correspondence between brightness of an image point on the monitor screen and the signal detected at the corresponding point on the specimen.

Magnification is the ratio of the size of the viewing monitor screen to the size of the area scanned on the specimen. Higher magnification is achieved by reducing the size of the area scanned on the specimen.

Gas Injection System (GIS)

Several FEI GIS (option) can be installed on the instrument, (depending on a system configuration) for electron beam-induced material deposition in conjunction with electron beam pattern definition, which offers the advantage of not sputtering the deposited material. This self-contained apparatus allows the material to be contained entirely within the vacuum system for simple, flexible, and safe operation.

Analysis Capability

Convergence of the SEM and X-ray detection system (e.g. EDX – Energy Dispersive X-ray) (option) at short working distance allows precision chemical analysis at high resolution of surface.

Various vendor options are compatible with the instrument.

2 SYSTEM CONTROL

System Layout

The standard layout is based around a dedicated microscope controller along with an electrical console to power the microscope console (vacuum, gun, column, stage etc.).

FIGURE 2-1 NOVA NANOSEM STANDARD LAYOUT SCHEME
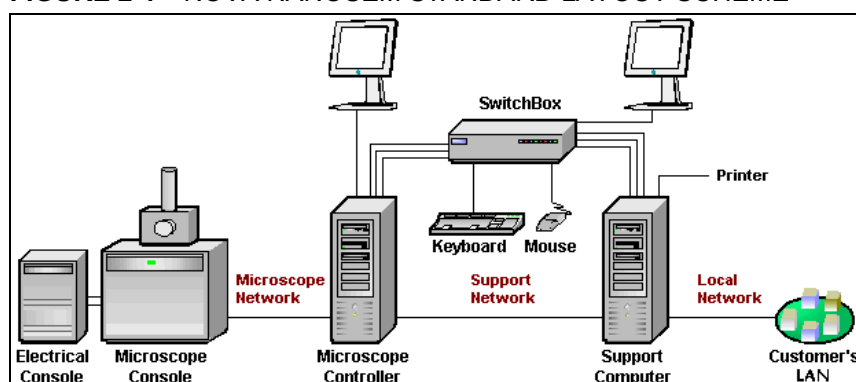
Interface Elements

SOFTWARE v6.2.X
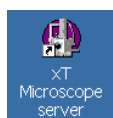
The software control contains graphic applications within Windows 7™ operating environment. **xT microscope Server** starts and stops basic microscope functions. It allows to open and close the **xT microscope Control** software (**UI** – user interface or sometimes **xTUI** within dialogue boxes) which controls all system functions including detection and analysis, scanning, image gathering, manipulation and output, magnification, etc.

All user account levels created via **FEI User Management** software ensure for the particular users admission to both the operating system Windows 7™ and the xT microscope Control software. The hierarchy of user account levels consists of the following:

• FEI Account Administrator
• FEI Supervisor Users
• FEI Microscope Users
• FEI Non-active Users

For information on Logging on and Logging off, the start-up of the system and all the features of the UI elements see Chapters 3 and 5.

HARDWARE

The system is computer controlled and as such has a **Microscope Controller** which must be turned on (use the power button on the PC) to operate the microscope by means of the software. The **Electrical Console** powers components of the **Microscope Console** (vacuum, gun, column, stage...). The **support computer** (option) can hold some other software utilities. The **switch box** switches the keyboard, the mouse and the LCD to either of the two computers. The control software facilities and data are displayed graphically on the **LCD monitor** and are superimposed around and on the image. The other LCD monitor (option) is used either as an extended desktop of the Microscope controller or as the support computer monitor. To control software utilities one can use a **keyboard, mouse, joystick** (option) or the **Manual User Interface** (option).

Microscope Console Control Panel

The console / system power is activated by pressing the front panel **Power button** located on the microscope console. This switches the sub-systems on and allows the interface and communication with the microscope controller. Most of the functions are activated via the software control. The power button green light indicates the Full Operation state, the orange light indicates the Standby state.

FIGURE 2-2 SYSTEM CONTROL PANEL POWER BUTTON

ON

Standby
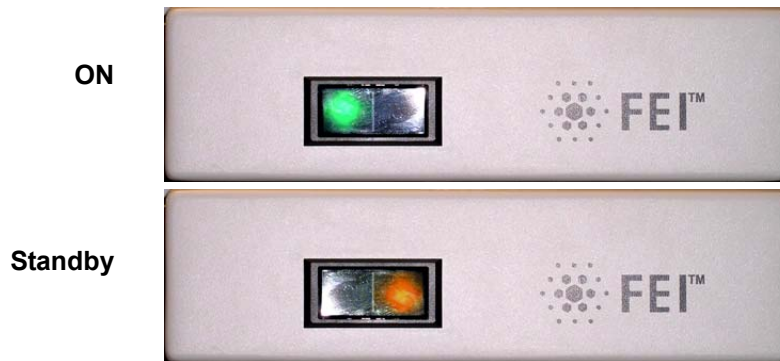
Final Lens Aperture Strip

The strip is made from a Mo coated Si. It enables to choose the aperture most applicable to your imaging needs.

The left-hand turn of the large ring moves the aperture holder outwards towards the larger aperture. After the aperture change , it is necessary to tune its position by using the inner knob and the one on the right side, controlling horizontal plane fine movements.

FIGURE 2-3   FINAL LENS APERTURE STRIP CONTROL KNOB

WARNING!

Aligning the final lens aperture is a mechanical process. It is possible to mis-align the aperture strip and obscure the beam from reaching the sample. Adjustment should only be done by those with the understanding of how to proceed (see Chapter 6 for a detailed description).
The aperture holes edges cleanness is also very important (see Chapter 8 for a detailed description).

TABLE 2-1   APERTURE SIZES AND THEIR USE

Aperture	Use
1000 µm	Service Alignment (hole in frame)
100 µm	High current applications
50 µm	X-ray mapping of low-Z elements at low kV
40 µm	General imaging or X-ray analysis
30 µm	Dynamic experiments
30 µm	High resolution imaging

Vacuum System

There are three main vacuum sections:

*   Electron source
*   Column
*   Specimen chamber.

In operation the Electron source and Column sections are always pumped to high vacuum. The specimen chamber is at the pressure required for the given status (Pump / Vent) or mode (HiVac / LoVac).

All valve and pumps operations are fully automatic.

FIGURE 2-4   Nova NanoSEM VACUUM SYSTEM

Legend:

AGV . . . . Auxiliary Gas Valve
BPV . . . . Bypass Valve
EG . . . . . ESEM Gauge
HVG . . . . High Vacuum Gauge (Penning)
CIV . . . . . Column Isolation Valve
EBV . . . . Environmental Backing Valve
ChEV . . . Chamber Evacuation Valve
ChIV . . . . Chamber Isolation Valve
IGP . . . . . Ion Getter Pump
PVP . . . . Pre Vacuum Pump
NVC . . . . Needle Valve Control
SIV . . . . . Servo Isolation Valve
TMP . . . . Turbo Molecular Pump
TVV . . . . Turbo Venting Valve
VV . . . . . . Venting Valve
WBV . . . . Water Bottle Valve

VACUUM STATUS

The vacuum status controls are in the **Vacuum** module. The **Pump** button starts pumping for the operating pressure and the **Vent** button starts venting for a sample or detector exchange (see Chapter 3).

In the **Status** module at the bottom of any page the actual vacuum status is represented by the colored icon, which may have three possible colors with the following meaning:

- **Green: PUMPED** to the desired vacuum mode
- **Yellow: TRANSITION** between two vacuum modes (pumping / venting / purging)
- **Gray: VENTED** for sample or detector exchange

Pump button

When the **Pump** button is clicked and the status is **Vented,** or when changing vacuum mode, the target pressure that the system pumps to depends on the selected vacuum mode. The Pump button is highlighted in and not accessible.

For the **High Vacuum** the system achieves the lowest pressure possible. For the **Low Vacuum** it achieves the pressure specified in the **Vacuum** module / **Chamber Pressure** adjuster. The purge function can be defined in the **Preferences…** dialogue / **Low Vacuum** tab (see Chapter 3).

When the **Pump** button is clicked and the status is **Transition** (venting), the venting procedure stops and the system immediately starts to pump to the currently selected vacuum mode.

Vent button
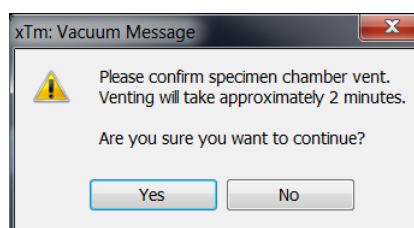
When the **Vent** button is clicked and the status is **Pumped**, the confirmation dialogue appears. After confirmation, the system switches off the detector voltages, high voltage supplies, vacuum pumps and uses the appropriate valves to vent the system with the use of the dry Nitrogen brought to the **Nitrogen Inlet** (option – see below). Nitrogen is recommended to obtain the better vacuum for high resolution imaging in HiVac mode.

The Vent button is highlighted and not accessible. After a specified venting time the venting valve closes and the vacuum status should indicate **Vented** (see **Preferences…** / **General** tab / **Venting valve opening time**). The chamber door could be opened and the button is enabled again.

When the **Vent** button is clicked and the status is **Transition** (pumping), the dialogue appears. After confirmation, the pumping procedure stops and the venting procedure starts.

When the **Vent** button is clicked and the status is **Vented**, the dialogue appears. After confirmation, the venting valves re-open for the specified venting time and then the valves close.

Note:
If you vent the system in order to change a detector, wait until the icon with a gray specimen chamber appears in the **Status** module. Otherwise there is a risk of a detector assessment malfunction, and as a result the PLA (see below) will not be known by the system.

VACUUM MODES
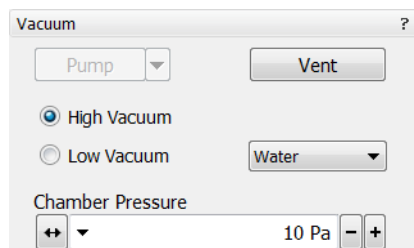
The **Vacuum** module / **High Vacuum** or **Low Vacuum** radio buttons are used to select the instrument target operating mode when a **Pump** sequence is initiated.

High Vacuum (HiVac) Mode

The high vacuum condition is common throughout the column and specimen chamber. The typical pressure value is within the order from 10^{-2} to 10^{-4} Pa.

Low Vacuum (LoVac) Mode

In this mode, the column section is under the lower pressure than the specimen chamber where the pressure ranges from 10 to 200 Pa (0.08 to 1.5 Torr). This mode uses water vapour from a built-in water reservoir or a gas from an auxiliary gas inlet (the drop down list).

The system automatically detects any Low Vacuum detector (LVD and Helix) and offers a relevant vacuum mode in the **Vacuum module**.

If relevant detector is not in place, a warning appears informing a user that the detector should be installed for the mode selected. The system will not abort the pump sequence, however.
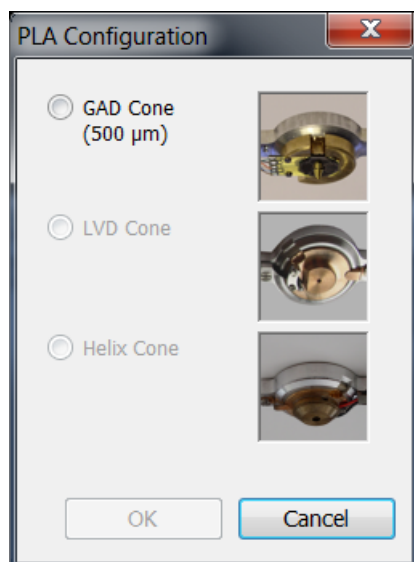
When **Low Vacuum** mode is entered from **HiVac** or from the **Vented** status, the system prompts a user with the PLA Configuration dialogue (this happens only for the first time after a particular Vent procedure).

Pressure

The **Chamber Pressure** adjuster is used to set and display the target chamber pressure. Pascal, Torr or Millibar units are available and can be selected in the **Preferences…** dialogue / **Units** tab (see Chapter 4).

When the system is in LoVac mode and the **Chamber Pressure** value is changed, the pressure automatically changes to the new value. When the system is in any other status and the chamber pressure value is changed, the new value is used as the target pressure when the system starts pumping to a Low Vacuum mode again.

The actual specimen chamber pressure is displayed in the **Status** module / **Chamber Pressure:** field.

Pressure Limiting Aperture (PLA)

The maximum allowed specimen chamber pressure in LoVac mode is determined by the size of the **PLA** and a gas type.

The **PLA Configuration** dialogue prompts to inform the system about the PLA size (in case it is not a part of a dedicated gaseous detector) according to the figure and the application when pumping or switching to LoVac mode. Along with a gas type, this information sets pressure limits and rates for pressure changes.

Clicking the **OK** button after selecting an appropriate pole piece radio button (cone or a detector with an integrated PLA) informs the system that it is mounted on the lens insert. The system starts pumping to the LoVac mode. From that point on, this information is automatically used until the system is vented again, when the PLA is set to "unknown". Clicking the **Cancel** button leaves the system in its actual status mode (Pumped or Vented).

Using Gas

The Low Vacuum mode allows a user to image samples in a gaseous atmosphere, which can be selected in the drop down list box:
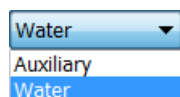
- the **Water** vapour from a built-in water reservoir located on the left side of the microscope console,

   Note:
   On occasion the water reservoir needs to be filled (see Chapter 6).

- the gaseous environment supplied by a user via the **Auxiliary** inlet placed on the back of the console.

Caution!

*Maximum overpressure for the Auxiliary gas and Nitrogen inlets is 10 kPa (0.1 bar). The **Nitrogen** inlet is used only for venting the chamber with air or the nitrogen preferably.*

When using a particular pressure limiting aperture, there are pressure limits for different gasses.

TABLE 2-2   MAXIMAL CHAMBER PRESSURE [PA (TORR)] UNDER DIFFERENT GASEOUS ENVIRONMENT

Working Gas	Maximum Chamber Pressure [Pa] (Torr)
Water - H_2O	200 (1.6)
Nitrogen - N_2	
Air	
Carbon Dioxide - CO_2	
Nitrogen Dioxide - NO_2	
Helium - He	100 (0.7)
70 % He + 30 % H_2	65 (0.5)
Argon - Ar [**)]	50 (0.4)
C_xH_y [*)]	200 (1.6)

Caution!

The system doesn't watch the limits and higher overpressure (especially for gasses not listed) set by a user! It could switch off the emitter! In some cases the system needs to be started up by a service engineer.

Note:
*) Combustible gases (acetylene for instance) must always be used with respect to safety issues.
**) The argon use should be minimized to a short time, because the IGP's are not optimized for pumping of it at all.

Purging

During this procedure the specimen chamber is automatically pumped down to a lower pressure to remove the old gas, then it is flooded with the new one (selected in the Vacuum module) to a higher pressure. This takes place several times, until the old gas is removed and the chamber is mostly filled with the new gas. This is applied when the system is:

- pumping to LoVac mode from vented status
- in LoVac mode and the gas type is changed
- in LoVac mode and the Purge button is pressed

   The purging can be set up, started and terminated in the **Preferences…** dialogue / **Low Vacuum** tab (see Chapter 3).

   Note:
   This procedure can take several minutes, according to Preferences setting. Wait until Vacuum status indicates **Pumped**, because detectors do not start operation till desired pressure is reached.

System States

There are several system states:

1. **Complete Shutdown** – service and emergency reasons
2. **Standby** – when not using the system for more than 1 day
3. **Overnight** – when not using the system overnight
4. **Full Operation** – when working

TABLE 2-3 STARTUP PROCEDURE GENERALLY

System State	Action
from Complete Shutdown to Standby	**1)** Connect the power cord to the microscope console, compressed air, water and the nitrogen (optional) inlets. Interlocks prevent the vacuum system from operating if any of these are not present (with the exception of nitrogen inlet). **2)** Start the electron column IGP pumps with the **5 - Emitter Startup** alignment (see Chapter 4). **Note:** If this is not possible, call the service!
from Standby to Overnight	**3)** Push the **power** button on the microscope front control panel. The orange light changes to the green one. **4)** Switch on the PC. The operating system [a] Windows 7™ loads and displays the appropriate icons on the monitor desktop. **5)** Double-click the **xT microscope Server** icon to start the software (all seeming LED's should be green). **6)** Click the **Start** icon to start the server. Wait until all dialogues are fully functional. **7.** Click the **Start UI** button to start the **xT microscope Control** software. The main window appears behind the **XTUI Log On** dialogue. **8.** Enter your **Username** and a **Password** [a]. **9.** Switch on the Emitter with the **5 - Emitter Startup** alignment (see Chapter 6).
from Overnight to Full Operation	**10.** Click the **Vacuum** module / **Pump** Button. Wait for the **Pumped** status. **11.** Click the **Column** module / **Beam On** button (must be yellow). A **Column** module / **Source** progress bar indicates the beam start.
	See Chapter 5 to set desired imaging conditions.

Note:

[a] Once you have your **FEI Microscope user** (or **Supervisor**) **account** set up via **FEI User management** software by **FEI Account Administrator** (see Chapter 4), you can use your name and password to access both Windows 7™ system and the **xT microscope Control** software. (Take note of the case sensitive passwords necessary at Windows 7™ and xT microscope Control server Log On points. A password is advisable for logging on to protect individual settings and results.)
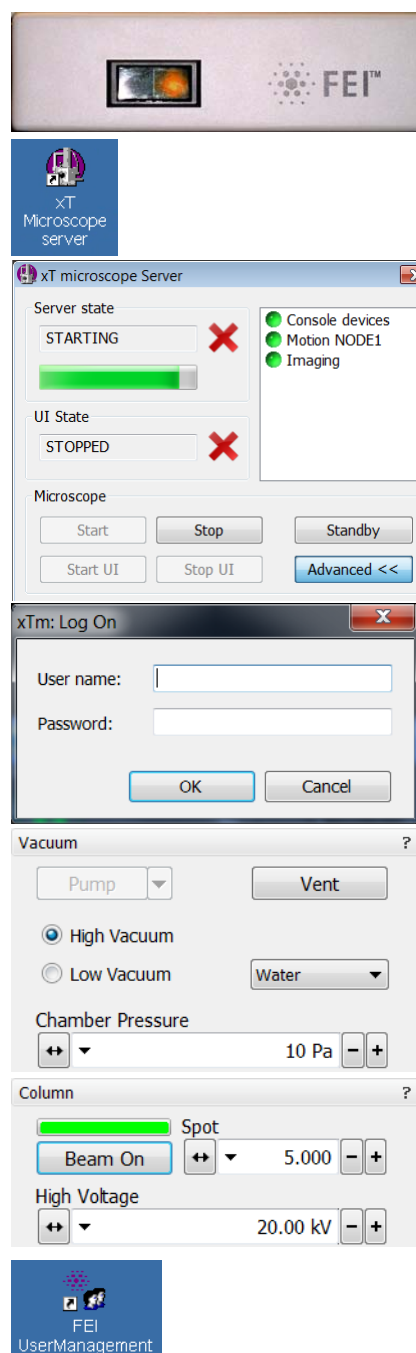
TABLE 2-4   SHUT DOWN PROCEDURE GENERALLY

System State	Action
from Full Operation to Overnight	**1.** Click the **Column** module / **Beam On** button to switch off the beam (must be gray). **2.** Click the **Vacuum** module / **Vent** button. Wait for the **Vented** status. Remove your sample if needed. If you want to shutdown the microscope, bypass steps 3 - 8. **3.** Click the **Vacuum** module / **Pump** [c] button to pump to the High Vacuum. **4)** Select [a] the **File** menu / **Log Off…** to log off the present user and to provide the **Log On** dialogue for entering another one. **5.** Switch off the monitor.
from Overnight to Standby [b]	**6.** Click the **Standby** button to stop the **xT microscope Server** software services. **Note:** If the system is left in the Pumped status, the pumps keep the vacuum all the time. If it is left in the Vented status or when the Standby button is clicked during the transition the pumps do not keep the vacuum. **7.** Exit the **xT microscope Server** and the **Windows 7™**. **8.** Switch Off the PC and the monitor.
from Standby to Complete Shutdown	**9.** Switch off the Emitter (see Chapter 6). [e] **10.** Click the **Standby** button to stop the **xT microscope Server** and to switch off the console. The **power** button on the microscope front control panel changes the green light to the orange one. **11.** Exit the **xT microscope Server** software and the **Windows 7™**. **12.** Switch Off the PC and the monitor.
Service [d]	**13.** Disconnect the power cord and any other optional input / output if used.

Note:

a) Waiting for a new user leaves the status of the **xT microscope Control** software not operational and only the **xT microscope Server** software is active. Therefore changing a user does not require Logging off / Logging on at Windows 7™ level, but just restarting the UI level.

b) The power plug should not be disconnected. The system can be left in this state if electrical power is supplied to the instrument because the pumps are running and pumping the column.

c) It is strongly suggested to always leave the chamber in HiVac mode when not being used. When the sample chamber is left in the LoVac mode, water vapour is likely to accumulate in it, PVP lifetime decreases and the water reservoir or gas cylinder empties prematurely.

d) The Complete shutdown procedure brings the system to the not powered state, where the vacuum in the column area is no longer supported by running pumps. All valves are closed, and the electron column and specimen chamber areas are vented.

This should only be carried out by a FEI service engineer. Normally it is used for a system transportation or for service actions, like repair to essential systems (electrical and air supplies).

[e] Switching off the console when **Emitter is On** is not optimal and may deteriorate the filament lifetime.

PASSWORD POLICY

After the FEI software installation there are two initial users / passwords common for the OS Windows and the xT microscope Control software (xT UI):

- supervisor / supervisor
- user / user

At the first operating system Windows 7 log in the user is automatically forced to change its password. After that the xT UI accepts it and enables to log in from that point on.

Each password (either for any new user or after the 90 day period expiration) has to meet the following conditions:

- at least 7 characters long,
- the stem significantly different from the previous password (shouldn't contain complete dictionary word),
- must contain at least one of these character types:
  – Uppercase letter
  – Lowercase letter
  – Number
  – Symbol

POWER OFF

Take sufficient measures to avoid power failures. If it occurs while the instrument is completely operational, the microscope comes down to a safe state and the following happens:

- The accelerating voltage is switched off abruptly.
- The electron emission is switched off.
- The specimen chamber vents gently, automatically.
- The column isolating valves close to save the vacuum in the gun areas.
- The vacuum in the instrument is no longer supported by running pumps. All valves are closed, so the vacuum in the column and chamber is not completely lost.

C a u t i o n !

Switching off the console when Emitter is on is not optimal and sparing way for the emitter. User should use the Shutdown System button only in case of emergency need.

- The microscope and support PC's are switched off, the momentary adjustments of all system parameters (accelerating voltage, magnification, stage positions etc.) are lost if they were not saved.

Emergency Off

is similar to that which would happen after a MAINS power off. Here are several possibilities how to quickly switch off the electrical power completely in case of emergency:

W A R N I N G !

The system and/or the temperature stage water chillers (if anyone is present – separate device in the microscope vicinity) are powered

by the individual power cord directly. The hazardous voltages may be present even when the microscope power plug is disconnected!

1. Push the red **EMERGENCY** (EMO) button (option - see the Safety Manual).

If the button is not installed proceed as follows:

2. Switch off the breaker switch labeled **MAINS S1** at the cabinet back, which is placed at the very right side in the row.

FIGURE 2-5   MAINS SWITCH BOARD

If this is not easily accessible:

3. Turn off the mains wall switch (if present), and / or disconnect the mains plug from the mains socket.

C a u t i o n !

If the Startup procedure fails (see above), contact the FEI Service Engineer.

UPS (option)

If the power failures occur occasionally it is recommended to use the microscope Un-interruptible Power Supply (UPS - option), which maintains the FEG emission for several hours.

In case of mains power off the microscope is powered by UPS batteries and the system starts 10 minute countdown. If the mains power is recovered within this time, the countdown is cancelled and nothing happens. After 10 minutes of continuous power off a shutdown with following actions is activated:

*   FEG emission is gently switched off
*   chamber is vented
*   UI is stopped
*   server is stopped
*   console is shut down
*   microscope PC and Support PC (if present) are switched off

User is informed about the countdown in the application status window (see below) together with the remaining time. When the xT microscope Server is started the first time after this event, a dialog is displayed to inform a user.

Note:
Supervisor must restart the system after an emergency power off (see Chapter 4). If the Startup procedure fails (see above), contact an FEI Service Engineer.

C a u t i o n !

Because the Emitter IGPs are supported by an UPS, which can hold its operation for approximately another 2 hours, some parts of the microscope are still under power.

Equipment
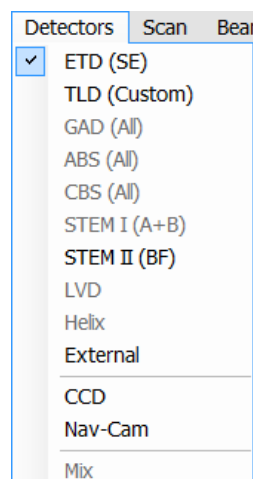
DETECTOR TYPES AND USAGE

The **Detectors** menu shows all installed detectors, the selected one has a tick mark next to its label. Availability of detectors (full color label) depends on the actual vacuum mode. The system remembers the last detector used for a particular vacuum mode in the quad and its Contrast & Brightness settings.

For settings and handling of particular detectors see Chapters 5 and 7.

TABLE 2-5   STANDARD AND OPTION DETECTORS

Note	Detector Name	Tag	Vacuum Mode	Detected Signal	SEM Mode
S	Everhard-Thornley	ETD	HiVac	SE (tunable energy) BSE	**1** / **3**
S	Through-lens	TLD	HiVac	SE (tunable energy) BSE	1 / **2** / 3
S	Low Vacuum	LVD	LoVac	SE + BSE	**1** / 2 / **3**
S	Infra-red CCD camera	CCD	any	light, infra-red light	any
O	Low Vacuum (Special) (delivered with GAD)	LVD	LoVac	SE + BSE	**1** / 2 / **3**
O	Gaseous Analytical	GAD	HiVac, LoVac	BSE	**1** / 2 / **3**
O	Concentric Backscattered Retractable	CBS	HiVac	BSE	**1** / 2 / **3**
O	Scanning Transmitted Electron Microscopy	STEM I	HiVac, LoVac	transmitted electrons	1 / 2 / 3
O	Retractable Scanning Transmitted Electron Microscopy	STEM II	HiVac, LoVac	transmitted electrons	1 / 2 / 3
O	Helix	Helix	LoVac	SE	1 / **2** / 3
3rd party	External	EXT	detector-dependent	detector-dependent	1 / (2) / 3
3rd party	Energy-dispersive X-ray	EDX	HiVac	X-ray photons	2 / 3
3rd party	Wavelength-dispersive X-ray	WDX	HiVac	X-ray photons	2 / 3

Note:
SE = secondary electrons, BSE = back scattered electrons
S = standard, O = optional
boldface - preferred SEM modes

C a u t i o n !
When any lens mounted detector is attached (GAD and CBS) the use of GIS's (option) is not allowed (see Chapter 7). The system does not block the functionality!

STAGES AND ACCESSORIES

The chamber is equipped with the 110 × 110 mm / 150 × 150 mm stage, which can be oriented with reference to five axes: **X**, **Y**, **Z**, **Rotation** and **Tilt**. All movements are motorised, software controlled (an integrated part of the **xT microscope Control** software – see Chapters 3 and 5). Stage positions are displayed on the screen.

FIGURE 2-6   NOVA NANOSEM 450 CHAMBER
                             NOVA NANOSEM 650 CHAMBER

Standard Stub Holders

There is one stub holder used for both stages and one for 110 × 110 mm only.

FIGURE 2-7   110 × 110 & 150 × 150 mm / 110 × 110 STUB HOLDER
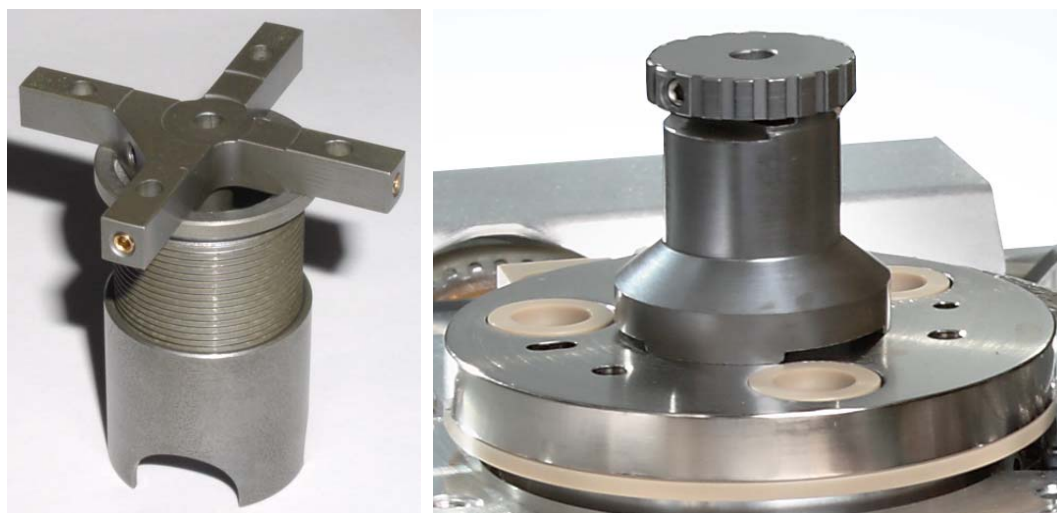
Stage movement Limits

The motorised movements of the stage can be operated under software control for more advanced location mapping. This includes **Shift**, **Get**, **Track** and the **Stage** module functionality. A live imaging can be repositioned either by the stage movement or by the **Beam Shift** (see Chapter 5). The tilting mechanism can be locked for more stability at high magnifications using the software **Clamp** feature.

Note:
When moving the stage or tilting the specimen, the magnification may need to be reduced not to lose the feature of interest off the screen.

FIGURE 2-8 STAGE MOVEMENT SCHEMA
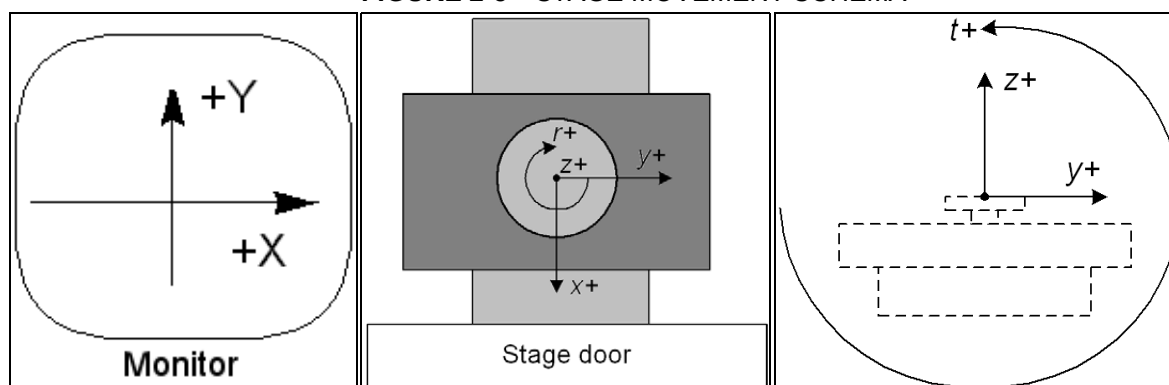
TABLE 2-6 STAGE FEATURES AND LIMITS

Item	110 × 110 mm	150 × 150 mm	Note
X	-55 to +55 mm	-75 to +75 mm	
Y	-55 to +55 mm	-75 to +75 mm	
Z	12 + 25 mm	0 + 10 mm	holder + stage*
R	360°	360°	continuous
T	-15° to +74°	-10° to +60°	
Eucentric Position	WD = 5 mm	WD = 5 mm	
Clamp	No	Yes	
Maximum sample weight	No restriction: 500 g	500 g	including stub-holder
	No Tilt: 2 000 g		
	X and Y movements only: 5 000 g		

Note:
* holder Z movement means possibility to manually screw the sample holder in or out, **stage** movement means motorised stage movement.

C a u t i o n !
*The positive Z value direction depends on the **Link Z to FWD** status (see Chapter 5).*

C a u t i o n !
If the maximum sample size is near to the limit, stage tilt could be limited. Beware of hitting the objective pole piece!

3 | SOFTWARE CONTROL

This chapter describes the functionality of each part of the user interface.

SOFTWARE INTERFACE
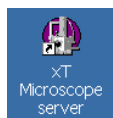
The software control contains graphic applications within Windows 7™ operating environment. **xT microscope Server** starts and stops the basic microscope functions.

It makes possible to open and close the **xT microscope Control** software (**UI** – user interface or sometimes **xTUI** in the dialogue boxes) which controls system functions including imaging, image and movie gathering / manipulation / output, detection and analysis, scanning, magnification, stage navigation, chamber and column pressure, etc.

All user account levels are created via **FEI User Management** software, ensuring for the particular users admission to both the operating system Windows 7™ and the xT microscope Control software.

OTHER SOFTWARE AND HARDWARE

Call Customer Service for advice before installing software or hardware that is not required for system operation. Other software, such as screen savers or hardware network cards, may corrupt the xT microscope Server / Control software under some circumstances and may invalidate warranty.

For more detailed information about Windows 7™, refer to the *Microsoft® Windows™ User's Guide* shipped with your system.

Software Interface Elements
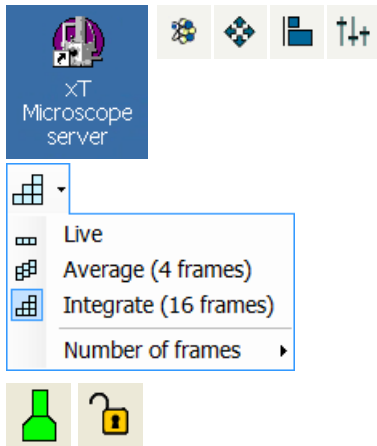
ICONS

Icons are small symbols indicating a specific software application. Double-click the icon to activate the program.

There are also **functional icons** in the toolbar for selecting some software functions quickly. Clicking causes it to be highlighted and activated, clicking it again or clicking another one (depending on a particular case) causes it to become normal and deactivated.

Some functional icons have additional down-arrow next to the right side. Clicking the arrow displays a pull-down menu with choices, while clicking the icon performs a particular function (cyclic changeover of choices, setting the default parameters etc.).

There are also some **informational icons** in the status field, for instance, that indicate some particular system status.
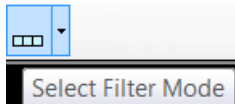
TOOL-TIPS

This functionality activates when the cursor is left over the user interface item for more than two seconds. A short explanation of the item appears until the cursor is moved away from the item.

PULL-DOWN MENUS

The microscope uses menu-oriented software; you perform functions by choosing items from the **Menu bar**. The Menu bar selections contain pull-down menus that display grouped listings of available commands or settings. Some menu items are shown in gray and cannot be selected because of the system immediate condition.

Pull-down menu selections followed by the ellipsis (…) indicate, that a dialogue box will display (the same behaviour occurs when the selection is a command). Selections with a right arrow indicate that an additional submenu of choices will display. If a selection is a parameter value, the new value is updated immediately and a check mark appears in the pull-down menu.
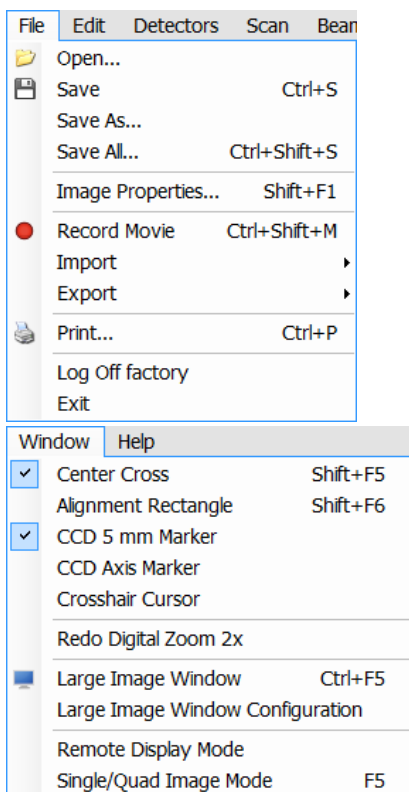
Using the Mouse

The click / right-click / wheel-click represents click with the left / right / wheel mouse button on the item throughout this manual. The click & drag / right-click & drag / wheel-click & drag means holding the mouse button during the action.

Click & drag the cursor down the menu to a desired item and then release the mouse button.

Using the Keyboard

Press ALT + the underlined letter (for example, **ALT + F** for the File menu), and then select from the choices by clicking it or by hitting the **Enter** button after its location with the up / down (left / right for submenus) arrow keys.

Some often-used commands can be quickly activated with the use of shortcut keys (a combination of simultaneously pressed keys) at any time. This possibility is given by a particular button combination on the right side of the pull-down menu adjacent to the appropriate command.

COMMAND BUTTONS

carry out or cancel functions. They activate when clicked and some are highlighted (changed color) to show the corresponding function activity.

Command buttons have labels that describe the actions performed by clicking them. The most common ones, which are typically used in dialogues are:

- The **OK** button applies all changes made in the dialogue and closes it.
- The **Finish** button saves new settings, ends the procedure and closes the dialogue.
- The **Save** button saves new settings at that point without closing the dialogue.
- The **Apply** button saves and applies new settings at that point without closing the dialogue.
- The **Cancel** button discards all changes (made from the last save) and closes the dialogue. It has the same effect as closing the dialogue with the cross (Alt + F4).
- The **Next** button moves a user to the following dialogue after necessary settings have been done.
- The **Previous** button moves a user to the previous page when settings need to be changed.

LIST BOXES
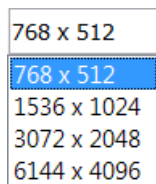
contain available choices, such as screen resolution, magnification settings, etc. Click the **List** box to roll down a list of available values, then click the desired one. The drop down list automatically closes and displays the new value as the actual one. The change of the setting is immediate.

PROPERTY EDITORS
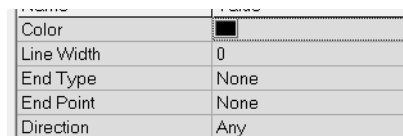
group list of related parameters and their values. The editable parameters have a white background, the fixed parameters are shaded. A user should click in the **Value** side of the relevant property **Name** and then select its value from the drop down list or enter it using a keyboard.

EDIT BOXES
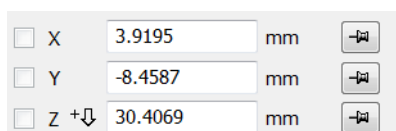
let you input text information (such as passwords, labels or precise numbers) using the keyboard. Some edit boxes, which are not part of a dialogue, require to confirm the input by pressing **Enter**. If you press **Esc** before leaving the edit box, its previous value is restored.

RADIO BUTTONS / CHECK BOXES
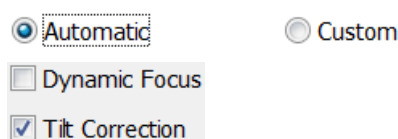
Within a group of related round **Radio buttons**, only one selection can be made active at any time by clicking in the individual box.

A single one or a group of square **Check boxes** can be ticked / cleared by clicking inside the individual one.

ADJUSTERS
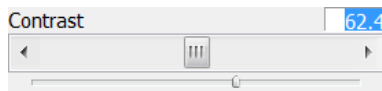
allow to change parameters, such as contrast, brightness, gamma etc. in a continuous way by clicking & dragging the middle adjuster or clicking in the grey bar. They always have a label in the upper left and right corners for readout information. Double-click the value in the upper right corner enables to enter a precise value (and the unit in particular cases) using the keyboard.

Exponential Adjuster

This is an exponential response adjuster – the further from the center is the large adjuster button pulled, the larger is the relative change. The adjuster button always snaps back to the center of the slider.

The middle adjuster button is for coarse adjustments, while the end arrows are for fine adjustments (single step increments).
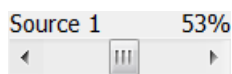
Linear Adjuster

Some adjusters have linear response (like the small adjuster placed below the exponential one). Its button position always corresponds to the actual parameter value within an available range.
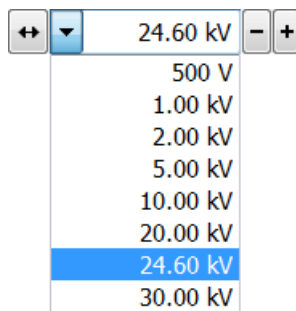
Preset Adjuster

This kind of adjuster is used for values that have both a continuous range, a list of presets and direct value editing to achieve total control. The button on the left side of the adjuster toggles between modes:

- **Drop down list:**
  clicking the -/+ buttons on the right of the drop down menu steps through the pre-set values Up / Down in the list, but only shows one value in the text area. Clicking the down-arrow rolls down the whole list of values. If the list extends further than is visible, a scroll bar appears. Clicking a value in the list enters it as an actual value in the text area displayed at the top.
  Double-clicking a value in the text area enables to edit it.
- **Adjuster mechanism:**
  The adjuster has a fine control (see above).

Spinner
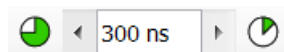
allows to change a parameter in an incremental way from a list of pre-defined values by clicking on an arrow.

2D CONTROLS
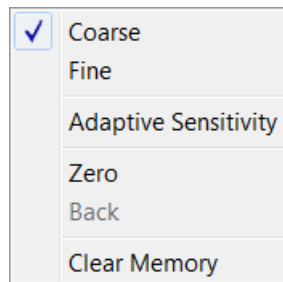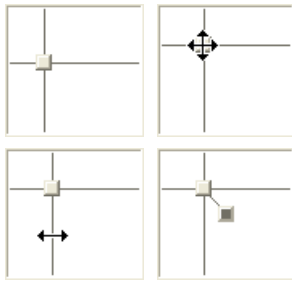
are represented by an X-Y box. The position of the crosshair corresponds to the actual parameter value with respect to its full range being represented by the perimeter of the box.

Clicking & dragging anywhere inside the box changes the active quad cursor to the four-ended arrow and positions it to the screen point corresponding to the actual control value (minimum in the middle of the screen and maximum at the edges). It can be dragged in four directions. Clicking & dragging directly on the X / Y axis changes the active quad cursor to the two-ended arrow, which can be dragged in the corresponding direction only. To fix the values, release the mouse button.

The right-clicking over the 2D box opens a dialogue with choices:

- The **Coarse** / **Fine** sets the mouse sensitivity – long / short mouse path necessary for the full range.
- The **Adaptive Sensitivity** adjusts the mouse control response to be the same at any magnification.
- The **Zero** brings the control value to zero and the cursor to the center of the box.
- The **Back** brings the control value one step back (only one step is remembered).
- The **Clear Memory** clears condition values, which have been remembered automatically during the considered 2D control use. These remembered values are used to estimate new values, which have not been remembered yet.

The menu may contain less or some other functions that are actually available for the particular parameter. Selecting the corresponding menu item activates the function.

MODULES
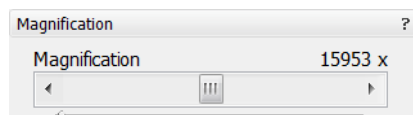
visually combine various software elements, which are related into a labeled group. Complex software elements like UI pages or dialogues are typically composed of modules.
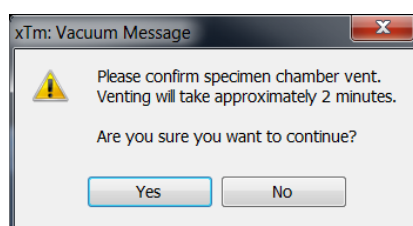
DIALOGUES

appear when the system needs more information from you before it can carry out a command, or want to give you some important actual information. Some dialogues do not let you access other functions until you close them, other ones let you perform other tasks while they remain onscreen and active (for example, the Preferences dialogue can remain opened while performing other tasks).

TABS
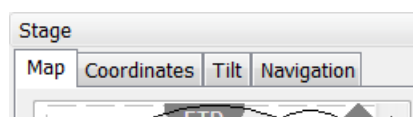
In modules or dialogues containing more interface elements than would fit into the limited area the **Tabs** are used. These related elements are split into the groups (sections) and each one is supplemented with the labeled Tab. Clicking the Tab brings it to the foreground displaying the corresponding group of interface elements.

PROGRESS BARS
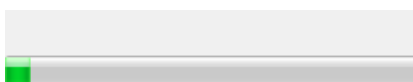
indicate progress of a long ongoing procedure over time. It is often displayed in a dedicated dialogue.

xT microscope Server Software
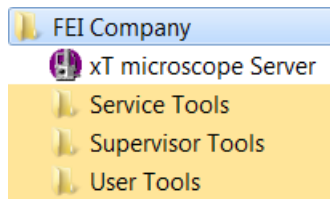
The **xT microscope Server** application starts and stops the software service controlling basic microscope functions and also the user interface (UI) software **xT microscope Control**.

Run the **xT microscope Server** (from the Windows Start menu or double-click the icon) – the application window appears. The title bar right-clicking opens a dialogue that offers the option to minimize the server to the UI top bar.

FIGURE 3-1   xT MICROSCOPE SERVER WINDOW
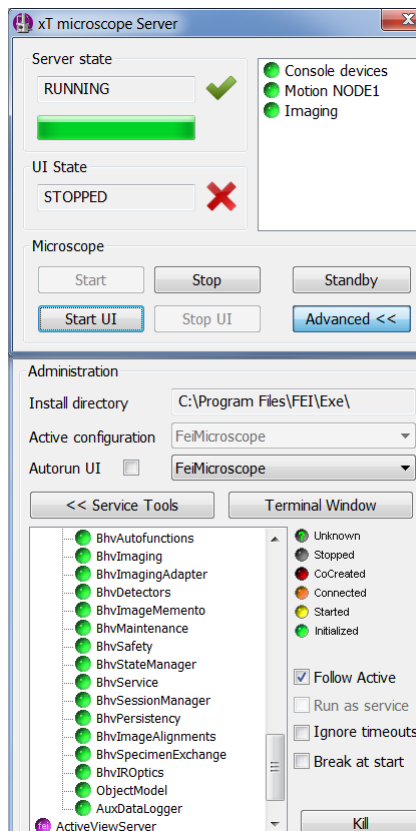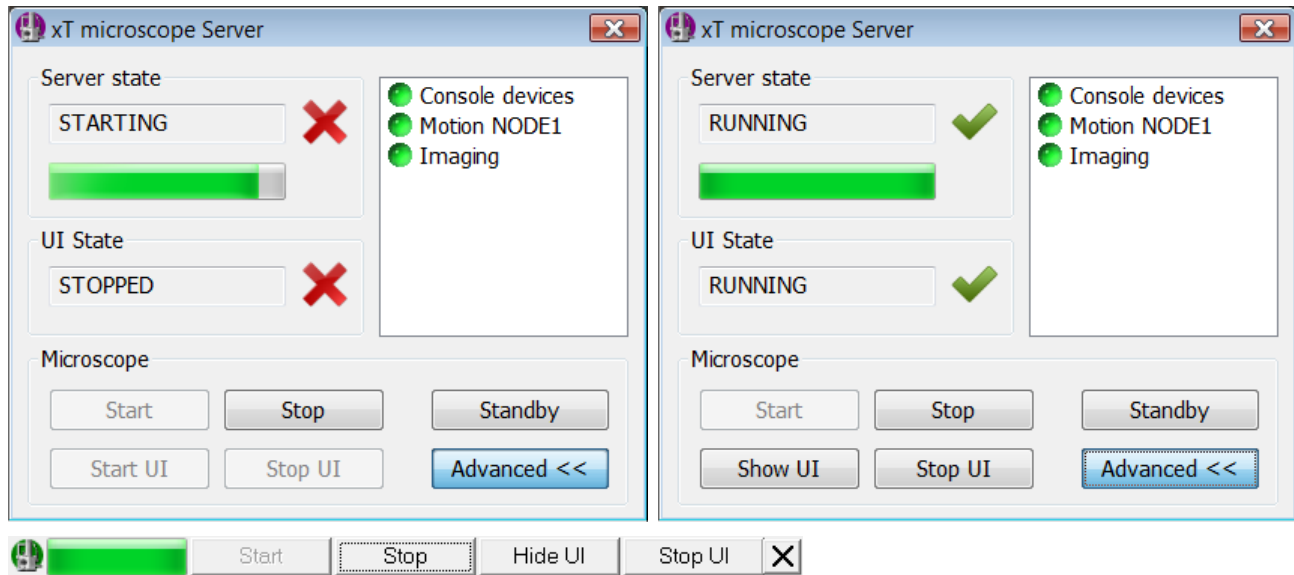
- The **Server State** / **UI State** modules display the **RUNNING** or **STOPPED** state of the xT microscope Server / xT microscope Control software services. During a transition between these states **STARTING** or **STOPPING** is displayed.

- Some **Microscope** module buttons change its label and behaviour depending on the actual state.

  The **Start / Stop** button starts / stops xT microscope Server services. If the xT microscope Control (UI) is running, Stop button closes it first.

  The **Start UI / Stop UI** button opens / closes xT microscope Control software.

  The **Show UI / Hide UI** button calls / hides the UI main window.

  The **Standby** button closes the xT microscope Control software (UI), stops the xT microscope Server services and brings the console to the Standby State (see Chapter 2).

  The **Advanced** button displays the **Administration** module containing information helpful when calling the service (specifying the software operation / hardware function state).

  – The **Autorun UI** check box: when ticked (default), the Start button automatically starts xT microscope Control after starting the Server.

xT microscope Control Software

xT microscope Control software – simply User Interface (UI) – is made up of several elements which compose the main window, displaying status and control features within the Windows 7 operating system.

Note:
To ensure correct displaying of all UI entries (dialog and edit boxes, info fields etc.) within the Windows 7 environment choose the **FEI 01** theme display appearance.

Note:
Today the UI supports wide screen display which leads to a slightly different appearance of some UI elements in comparison to this manual.

FIGURE 3-2   THE MAIN WINDOW
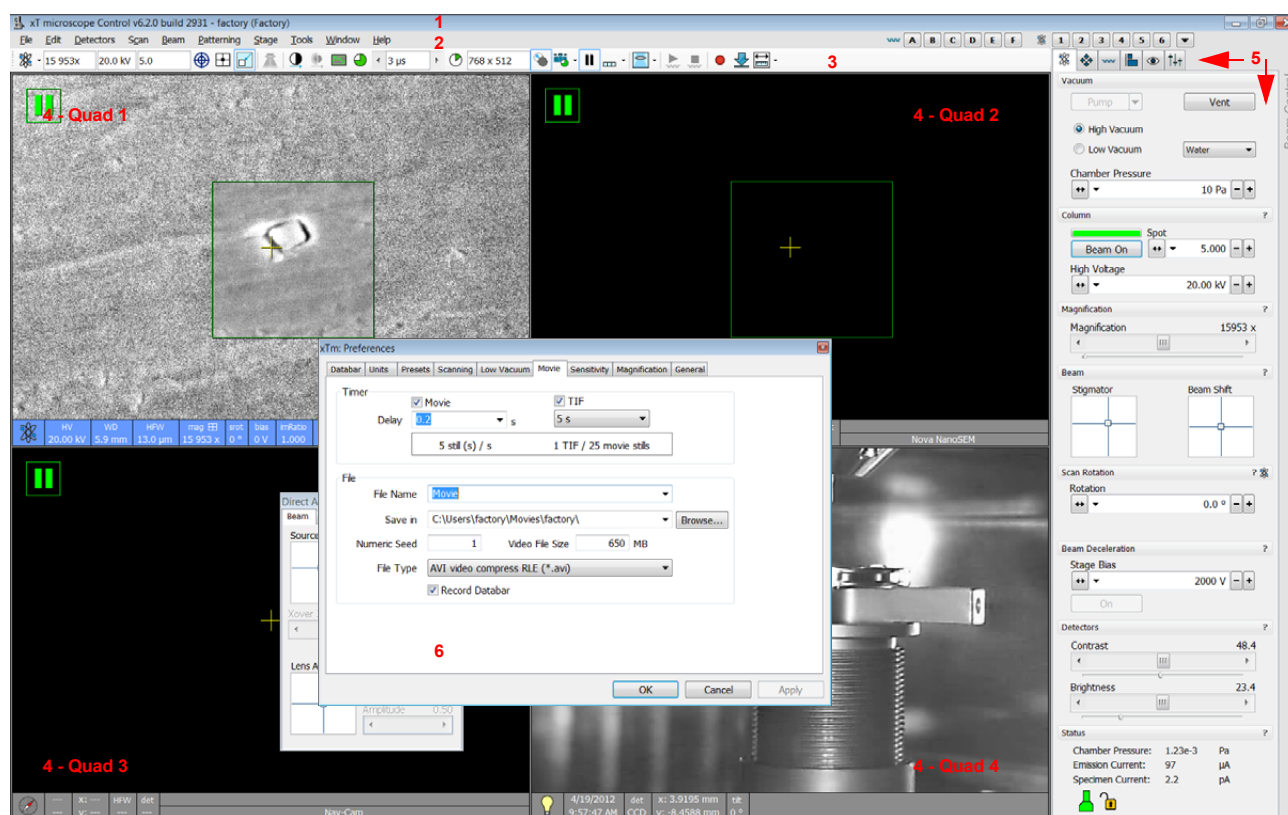
1. The **Title Bar** – labels the application
2. The **Menu Bar** – contains all operation menus and submenus
3. The **Toolbar** – contains functional icons for the most frequently used microscope controls and for the fast access to the Pages
4. **Image Windows** – image windows with adjustable Databar
5. **Pages and Modules** – microscope and image control elements organized into modules making up the pages
6. The **Preferences dialogue** – presetting of operating conditions

TITLE BAR

displays the application icon and name plus the standard Windows buttons: **Minimize** and **Close**, which are enabled.

FIGURE 3-3   THE TITLE BAR
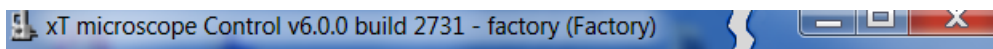
The Close button quits the xT microscope Control software (accelerating and detectors voltages are switched off for the security reasons).

MENU BAR

displays pull-down menus across the screen below the Title Bar.

FIGURE 3-4   THE MENU BAR
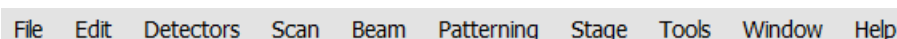
Select pull-down menus from the menu bar by:

- clicking on the Menu title
- ALT + underscored keyboard letters
- ALT + keyboard arrows + Enter button

Note:
Some menu functions have their equivalents in the toolbar. In such cases, the corresponding toolbar icon is shown next to the function title in the following text.

File Menu (Alt + F)

opens File menu administrative functions:

Open…

displays a standard dialogue for opening images previously stored to a media. Supported file formats are TIF8/16/24, JPG and BMP (see Chapter 5). The dialogue displays, by default, the location (path) last used to open or save files from the UI.

Save (Ctrl + S)

saves the image using the format, location and base of name set by the last used **Save As** function in that quad. An incremental suffix with a selectable number of digits ensures that every image is saved as a new file, e.g. Name_001.tif, Name_002.tif, etc.

Save As…

opens a dialogue for saving images, which provides an opportunity to change the file name and location. An image can be saved in **TIF8/16/24**, **JPG** or **BMP** file format.

The dialogue displays, by default, the location and the name last used to save / open a file in the selected quad. A user can change a location, name base or suffix, select different image format (**Save as type**), and also choose whether to **Save** the **image with** / without **Databar** and **with** / without **overlaid graphics** by ticking / clearing an appropriate check box. The settings is remembered per quad and used for the subsequent Save actions.
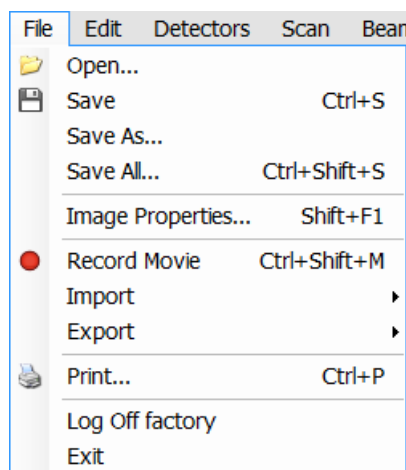
FIGURE 3-5 SAVE AS… DIALOGUE
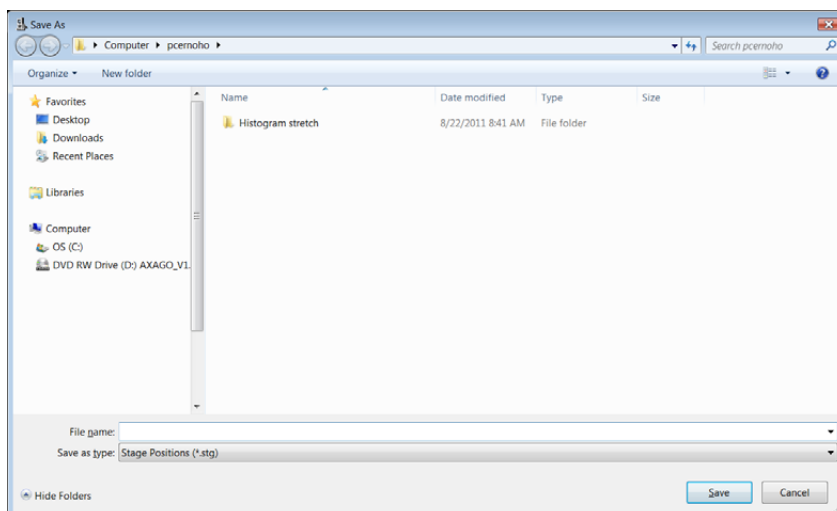
Save All… (Ctrl + Shift + S)

opens common dialogue for saving images from each quad, providing an opportunity to change the file names and locations.

FIGURE 3-6 SAVE ALL… DIALOGUE
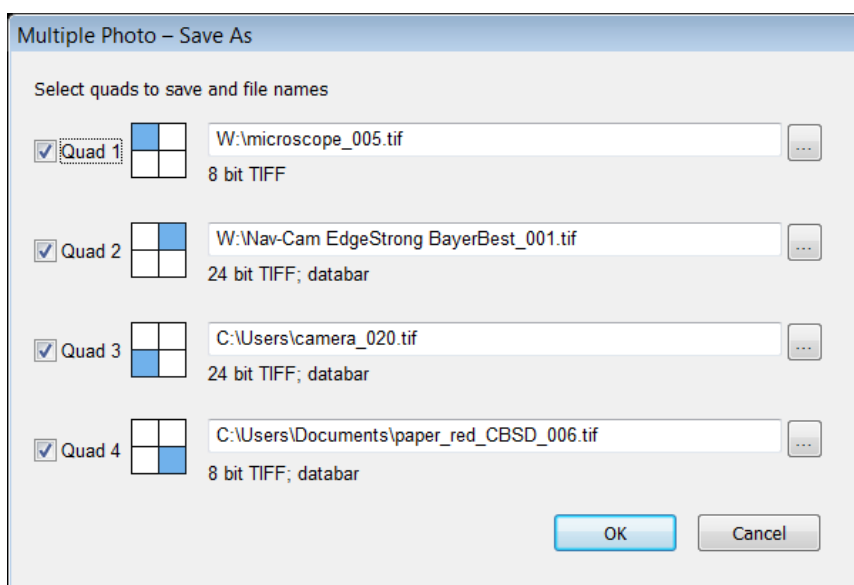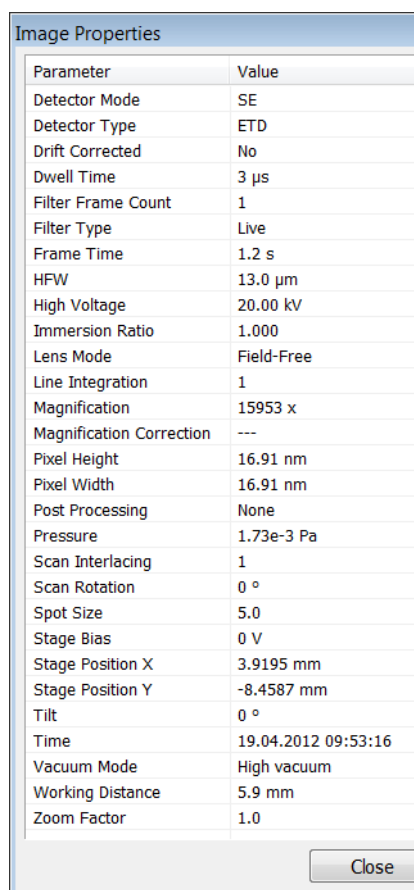
Image Properties (Shift + F1)

allows a user to view multiple parameters at which an image was captured.

Record Movie

allows a user to make digital video files (AVI) for dynamic experiments. The tick next to this menu item and the change of the corresponding toolbar icon indicates the movie recording (see Chapter 5).

Import / Export

opens a sub-menu with selection of importable / exportable items Selecting an item opens standard Open / Save As dialog for choosing location and file name. Following items can be both imported (i.e. loaded and used) / exported:

Image Properties	
Parameter	Value
Detector Mode	SE
Detector Type	ETD
Drift Corrected	No
Dwell Time	3 µs
Filter Frame Count	1
Filter Type	Live
Frame Time	1.2 s
HFW	13.0 µm
High Voltage	20.00 kV
Immersion Ratio	1.000
Lens Mode	Field-Free
Line Integration	1
Magnification	15953 x
Magnification Correction	---
Pixel Height	16.91 nm
Pixel Width	16.91 nm
Post Processing	None
Pressure	1.73e-3 Pa
Scan Interlacing	1
Scan Rotation	0 °
Spot Size	5.0
Stage Bias	0 V
Stage Position X	3.9195 mm
Stage Position Y	-8.4587 mm
Tilt	0 °
Time	19.04.2012 09:53:16
Vacuum Mode	High vacuum
Working Distance	5.9 mm
Zoom Factor	1.0

Stage Positions…
Patterns…
Scanning Presets…
Quad Presets…
System Parameters…
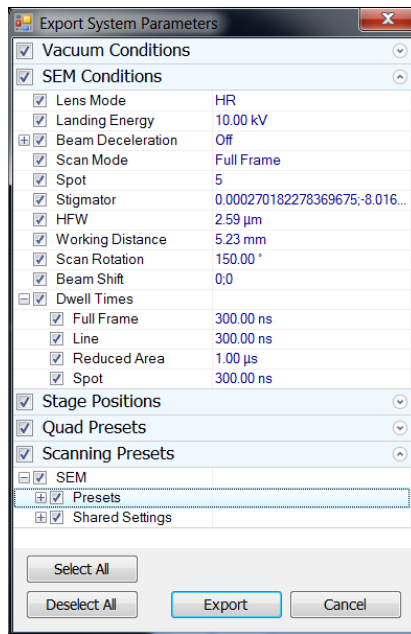
- The **Stage Positions…** stored also with the use of the Stage module (.**stg** files)
- The **Patterns** used in the patterning module (option) (.**ptf** files)
- The **Scanning Presets…** parameters (.**scp** files)
- The **Quad Presets…** parameters (.**qps** file: Beam type / Detector type / Detector Mode / Detector contrast & brightness / Digital Contrast / Digital Brightness)
- The **System Parameters…** saves wide range of actual microscope settings, including above mentioned ones (.**par** files). When importing them back likewise only selected ones are loaded.

Print (Ctrl + P)

opens the print dialogue enabling a choice of printer and settings suitable to print an image.

Log Off *User*

logs off a present User and provides the **Log On** dialogue for the next microscope user. When a user logs off the system goes to a safe state: the accelerating and detector voltages are switched off automatically.

C a u t i o n !

Logging off an actual user does not close all microscope operations! (see Chapter 2)

Exit

closes the xT microscope Control software (the actual user is automatically logged off first) and leaves a user in the operating system environment. xT microscope Server is still running and controls the microscope in operation.
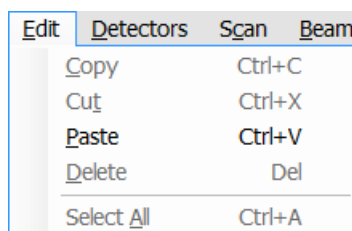
The Edit Menu (Alt + E)

opens some helpful functions:

Copy (Ctrl + Ins) / Cut (Ctrl + x) / Paste (Ctrl + v) / Delete (Del)

These functions represent commonly used operating system functionality.

Select All (Ctrl + A)

selects all items within a selected quad.

The Detectors Menu (Alt + D)

opens the selection of all installed Detectors (see Chapters 5 and 7).

Detector list

contains various detectors for the microscope operation. Detectors not mounted or not serviceable under an actual microscope conditions are disabled (greyed out). The selected detector for the selected quad shows a tick next to its label.

- An 3rd party video signal can be selected, which is indicated as "**External**" in the databar. Contact a FEI service person about a connection details.
- The **CCD** camera reflects the inner space of the specimen chamber.
- The **Mix** sets a possibility to interfuse signals from 2 or 3 detectors.
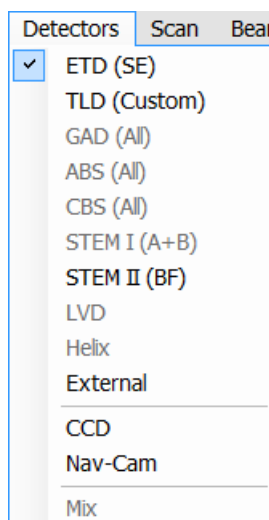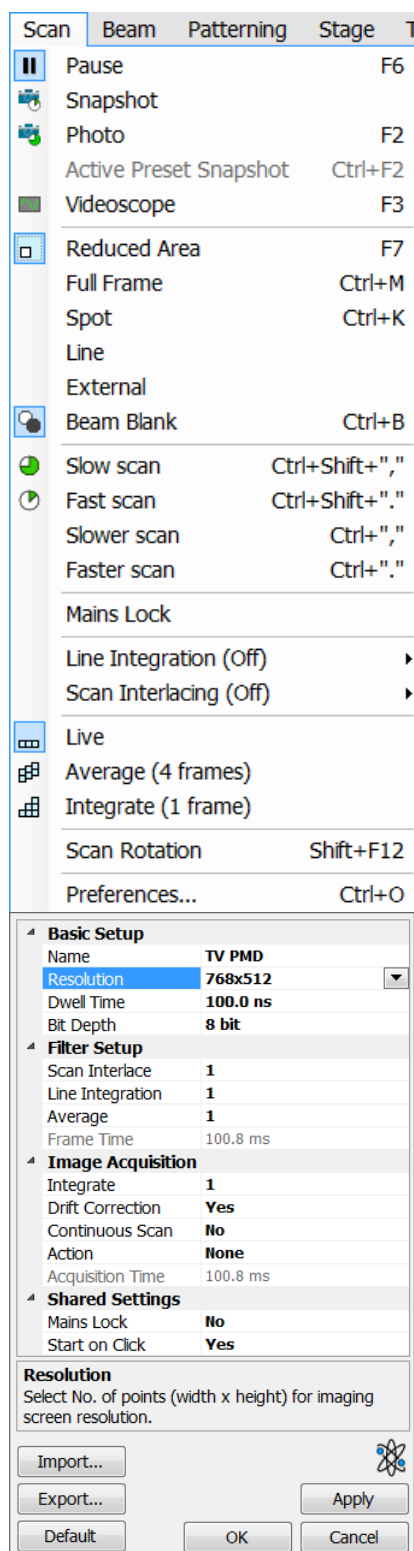
The Scan Menu (Alt + S)

opens the scanning control functions:

Pause (F6)

pauses the imaging. This function is used automatically with Snapshot and Photo functions.

Select the Scan menu / Pause or press the F6 button or click / double-click the toolbar pause icon to stop scanning at the end of the actual frame / immediately.

When the quad is going to be paused at the end of the frame the toolbar pause icon is pressed-in and has an orange background. When the quad is paused the icon remains pressed-in and its background colour reverts to normal and a large pause icon appears in the corresponding quad.
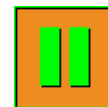
Select Scan menu \ Pause item or press F6 button or click the toolbar or quad pause icon to release the pause function (the icon button pops out) and to return the scanning to the previous state.

Shift + clicking the toolbar pause icon pauses / activates all quads with an electron imaging at once.

Snapshot (F4) / Photo (F2)

activates a preset scan (see the **Preferences… / Scanning** tab) to acquire an image. The icon could be selected by clicking the small black arrow next to the toolbar icon.

Active Preset Snapshot (Ctrl + F2)

If any of six presets is activated by clicking the numbered button (becomes yellow), image acquiring starts with corresponding parameters. Use the toolbar expand / hide arrow to change preset parameters. These presets could be Exported / Imported with the use of appropriate buttons / menu items. The functionality is available only if activated in the **Preferences…** / **General** tab /).

Note:

Shift + clicking the Photo icon / active Preset Snapshot button or when pressing Shift + F2 / Ctrl + Shift + F2 key takes Photo / active Preset Snapshot from all quads at once.
In this case when in addition a large screen resolution is selected (4096 x 3536) and the **Drift Correction** functionality is used an imaging is delayed, but the result will be correct.

Videoscope (F3)

This function shows the video intensity along the currently scanned horizontal line for correcting contrast and brightness.

Reduced area (F7)

This mode is useful when focusing and correcting astigmatism as the scan speed is faster in the smaller area. When Reduced area is chosen, the small green frame appears at the last used place onscreen, which could be adjusted by clicking & dragging. It is also possible to adjust scan parameters independently on the full-frame setting.

- **Moving:** Place the mouse cursor over the selected area. The arrow changes to a 4-ended arrow. Click & drag the selected area to the desired position and release the mouse button.

- **Changing the size:** Place the mouse cursor over the edge of the selected area. The cursor changes to a 2-ended arrow, either horizontal or vertical. A corner can also be used to move two sides. Click & drag the side out or in to obtain the desired size and release the mouse button.

When the Reduced area frame is being manipulated, it turns yellow until released, then it reverts to green.

Full Frame (Ctrl + M)

is the default scanning mode, typical for navigation and imaging.

Spot (Ctrl + K)

When starting this mode, the beam is blanked and the scanning is switched off. Actual beam position is represented by a green cross in all electron quads. You can click & drag it or click anywhere around the screen to change its position.

Line

In this mode, the green horizontal line is displayed in all quads. The beam scans along this line. You can click & drag it or click anywhere around the screen to change its position.

External

switches to activate an external control of the scanning system, such as EDX system beam control. The external scanning mode is indicated by the External label displayed in the upper right corner of all imaging quads.

Beam Blank (Ctrl + B)

deflects the beam off axis high in the column and protects the specimen from unnecessary exposure. When the beam is blanked the toolbar icon is highlighted. Clicking it releases the blanker and returns the beam to scan the specimen.

Slow / Fast Scan (Ctrl + Shift + , / .)
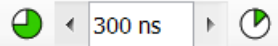
brings the scanning condition to the preset
Slow (left icon) / Fast (right icon) scan value (see the **Preferences… / Scanning** tab). When either of the two presets is selected the respective icon is highlighted.

Slower / Faster Scan (Ctrl + , / .)

sets the scanning condition to the next preset Slower (left arrow) / Faster (right arrow) value (see the **Preferences… / Scanning** tab). The spinner box shows the actual dwell time, but does not enable to change or select directly its value - the values are changed one step up or down.

Mains Lock

When ticked, the scanning (line or frame sawtooth signal) is synchronized with the mains AC oscillation. This greatly diminishes blurring and jittering of the electron imaging resulting in smooth image edges at higher magnifications and slow scan conditions.

Line Integration

With this function each line scan is repeated several times (from 2 to 255) before proceeding to the next line. Signal data collected from these passes are integrated and displayed as an actual image line.

This imaging method reduces sample charging (in comparison with single pass with longer dwell time) and improves overall image quality.

Scan Interlacing

This function splits an imaging area into blocks defined by the number of lines (from 2 to 8). In the first instance the first line of each block is scanned, then the second one etc. This imaging method significantly reduces sample charging.

Live

is the default mode, leaving the imaging unfiltered for collecting raw direct images - one frame follows another.

Average

continuously averages a specified number (2 or more) of frames, resulting in a better signal-to-noise ratio. This process continues until stopped by changing the scanning condition or by pausing the quad.

This is used mostly for fast scanning to reduce imaging noise. During averaging, the image is updated continuously and actions such as focusing, moving the stage, etc. can still be performed.

Note:
The Average is set independently also for the optical window (option), but using averaging with more than 4 frames is not recommended, especially when moving the stage.

Integrate

allows accumulative noise reduction by true integration over a specified number (1 or more) of frames. This process continues until the selected number of frames is reached and then pauses the quad automatically. During and after image accumulation, you cannot change the focus or perform other actions influencing the imaging.

This can be used as an alternative to slow scanning to obtain high quality images of slightly charging specimens.

Note:
Clicking the down-arrow next to the toolbar icon displays menu items **Live** / **Average (# frames)** / **Integrate (# frames)** / **Number of Frames** enabling to select number of averaged or integrated images (depending on the actually active **Filter Mode** indicated by the icon for the selected quad). Clicking the toolbar icon itself changes the Live / Average / Integrate mode in cycle.
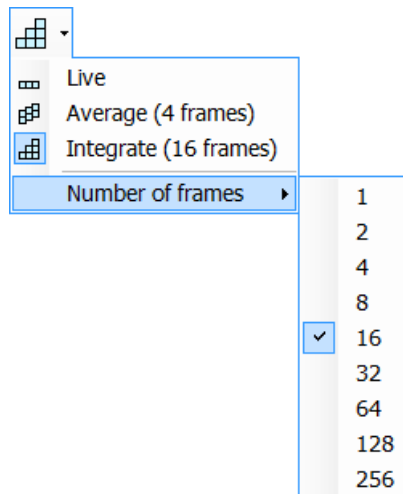
The Number of Frames is set and remembered independently for the Average and Integrate filters. Both the Filter mode and Number of Frames is set and remembered per quad, so live and filtered imaging can run at the same time. Settings are particular for the Reduced Area and for the Full Frame also. The Photo function uses the Filter Mode and Number of Frames pre-set (see the **Preferences… / Scanning** tab).

As the scanning could take a significantly long time period, one can restart it from the beginning with the use of **Ctrl + R** keys (Restart Scan).

Scan Rotation (Shift + F12)

activates the on-screen tool to rotate the scan field. It has no effect on the stage movements and is solely a scan coil function used to orient the imaging relative to a specimen feature and/or detector direction.

A not zero scan rotation is indicated by an icon in the **Status** module, and its value can be also displayed in optical quads (see Chapter 5).
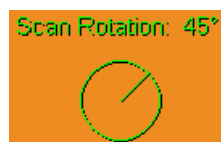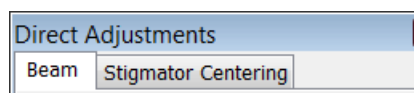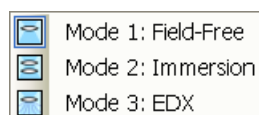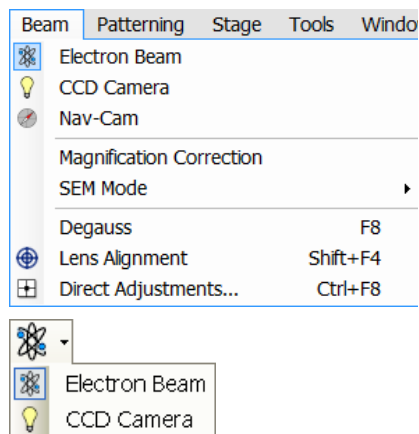
The Beam Menu (Alt + B)

opens the Beam menu functions:

Electron Beam / CCD Camera

makes the quad or single screen active to the **Electron Beam / CCD Camera** (the displayed icon sequence) with respect to the source, column, scanning, and detector settings. Only one is active at any time, but can be operated independently for each quad.

Another possibility to change the beam for the particular quad is right or left clicking the toolbar or image databar beam icon.

Magnification Correction

This function is intended to enhance factory calibration accuracy under particular, user selectable conditions. When the Magnification Correction is ticked, the **E-column: Magnification Correction** alignment (must be done for proper functionality, see Chapter 4) influences the magnification accuracy, otherwise it is not applied. The "c" letter is added to appropriate databar fields (Mag, HFW) and the "Magnification Correction" text is added to the imaging quad.

SEM Mode

This item opens a sub-menu with selection of three different imaging modes, in which the electron column could be operated. They can be selected directly from the toolbar also (see Chapter 5).

Degauss (F8)

triggers the procedure which puts all actually used electron lenses to a normalized state by removing their hysteresis effects. For a few seconds while the procedure is running all live imaging disappear or turn fuzzy, and then return back.

Use this function with (almost) focused imaging to obtain the most accurate Magnification, Horizontal Field Width (HFW) and Working Distance (WD) readouts.

Lens Alignment (Shift + F4)

This feature activates / deactivates the final lens alignment mode for the fine alignment of the electron beam. The scanning conditions change to the last selected value, lens modulator turns on and the alignment cross appears in the respective position in all imaging quads.

Clicking & dragging activates a 4-arrow ended cursor and starts the final lens alignment (see Chapter 5).

Direct Adjustments… (Ctrl + F8)

opens the Direct Adjustment window (or places it over the 4th Quad, if it is already opened) for fine-tuning the beam geometry to achieve the best focus and brightness. The controls are separated into two tabs (see Chapter 5).
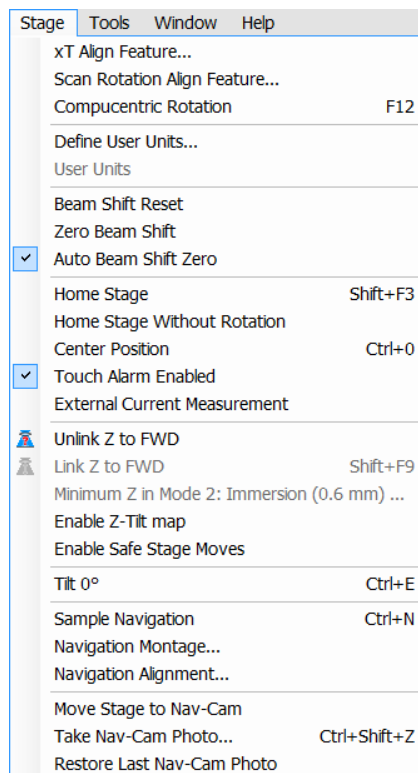
The Stage Menu (Alt + S)

opens the stage and sample navigation functions:

xT Align Feature

opens the procedure that helps to navigate along a feature that extends off the screen at the desired magnification. The procedure uses the stage rotation (see Chapter 5).

Scan Rotation Align Feature…

opens the procedure that helps to navigate along two sample points. The procedure uses the scan rotation (see Chapter 5).

Compucentric Rotation (F12)

places a green circle in the selected quad. By rotating the circle a different viewing orientation of the sample area can be achieved by a physical stage rotation and adjustment of X and Y axes. Stage rotation keeps the observed feature in the center of the field of view. If this does not occur, the alignment should be performed to locate the stage center and calibrate the stage (see Chapter 4).

Define User Units…

activates a procedure guiding a user to determine User Units for X and Y stage axes. These are used for relative stage movements associated with the regular features mapping (in particular integrated circuit applications) (see Chapter 5).

User Units

organises the stage software to recognise the defined user units rather than the default metric measurements. The X and Y coordinates now operate in User Units which are indicated in the **Stage** module / **Coordinates** tab by the UU symbol (see Chapter 5).

Beam Shift Reset

zeroes the beam shift. A feature observed with a not zero Beam Shift is automatically moved back to the imaging center using the stage.

Zero Beam Shift

zeroes the beam shift without moving the stage. A feature observed before selecting this function is moved from its position by the measure of the applied beam shift.

Auto Beam Shift Zero

automatically resets the beam shift each time it reaches the maximal value during the Get function (the point-to-point stage movement) and corrects the imaging position with a stage movement.

Home Stage (Shift + F3)

starts procedure which moves all motorized axes to their hardware limits and ensures that the physical stage position agrees with the coordinates readout. During the home stage procedure the **xTm: Stage Information** dialogue displays its progress. The stage axes are moved to their end-switches in the following order:

1. Z (lowest position), **2. T** (tilt), **3. X**, **Y** and **R** (rotation) at the same time.

When the stage is homed correctly it ends up in the following position:

X / Y position is set to the factory pre-set stage rotation centre
R = 0°
T = 0°
Z = preset working distance (depends on the stage type)
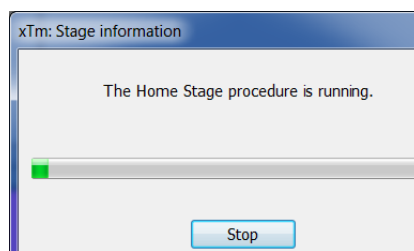
Home Stage Without Rotation

executes Home Stage function (see above) without rotation. When the stage is homed without rotation the stage Rotation reference is greyed out. This is useful when a large specimen is inserted and stage rotation could cause a collision with equipment inside the chamber.

Center Position (Ctrl + 0 - digit)

moves the stage to coordinates X = 0, Y = 0.

Touch Alarm Enabled

activates the Touch Alarm for the stage. This function automatically stops the stage movement and displays Touch Alarm warning dialogue whenever the stage or a conductive specimen touches the objective lens or any other equipment conductively connected to the chamber. This functionality is used also when the stage engines start to rise the power over the determined level.

External Current Measurement

When you need to use an external measuring device (option - see Chapter 7) click this item. The **Status** module / **Specimen current** value shows **Ext** from that point on.
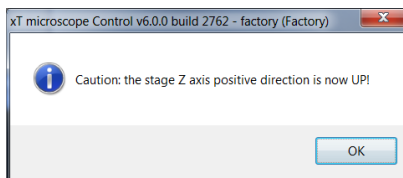
Unlink Z to FWD

This feature functions in an opposite way as the following one. The Z coordinate value represents then the distance from the Z home position (stage base). The dialogue warns you about the stage Z-axis positive move direction.
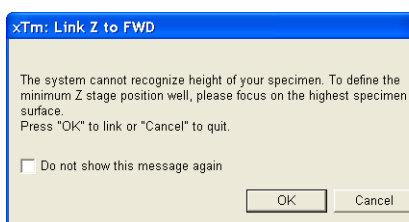
Link Z to FWD (Shift + F9)

sets the Z coordinate value to the actual Free Working Distance (FWD) value. This allows accurate movement between the sample top surface and the end of the objective lens. The related toolbar icon changes according to the Z-coordinate status:

- **Greyed icon**: the function is disabled – the high voltage is switched off (so there could be no electron imaging) or all quads are paused.
- **Red question mark**: the function is enabled – Z is not linked to FWD. Use this function as soon as possible, after a proper focus.
- **Red circle**: the function is enabled – Z is roughly linked to FWD, but it needs correction. It happens e.g. after: changing the specimen, focusing and linking Z to FWD at a long WD and then moving the stage to a short WD. Focus carefully at a WD around 5 mm and use this function again.
- **Green double-ended arrow**: the function is enabled – Z is properly linked to FWD. Now it should be safe to change the working distance by setting a Z coordinate in the Stage module.
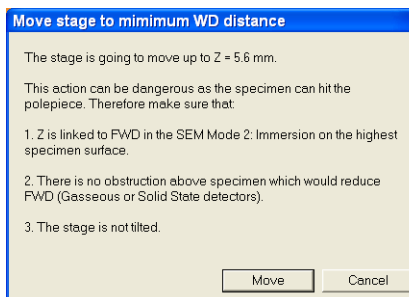
Minimum Z in Mode 2: Immersion

This function is enabled only in SEM Mode 2. The dynamically updated value displayed in this menu item means the (estimated) minimum Working Distance achievable at the actual accelerating Voltage.

When selected, a dialogue with a warning and explanation is displayed so that user can decide whether it is save to proceed or cancel this action. Clicking the **Move** button moves the stage to the shortest possible WD and closes the dialogue.

Enable Z-Tilt map

Some movements of the tilted stage are not safe because of a possible collision with the final lens. The table (not user editable) with a pairs of

values indicates the maximum safe Tilt angle for a certain Z value when coupled. It can be used to guarantee safe usage of the stage (tilt restriction) for a flat samples only and when a proper Link Z to FWD is established.

Enable Safe Stage Moves

When ticked the software takes into account all accessories installed inside the chamber. That's why the stage doesn't move to the target position following the straight path. When the magnification is large and stage movements are expected to be tiny, it is not necessary to switch on this functionality.

Tilt 0° (Ctrl + E)

tilts the stage to 0°.

Sample Navigation (Ctrl + N)

toggles on / off function that enables to navigate electron imaging (scan field) towards desired places on a specimen using either paused or loaded sample image (usually captured at much lower magnification).

The Sample Navigation can be selected independently for any quad, regardless of its actual content and status. A tick next to the menu item indicates that the function is selected for the active quad. As soon as this quad is paused, the Sample Navigation indicator appears in the upper right corner of the quad. The indicator is green as long as the paused imaging can be used to navigate the live one, otherwise turns red (e.g. when the stage rotation or tilt changes).

Navigation Montage...

This procedure enables to capture the sample Navigation image to be used in the Sample Navigation (see Chapter 5).

Navigation Alignment...

This procedure aligns the Navigation image according to the live reference image (see Chapter 5).
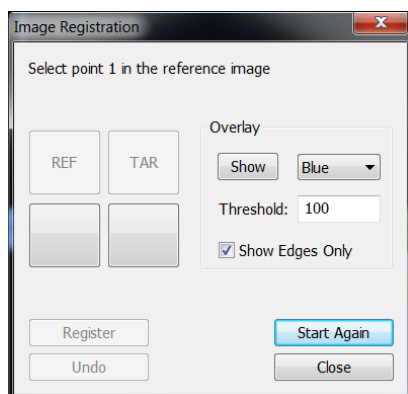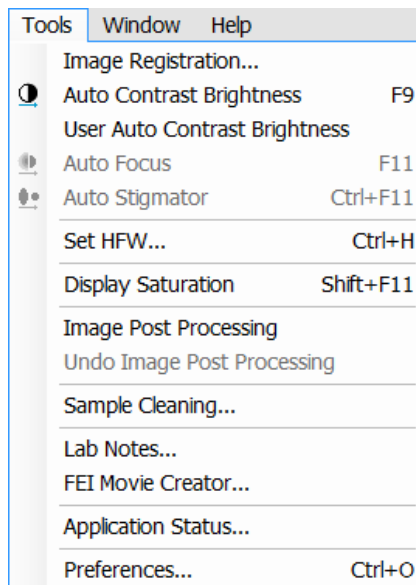
The Tools Menu (Alt + T)

opens the Tools menu functions:

Image Registration

This functionality is used to interconnect images of the same area of interest acquired from different sources or at different conditions (for instance images acquired from optical and SEM microscopes, images acquired at various depth of focus etc.).

Click the **Tools** menu / **Image Registration…** item and follow the prompts at the top of the window:

1. Selects the quad with the reference image.
2. Select the quad with the target image (the one that will be transformed).
3. Select 1, 2 or 3 corresponding pairs of points in both the reference and target images.
   Note:
   When selecting 1 point, image is shifted only, 2 points shifts and rotates it and by selecting 3 points it is skewed furthermore.
4. Click the **Register** button to apply the transformation.
5. Click the **Close** button to close the Image Registration window.

Clicking the **Start Again** button enables to repeat the procedure in the same way with the changed (or another) target and reference images placed in the same or different quads. Clicking the **Undo** button restores the image to the situation before the last transformation.

Clicking the **Overlay** panel / **Show** button shows a copy of a registered target image (in **Red** / **Green** / **Blue** color) over the reference image which reveals a quality of the registration and enables to compare information from both images. The **Threshold** value (0 to 255) determines which gray levels of the target image are shown in the overlay and the **Show Edges Only** check box ensures to display only the edge outlines.

After registration the micron bar and magnification of the target image take on the same values of the reference image. Any operation that is applicable to an acquired SEM image can be applied to a transformed image, including saving a file.

Auto Contrast Brightness (ACB) (F9)

activates the automatic contrast and brightness routine.
The system attempts to set the Contrast and Brightness of the selected detector in the selected quad to suit the actual sample and conditions so that the majority of grey levels is displayed.

User Auto Contrast Brightness

examines grey levels of the selected quad imaging and stores their minimum and maximum. Next time the ACB function is used, it attempts to set the Contrast and Brightness so that the resulting imaging grey levels lies between this minimum and maximum instead of full black and white.

A tick next to this menu item indicates the user grey level limits active. Clearing the tick reverts the ACB to its default setting.

Auto Focus (F11)

activates the automatic focus routine. The system attempts to correct the focus independently of the working distance or Z-coordinate set.

Auto Stigmator (Ctrl + F11)

activates the automatic procedure to correct the astigmatism
(see Chapter 5).
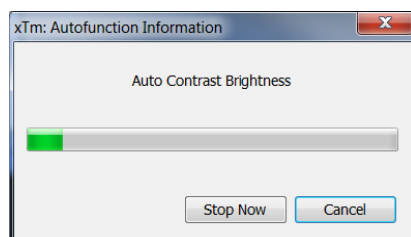
Note:
When ACB / Auto Focus / Auto Stigmator is activated the dialogue appears to show the progress. The function can be interrupted by clicking the **Stop Now** button, which leaves the imaging / the focus (WD) at the actual stage of progress. Clicking the **Cancel** button before the function ends returns the imaging back to its original status / the original WD value.

Set HFW… (Ctrl + H)

enables to set the desired Horizontal Field Width, i.e. the width of the scanned area. This is an alternative to the setting of magnification.
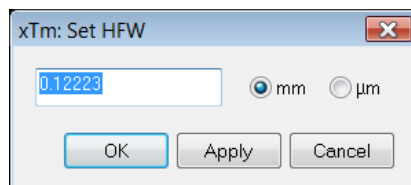
Display Saturation (Shift + F11)

displays signal clipping in the selected quad by means of replacing the full black / white with dark blue / yellow color. The function can be used both for electron and ion imaging, but cannot be applied to the optical imaging.

The saturation display is selected independently for each quad. A tick next to the menu item indicates whether the function is active for the selected quad.

Image Post Processing (Ctrl + F7) /
Undo Image Post Processing (Ctrl + Shift + F7)
Starting this function corrects image properties according to the **Image Enhancement** module / **Process** tab setting (see below).

Sample Cleaning…
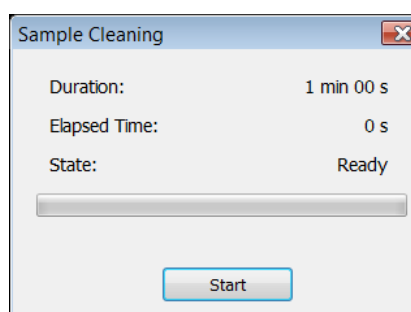
This feature starts the sample cleaning procedure set in the **Vacuum Actions** / **Plasma Cleaning** alignment (see Chapter 4). This cleaning method is effective process for removing very thin contamination layers, which are typically formed by hydrocarbons residues remaining on vacuum parts after conventional cleaning or could be transferred into the microscope chamber with sample (see Chapters 4 and 7).

Lab Notes…

opens the Windows Notepad application over the UI for a user to make immediate notes and remarks. The Lab Notes can be used to open, edit and save any text file without the necessity to hide the xT UI.

FEI Movie Creator…

provides a dialogue over the UI for setting up a collection of sequenced TIF images, and lining them up into an AVI movie (see Chapter 5).

Application status…

The dialogue is displayed over Quad 4 showing continuously updated system **Messages**. The **System status** tab offers informations about the system hardware, which are used for service engineers.

- **Pop-up on Message Severity**: None / Error / Warning / All specifies which kind of messages is going to be shown automatically on screen. Three icons in the lower right corner enable to separately switch on / off displaying of Error / Warning / Information messages.
- **Clear** button clears all actual messages from the window.
- **Hide** button hides Application Status window.

FIGURE 3-7   APPLICATION STATUS
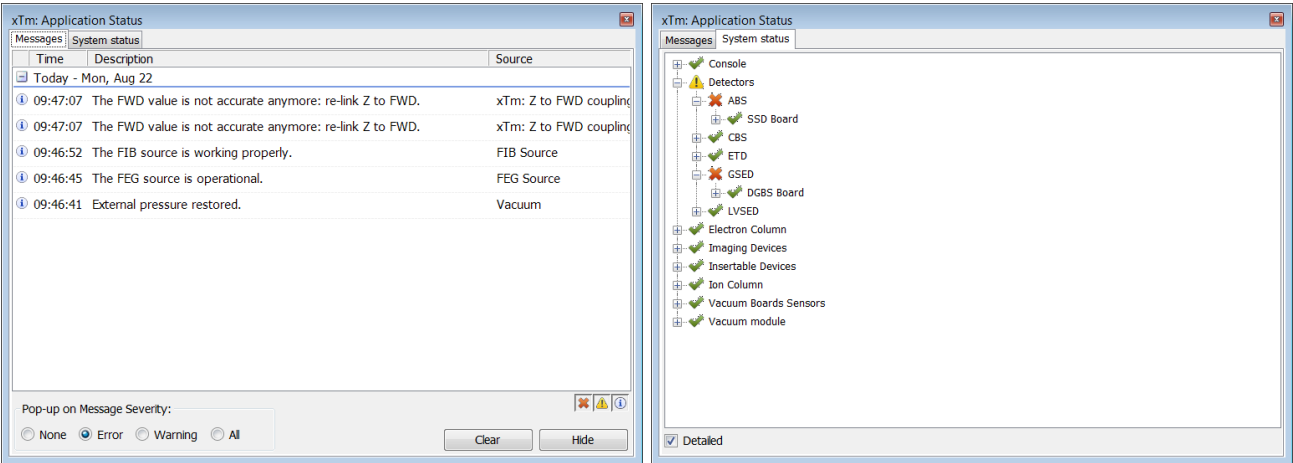
The Window Menu (Alt + W)

opens the Window menu functions:
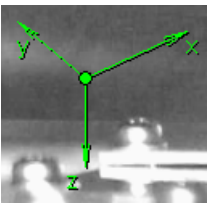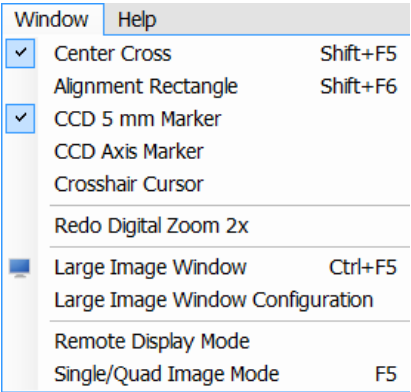
Center Cross (Shift + F5)

places a cross in the center of all imaging quads. This function is automatically used in Alignment procedures to aid the centering of features and can be used to align a sample against a stored image in another quad.

Alignment rectangle (Shift + F6)

places a dashed rectangle in the center of all electron image quads. This function is used for some Alignment procedures automatically.

CCD 5 mm Marker

places a short horizontal line with 5 mm label in all optical quads to help user with a sample positioning to a correct working distance and with the first focusing. Only Supervisor is allowed to change the marker position by double-clicking a new position and by confirming this action in the popped up dialogue.

CCD Axis Marker

places axes indicator in all optical quads to help user with 3D orientation.

Crosshair Cursor

shows the cursor as a rectangular cross through the entire quad.

Undo / Redo Digital Zoom #x

When using the digital zoom (see below), it is possible to undo / redo the last magnification / reduction step.

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Large Image Window (Ctrl + F5)

This function activates / deactivates the full screen quad imaging on the secondary monitor.

FIGURE 3-8 LARGE IMAGE WINDOW
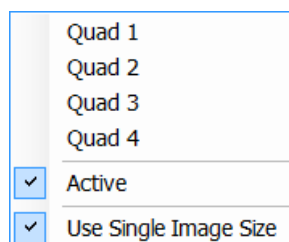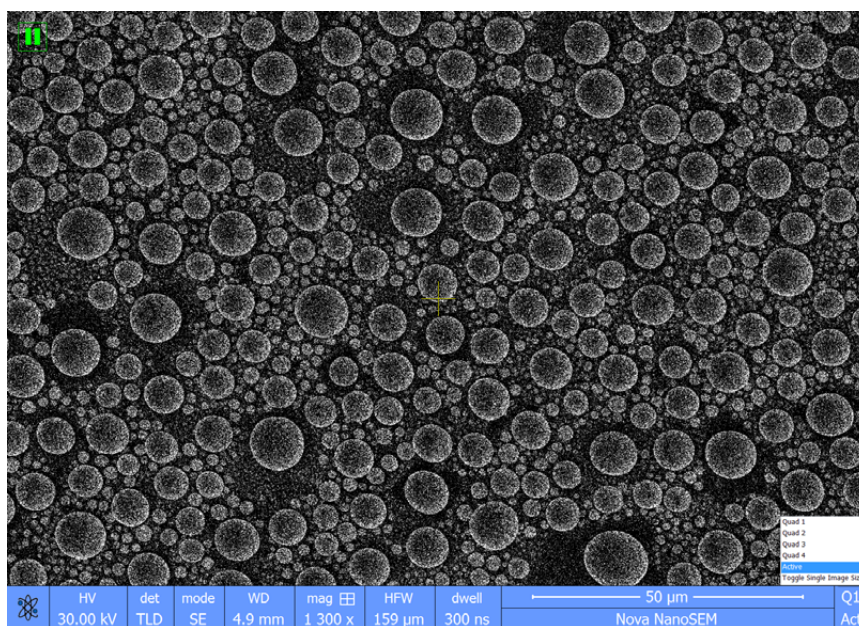
Large Image Window Configuration

Here one can select, whether to show an **Active** quad, or any selected one. Activating the **Use Single Image Size** option sets the imaging window size corresponding to Single Image mode size. These options are also available in the bottom right corner of the large image window.

Remote Display Mode

When using the Remote Imaging (option) this feature enables correct UI imaging at the remote site. It is also used for a remote service.

Use of this function decelerates slightly a UI performance and it is displayed in the bottom left quad corner.

Single / Quad-Image Mode (F5)

toggles the image display area between two possibilities:

- **Single Image Mode** displays one quad over the whole UI imaging area – useful for observing details.
- **Quad Image** mode is useful for comparing imaging of the same sample area taken with different detectors or scan properties.

1 / 2 / 3 / 4

The selected quad is indicated by a tick mark next to the respective number. In the quad Image mode, quad 1 / 2 / 3 / 4 is displayed top left / top right / bottom left / bottom right. In the Single Image mode, the selected quad is displayed.

The Help Menu (Alt + H)

opens the Help menu and system information functions:
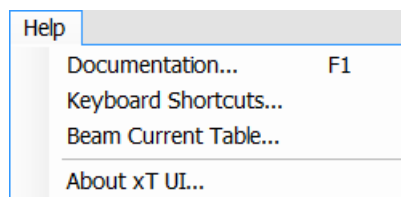
Documentation… (F1)

The Help window shows complete User Manual in PDF format using an embedded Acrobat Reader with its useful navigation, search and selection tools. The window remembers its position and size for the next showing up.

Clicking the **Question mark** at the right side of the module header (see below) opens the relevant part of the User Operational Manual.

FIGURE 3-9   ONLINE DOCUMENTATION
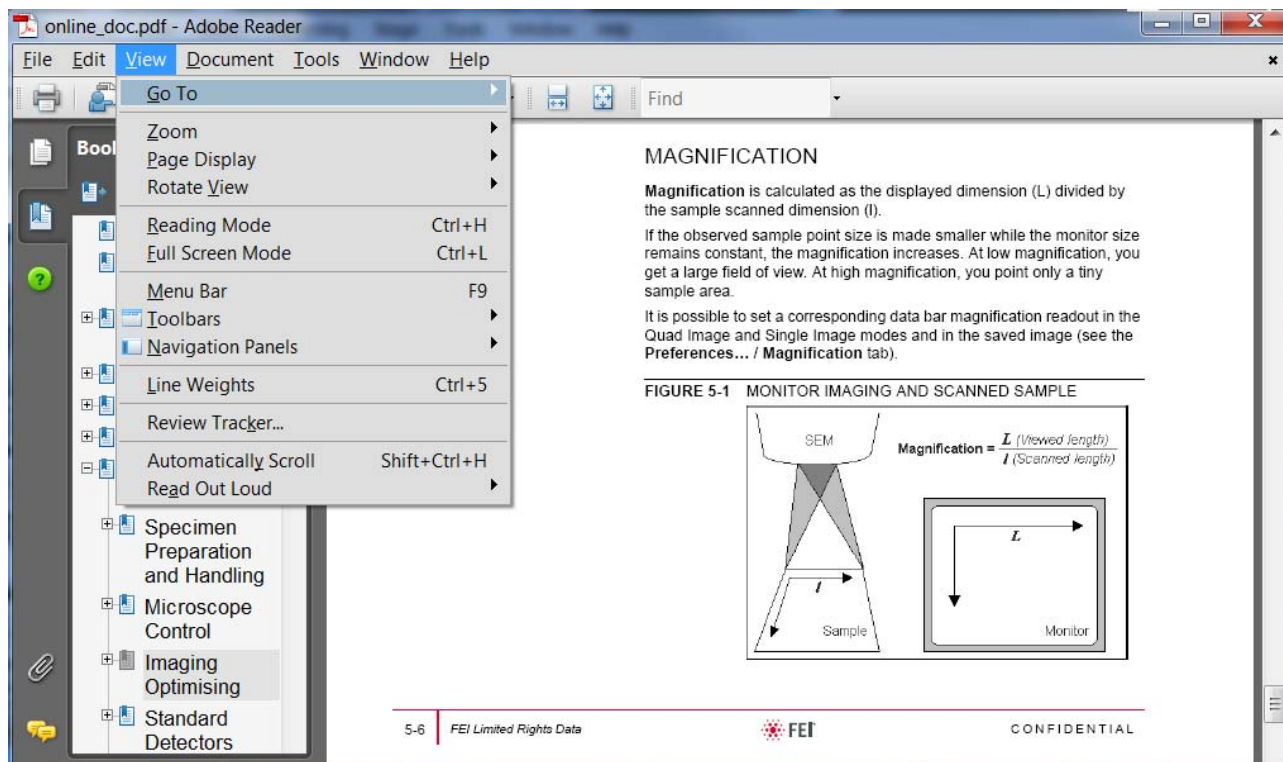
Keyboard Shortcuts…

The shortcuts list in tables is displayed in the same way as the on-line documentation (see above) and with the same behaviour.

Beam Current Table…

This feature brings out the table with beam current values in relation to HV, final lens aperture and spot size (see Chapter 5).

About xTUI…

displays a window containing information about the product version. The window automatically disappears after the first click.

TOOLBAR

displayed below the Menu bar is made up of functional icons linked to the most frequently used system controls. It also contains group of icons for quick switching between UI Pages. The toolbar can be a bit different in content or style (see the **Preferences… / General** tab).

Rest the cursor over the icon for two seconds without clicking it to see its explanatory tool-tip.

Whenever a function is selected the corresponding icon is highlighted (blue frame) to indicate the function is active (except of auto-functions, which display a progress bar).

Note:

If any icon represents a menu function, refer to the corresponding menu for its description.

Magnification / High Voltage / Spot List Boxes

Click the list box to open a selection of the pre-set and actually allowed values, choose one and it is applied immediately (see the **Preferences… / Presets** tab).

- The **Magnification** / **HFW** range differs for different Lens Modes, and in Immersion mode dynamically changes with the Working Distance and High Voltage.
- The **High Voltage** range changes in Immersion Lens mode, where the High Voltage values are upper-limited depending on the Working Distance.
- The **Spot Size** range updates immediately when the SEM Aperture is changed. Spot sizes corresponds to the pre-set values (see Column module) and to the selected SEM Aperture (see Chapter 2).

Imaging Pixel Resolution List Box

This list contains available imaging pixel resolutions (also effective for captured images). Selecting a new resolution results in an immediate change of the scanning raster and since the present dwell time remains unchanged, the actual scanning frequency (both Line and Frame time) changes.

Direct Measurement

This button enables to quickly access the measurement tool without necessity to change a page. Clicking the icon deactivates (grey color) / activates (yellow color) the functionality (see Chapter 5).
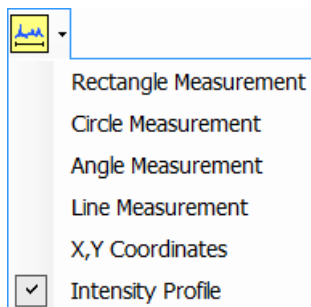
IMAGE WINDOWS

The xT microscope Control software (UI) uses 4 independent image windows – quads for imaging samples. Each quad can contain imaging from any detector (including External and CCD), paused imaging or images loaded from a file. Additionally, quad 3 can display a mix of imaging from quads 1 and 2, and quad 4 can display a mix of imaging from quad 1, 2 and 3.

It can be displayed either 4 quads at the same time – **Quad Image** mode or one quad over the UI imaging area – **Single Image** mode.

Each quad consists of its imaging area, adjustable Databar containing the imaging parameters, selectable overlay (user-defined coloring, annotations, measurement) and some status symbols (Pause, Sample Navigation, etc.).

At any time, just one quad is selected (has focus), and all functions (related to a single quad – Pause, Sample Navigation, image processing) applies only to imaging in this quad. The selected quad is marked by the highlighted (blue) Databar and optionally also by the blue frame (see **Preferences… / General**).

Depending on the quad content and the status, some mouse functions are available over its area:

- **Electron imaging** (incl. External and Mix): focus, astigmatism correction, Beam Shift, magnification change (coarse, fine), zoom (in / out), Contrast & Brightness, lens alignment, Scan / Compucentric Rotation, XY-move (get or track mode)
- **Optical imaging**: 5 mm Marker placement, Compucentric Rotation, Z-move (track), Tilt

Note:
Due to a hardware limitations, some detectors cannot be used simultaneously. They can still be selected for different quads at the same time, but if one of them is started, the other quads with incompatible detectors are automatically paused.
The optical imaging is automatically activated (if it is paused), when the venting procedure starts.
When it is paused and any stage movement takes place, the pause icon turns red and a list of changed axes is displayed.
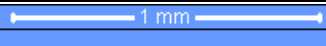
The Databar

displays optional instrument, imaging and labeling information. They can be placed in any order and expand or contract to fit the quad width as long as there is enough room (see the **Preferences… / Databar** tab).

Clicking some of the image databar fields induces an active menu related to it with appropriate choices. Clicking the label field induces the label editing menu and double-clicking the micron bar induces the image properties window (see above).

FIGURE 3-10 DATA BAR EXAMPLES

Active electron quad

Inactive electron quad

Active optical quad

Note:
The Databar information are always related to the actual imaging. If the imaging is paused or an image is loaded from a file, they could differ from the actual system conditions.

PAGES AND MODULES

The software controls on the right side of the screen are organized into **Pages**, which are divided into **Modules** holding specific functions. The required page can be selected either by clicking the corresponding icon button or with the use of short-cuts (see below).

TABLE 3-1   PAGES AND MODULES LIST

Pages	Modules (Tabs)
Beam Control	1. Vacuum, 2. Column, 3. Magnification, 4. Beam, 5. Scan Rotation, 6. Beam Deceleration, 7. Detectors, 8. Status
Navigation	9. Stage (Map / Coordinates / Tilt / Navigation) 10. Stage Z, 7. Detectors, 8. Status
Processing	11. Measurement / Annotation, 12. Digital Zoom, 13. Enhanced Image (LUT / Mix 3 / Mix 4 / Color / Process), 7. Detectors, 8. Status (reduced)
Detectors	14. Detector Settings, 15. Quad Presets, 6. Beam Deceleration, 7. Detectors, 8. Status
Alignments	16. Alignments (Instructions / Individual steps), 8. Status

Note:
The number in front of the module name represents an order in which the modules are introduced in the following text.
For Software Interface Elements control see above.

1. The Vacuum module
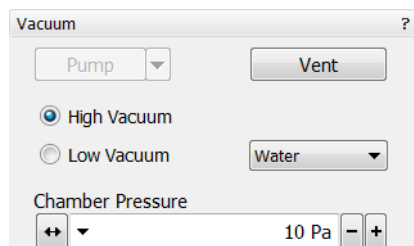
is used to control the pressure and the gas type in the specimen chamber. The **Pump** button starts the pump down procedure for the specimen chamber and the column. The system allows the accelerating voltage to be switched on only when the column is sufficiently evacuated. The **Vent** button starts venting for a sample or detector exchange after the user confirmation (see Chapters 2 and 5).
The **Mode** radio buttons bring the system to:

*   the **High Vacuum** mode, which is the conventional operating mode (associated with all scanning electron microscopes), used for observing conductive specimens that can withstand low pressure conditions and do not release gas.

    In this mode the system pumps continuously to achieve the lowest possible pressure.

*   the **Low Vacuum** mode for observing not coated and not conductive or partially conductive specimens.

    In this mode, the chamber pressure is controlled using the **Chamber Pressure** adjuster, while the column is at a much lower pressure. The gas environment can be selected from the list box.

The system automatically switches to one of the modes when the chamber is Vented and a dedicated detector is installed. If no dedicated detector is installed, user is asked to determine a detector mounted.

The **Pump with Sample Cleaning…** choice pumps the system, makes Sample Cleaning procedure (see Chapter 7) and keeps columns pumped.
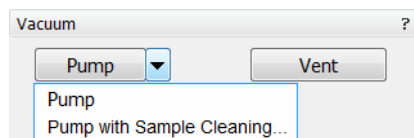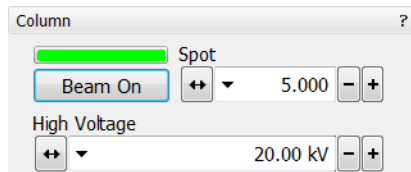
2. The Column Module

contains controls for setting the electron beam conditions:

The Beam On Button

switches the accelerating voltage on (yellow button) / off (grey button). If the source is not started (empty progress bar), this button starts the ion source first (green progress bar).

The Spot Preset / Continuous Adjuster

enables to adjust the electron beam **Spot** size in the selectable accuracy steps (see the **Preferences… / General** tab). The actual spot size number from the factory preset list is displayed in the text area of the adjuster, toolbar (default) and in the Databar (if selected). Only values usable for actual imaging conditions are displayed.

Beam **Spot** size number could be set in the range from 1 to 7 (values from 3.9 to 4.0 are disabled) and it influences both the focused electron beam area and the Beam Current. The lower is the Spot number, the lower is the Beam Current.

The High Voltage Preset / Continuous Adjuster

enables to adjust the overall electron beam acceleration voltage (from 200 V to 30 kV in 100 V steps) either continuously or using the pre-set values (see the **Preferences… / Presets** tab). The actual High Voltage value is displayed in the text area of the adjuster, toolbar and in the Databar (if selected).
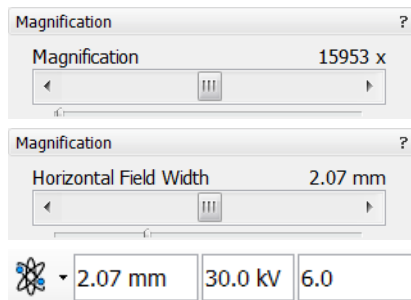
3. Magnification / HFW Module

The continuous adjuster offers a variety of ways to control the imaging magnification (see above). The magnification range changes dynamically according to the working distance and can also be controlled with the use of other tools (see Chapter 5).

The **Magnification** is possible to display as the **Horizontal Field Width** (HFW) alternatively (see the **Preferences… / General** tab).

Magnification Control

- Clicking the **end arrow** increases / decreases magnification by **5%**.
- Clicking **between** the **end arrow** and the **button** increases / decreases magnification by **20%**.

4. Beam Module

Stigmator 2D Control

enables to correct image astigmatism. The crosshair indicates the actual setting of the stigmator.

Shift + right-clicking over an imaging quad triggers the astigmatism correction. Unlike the 2D box control, this is magnification sensitive and therefore it suits for fine corrections at high magnifications, or employ the Adaptive Sensitivity functionality (see above).

Beam Shift 2D Control

indicates and controls the beam shift with respect to the objective lens axis. It is useful for fine image shifts without stage movement.

Shift + clicking over an imaging quad triggers the Beam Shift function. The mouse cursor changes to a hand one that "holds" the image and drags it over the screen. Because of a limited Beam Shift range, this works well only for high magnifications, or employ the Adaptive Sensitivity functionality (see above).
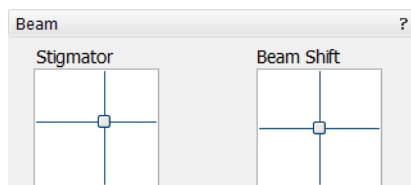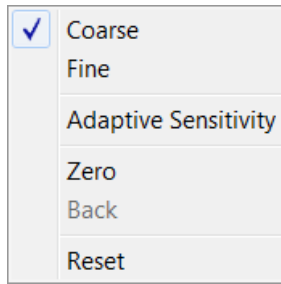
Note:

Right-clicking over the 2D box opens the menu with following particular choices:

• The **Reset** sets the Beam Shift value to zero and moves the stage to compensate the resulting imaging shift (same as the **Stage** menu / **Beam Shift Reset** function).

5. Scan Rotation Module

controls and displays the Scan Rotation value (see Chapter 5).
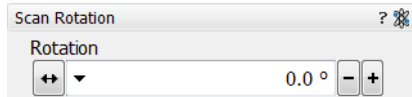
6. Beam Deceleration Module

In the Beam Deceleration mode a negative potential (Stage Bias) is applied on the stage, which influences both primary and signal electrons. It allows to decelerate the primary beam up to 50 V landing energy (see Chapter 5).
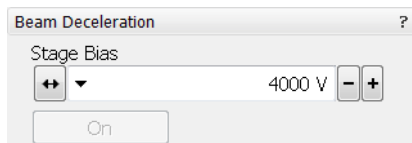
7. Detectors Module

contains continuous adjusters to control the active detector **Contrast** (electronic gain) and **Brightness** (voltage offset). The values are remembered for each detector and quad. The adjusters are disabled if the detector is not available or cannot be controlled (e.g. CCD camera or an External detector).

Contrast / Brightness / Enhance Continuous Adjusters

Regardless of the detector actual gain range, the Contrast & Brightness range is always 0 - 100 (%) and the small / large step size is 0.1 / 1 (the Brightness step size may differ for some detectors in order to achieve a sufficient sensitivity). A direct value can be entered by double-clicking the Contrast / Brightness value.

The Ctrl + Clicking & left-right / up-down dragging controls Contrast / brightness.

Note:

Some of the Low Vacuum detectors could have the special Detectors module with specific controls.
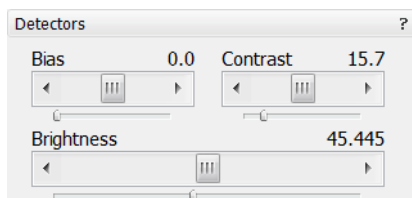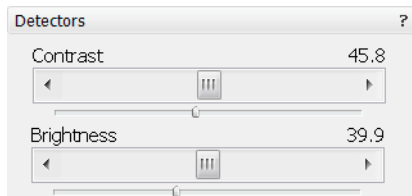
8. Status Module

can be found at the base of most pages, displaying the following information in a full or constricted form, some of them as a tooltip (said values are approximate only):

• The **Chamber Pressure:** shows the specimen chamber pressure.

• The **Emission Current:** shows the electron current emitted from the source.

• The **Specimen Current:** shows the electron current reaching the specimen.

• The **E Source** / **E Middle** / **Chamber:** shows pressure in the corresponding vacuum system section.
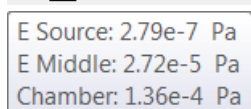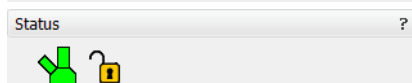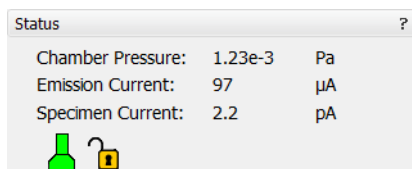
The system conditions are displayed by means of the icons:

TABLE 3-2   STATUS ICON MEANING

Icon	Status
	Column Vacuum / Chamber Vented
	Column Vacuum / Chamber Pumping or Venting
	Column Vacuum / Chamber Vacuum (Vacuum ready for microscope operation)
	Column Vented / Chamber Vented
	Stage axes – Lock (any one) / Unlock (all)
	Displays when Dynamic Focus is On
	Displays when Scan Rotation is not zero
	Displays when External scanning mode is On

9. Stage Module

consists of the tabbed sections (see Chapter 5).

- The **Map** tab displays the stage positions location in a visual map form and as a list for selection.
- The **Coordinates** tab displays numerical values of a particular position. Stage movements along selected axes could be locked.
- The **Tilt** tab contains correction features for the tilted imaging.
- The **Navigation** tab helps to navigate across the sample surface.

Note:

The stage movement can be aborted by hitting the keyboard **Esc** key. Don't hesitate to do so if you are not sure that the initiated movement is safe!

FIGURE 3-11 THE STAGE MODULE
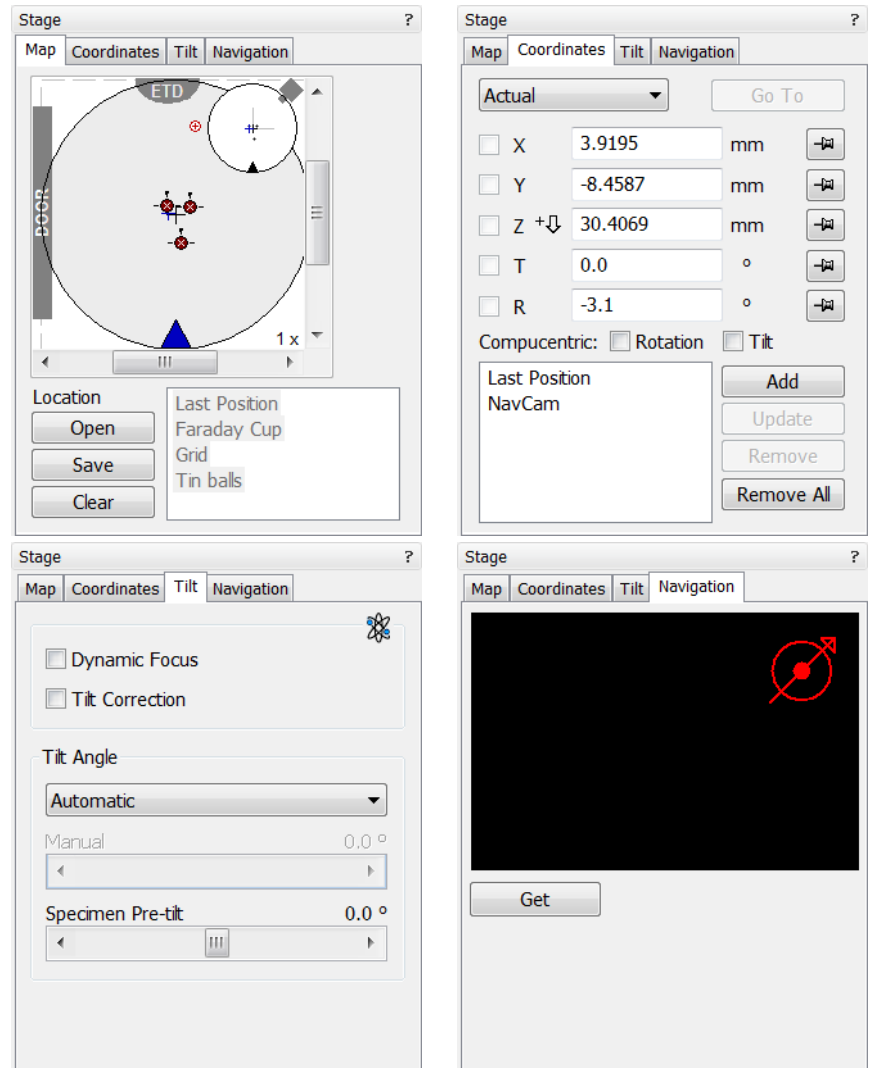
10. Stage Z Module
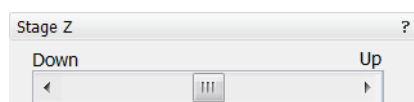
This module enables to softly move the stage in the Z-axis direction. The more the slider is pushed to the each side, the faster is the stage motion. Clicking the slider bar moves the stage by a small step.

11. Measurement / Annotation Module
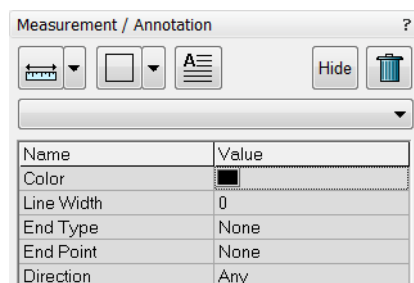
combines tools for measuring and making annotations in an imaging quad. A measurement tool, an annotation shape or a text label can be selected from the first three icons at the top of the module, and then drawn in an imaging quad. All objects are sequentially indexed and displayed in the list box below icons. The properties of the objects is possible to change in the property editor (see Chapter 5).

12. Digital Zoom Module
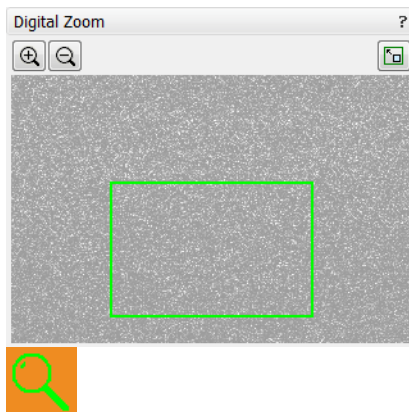
The procedure takes place in the computer memory only and helps to navigate across the enlarged view. Click the **+** / **-** **magnifying glass** button to enlarge / reduce the view in the selected quad. Click the **Undo** button at the top right side of the module (visible only when applicable) to turn over between a digital magnification last used and a normal view.

Click & drag the green bordered area inside the Digital Zoom image or click inside the green rectangle and move it by Ctrl + keyboard arrows to change an observed area in the selected quad. Change the observed area by dragging the green borders. Press the **Ctrl + + / -** keyboard button to enlarge / reduce imaging in the selected quad. When the digital zoom is applied, the icon appears in the appropriate quad.

13. Enhanced Image Module

consists of tabbed sections offering various digital image enhancements. In contrary to **Detector** module / **Contrast** and **Brightness** functions, these enhancements are applied only to the active quad independently. In case a user changes the default settings of **LUT** / **Color** / **Process** tab, its background color changes to green. The digital processing can be applied to any live, paused or loaded image, including an optical one (see Chapter 5).

FIGURE 3-12 THE ENHANCED IMAGE MODULE
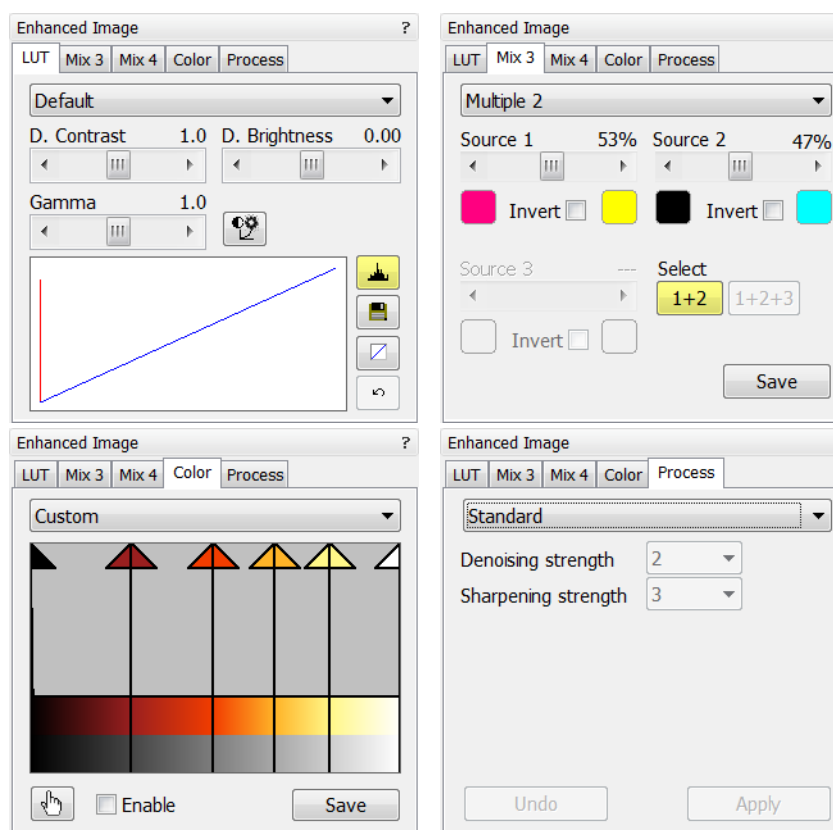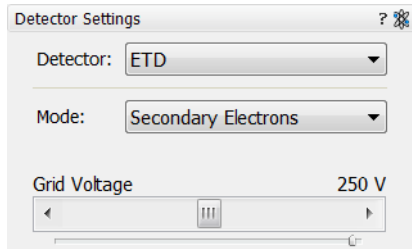
14. Detector Settings Module

enables to choose the selected quad detector
and adjust its parameters.

The **Detector** list box contains list of detectors actually available for the selected quad (the same as enabled items in the Detectors menu). The list box always displays the detector actually selected in the selected quad.

The rest of the module dynamically changes according to the selected detector and its parameters, which may change from quad to quad (see Chapters 5 and 7).
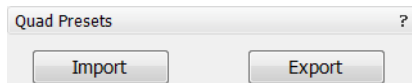
15. Quad Presets Module

The **Import** / **Export** button functionality is the same
as the **File** menu \ **Import** / **Export** items (see above).
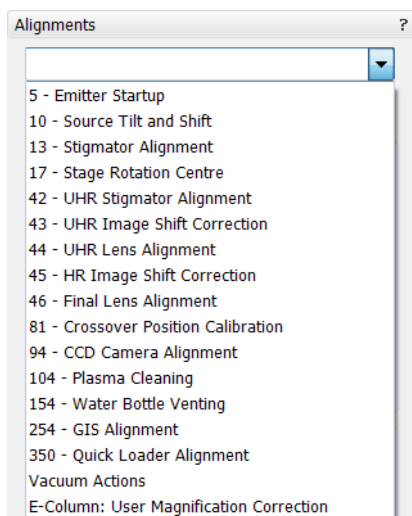
16. Alignments Module

contains alignments which enable to optimize the system performance (see Chapter 4).

- The **Alignments** list box contains list of Alignment procedures available for the actual user level (User, Supervisor or Service).
- The **Instructions** info box displays the selected alignment procedure instructions.
- The **Steps** module shows an actual alignment page with all necessary components.

C a u t i o n !

A user must understand the procedures at the appropriate level before proceeding with any adjustment. Improper alignments can make the system difficult to use.

Note:

Some alignment modules may have some features distributed differently than others, but functionality is the same, if it is not mentioned.

Detector Settings panel:

Detector Settings ? ⌘
Detector: ETD ▾
Mode: Secondary Electrons ▾
Grid Voltage   250 V
◄ ||| ►

Quad Presets panel:

Quad Presets ?
Import   Export

Alignments panel:

Alignments ?
▾
5 - Emitter Startup
10 - Source Tilt and Shift
13 - Stigmator Alignment
17 - Stage Rotation Centre
42 - UHR Stigmator Alignment
43 - UHR Image Shift Correction
44 - UHR Lens Alignment
45 - HR Image Shift Correction
46 - Final Lens Alignment
81 - Crossover Position Calibration
94 - CCD Camera Alignment
104 - Plasma Cleaning
154 - Water Bottle Venting
254 - GIS Alignment
350 - Quick Loader Alignment
Vacuum Actions
E-Column: User Magnification Correction

Preferences… Dialogue

This dialogue can be opened by selecting **Preferences…** **(Ctrl + O - *letter*)** from the pull-down menus: **Scan, Beam, Stage** and **Tools**. The menu from which it is chosen dictates the tab opened on entry. Once the Preferences dialogue is opened, any of the tabs can be chosen.

The Preferences dialogue consists of tabbed sections. Clicking the required tab opens a section that allows changing and presetting conditions for a group of the related functions. Only one tab can be opened at any time.

The items changed remain valid (for a specific user) until changed for the next time.

Some of the preference controls are beam dependent. In this case, an active beam type is indicated by the corresponding icon and items change accordingly.

The Units Tab

allows a user to change the **Units of Measure** and **Pressure**. The choices affect the Stage module input boxes, the databar display, the status module and so on.

FIGURE 3-13 UNITS PREFERENCES
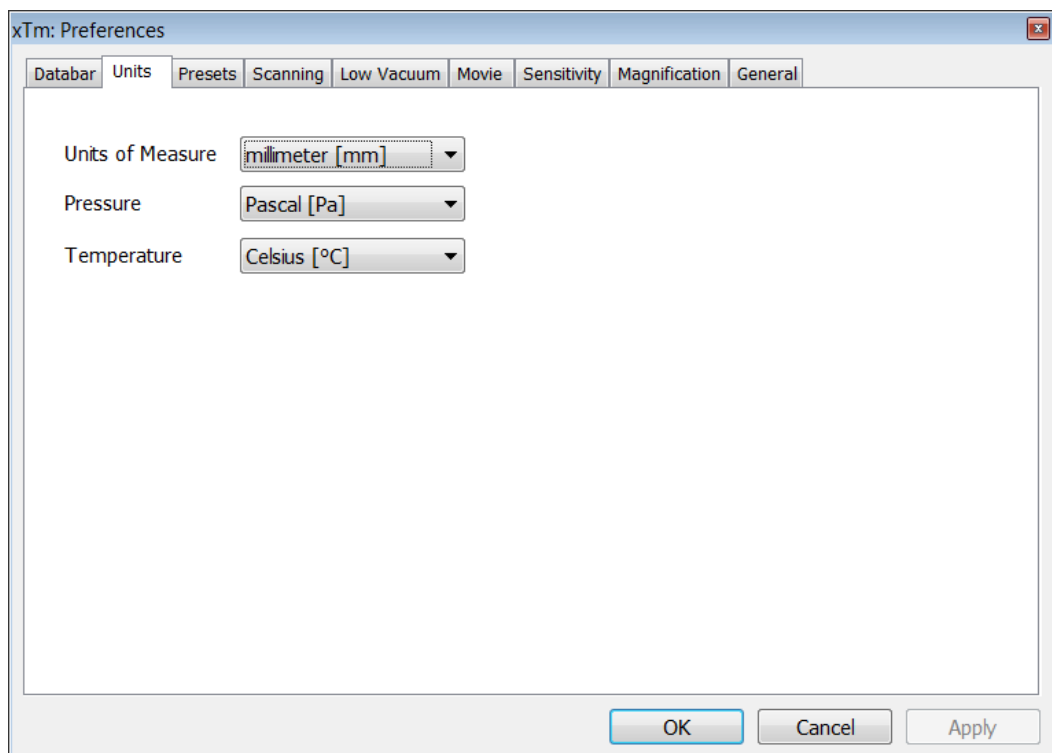
Selection possibilities are:

*   **Units of Measure:**   Millimeter [mm] / Micrometer [µm]
*   **Pressure:**   Pascal [Pa] / Torr [Torr] / millibar [mbar]

Option

*   **Temperature:**   Kelvin [K] / Celsius [°C] / Fahrenheit [°F]

FEI

The DataBar Tab

specifies content of the databar displayed at the base of all quads. The configuration and available items differ for the beam selected (Electron / Optical) for the selected quad. The Label can be set independently for each quad.

FIGURE 3-14 DATABAR PREFERENCES
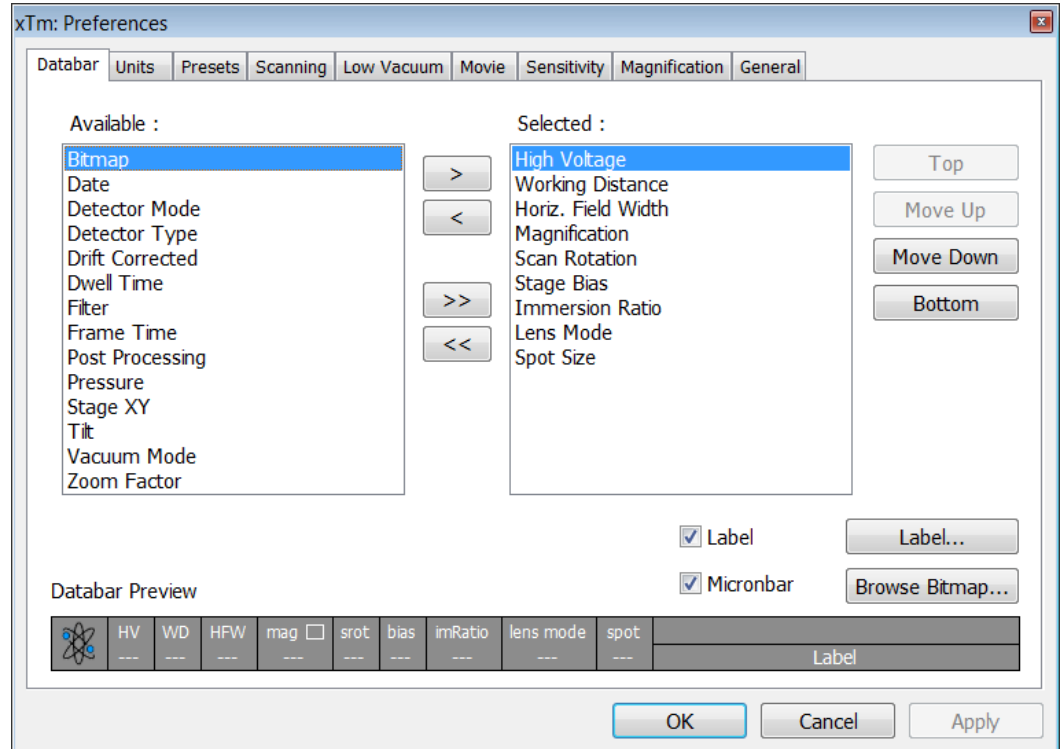
There are two lists in the dialogue, one labeled **Available** and the other **Selected**. Items in the Available list can be added / removed individually (**>** / **<**) or as a whole (**>>** / **<<**) to / from the Selected list. The Selected list contains items that are displayed in the Databar. The items in the Selected list can be **Move**d **Up**, **Move**d **Down**, **Top** or **Bottom** according to priority or preference. This in turn changes the order of the displayed items in the databar.

The **Label** and **Micronbar** can be chosen by ticking an appropriate check box. Their area expands or contracts as other items are added to or removed from the databar. The Micronbar scales to the magnification.

Clicking the **Label…** button brings up a dialogue to edit the label of any quad(s). The same dialogue can be opened by double-clicking the actual label in any quad.

Clicking the **Browse Bitmap…** button opens a dialogue to load a bitmap into the databar.

Note:
The limit for entries is displayed in the dialogue as it is updated. It is possible to select more items than can be displayed. The databar preview should be used to check available space.
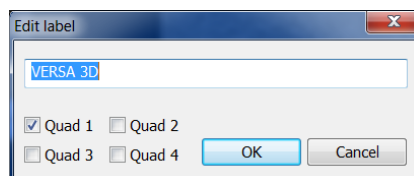
The Presets Tab

allows a user to change the pre-set values in the **High Voltage**, **Magnification** and **Pressure** drop down lists. The configuration and available items differ for the beam selected (Electron / Optical) for the selected quad. A value can be changed by selecting it in the list and entering a new one in the edit box just below the respective title. The new value replaces the selected one and is immediately sorted into the list. The number of entries in the list remains fixed.

FIGURE 3-15 PRESETS PREFERENCES
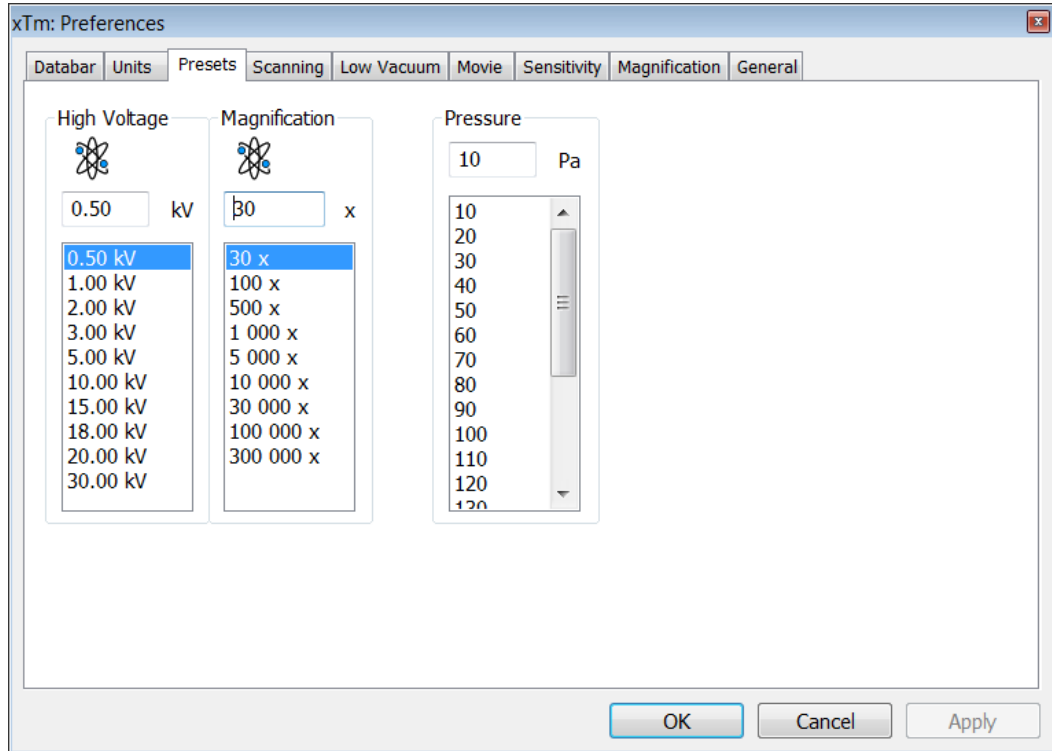
The **High Voltage** list can be changed to span any values from 200 V to 30 kV. The values must be entered in kilovolts (0.2 means 200 V).

The **Magnification** list can be changed to hold frequently used magnifications. Values that are in the pre-set list but cannot be applied to the actual SEM conditions are not shown in the toolbar / Magnification list box. Magnification range is from 20× to 1 000 000×.

Note:
Alternatively the Magnification could be displayed as the Horizontal Field Width (see the **Preferences… / General** tab).

The **Pressure** list can be changed to hold specific values frequently used in the Low Vacuum mode in the range from 10 to 200 Pa (from 0.08 to 1.5 Torr).

The Scanning Tab

allows a user to change the dwell-times (scanning speeds) table and to set-up the Slow scan / Fast scan / Snapshot / Photo function. The configuration and available items differ for the beam selected (Electron / Optical) for the selected quad.

FIGURE 3-16 SCANNING PREFERENCES
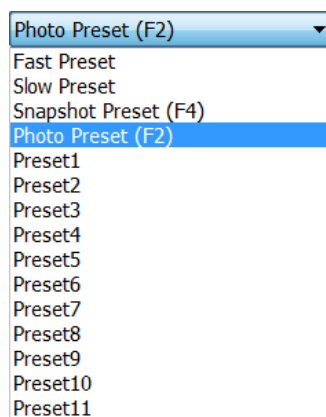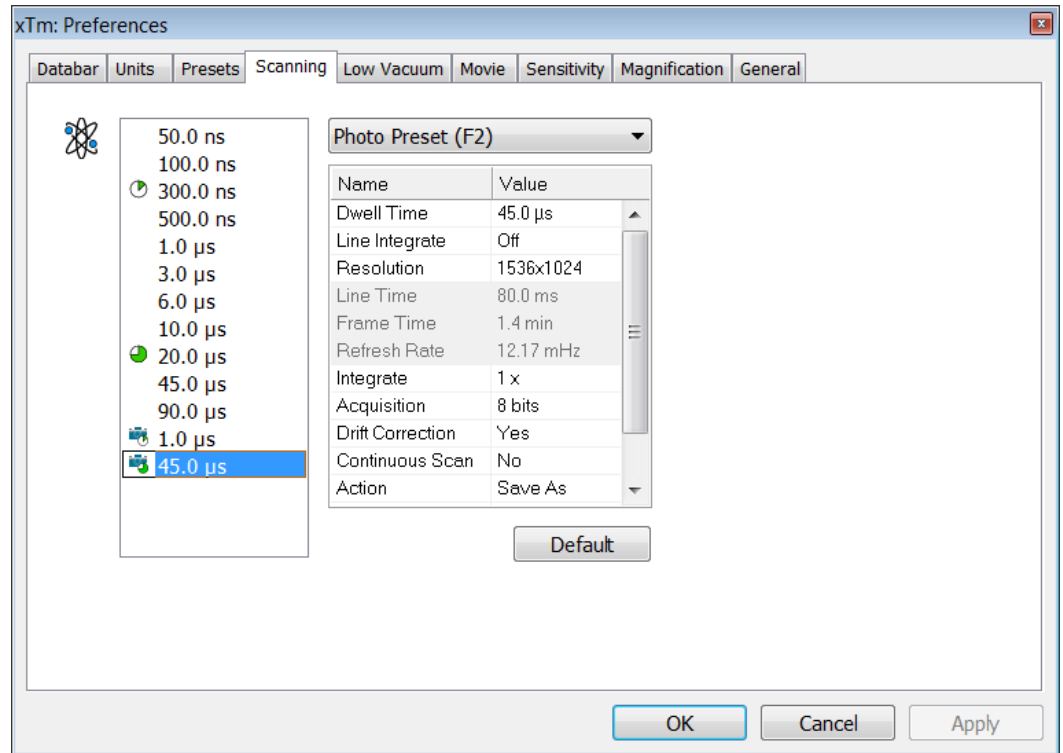
On the left side of the module there is a dwell-time preset list with the fixed number of entries. Selected **Preset** values can be changed in the Property Editor on the right side of the module. Following properties are editable (depending on the kind of the preset):

- **Dwell Time:** one point beam duration time
- **Line Integrate:** no. of line scanning repetition
- **Resolution:** no. of points, Width × Height (image resolution)
- **Integrate** (1, 2, 4, 8, 16, 32, 64, 128, 256): no. of integrated frames
- **Acquisition** (8 bits / 16 bits): sets the captured image bit depth
- **Drift Correction** (Yes / No): corrects imaging drifting when integration filter is active. When activated, the text below the blinking quad pause icon notifies a user.
- **Continuous Scan** (Yes / No): when starting up a Snapshot / Photo function, scan in progress is finished before image grabbing starts.

  This functionality is convenient for charging samples but it requires same scanning conditions for scan in progress and Snapshot / Photo function preset.

- **Action** activated at the end of Photo / Snapshot function**:**

  Save saves the image using an automatic file name and format,
  Save As… opens the Save As dialogue to save the image,
  None just pauses imaging.

- **Post Processing** (None / Image enhancement): enables to start Image Post Processing after an image acquisition.

Following properties are informative and non-editable:

- **Line Time:** line scan duration time,
- **Frame Time:** image-scan duration time,
- **Refresh Rate:** imaging refresh frequency.

Slow (large green sector) / **Fast** (small green sector) preset icon indicates the matching dwell-time value. To change it move an icon up or down just by clicking & dragging it.

Snapshot (F4) / **Photo** (F2) (different cameras) preset icon indicates the matching dwell-time value. Set all possible properties in the Property editor.

The **Default** button restores the default dwell-time list and preset settings.

Sensitivity Tab

The preset sliders control the sensitivity of the Manual User Interface (**MUI** – option).

FIGURE 3-17 SENSITIVITY PREFERENCES
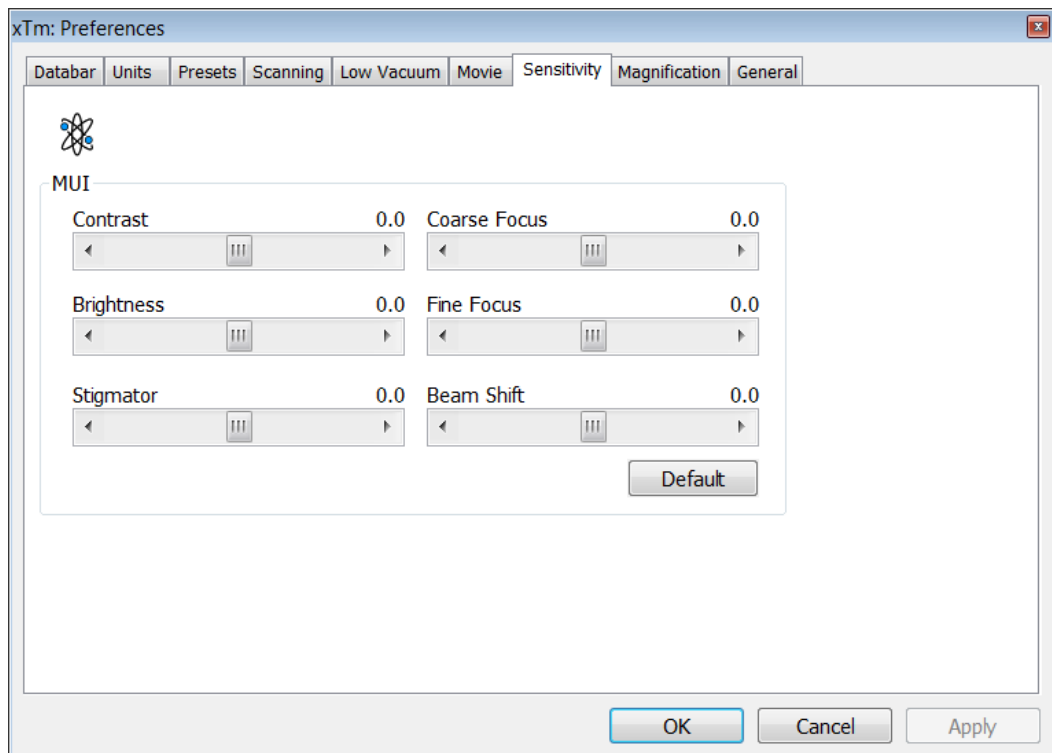
All MUI controls are represented except the Magnification. The **Default** button sets the original settings.

The Low Vacuum Tab

enables to customize the specimen chamber purging, which is automatically initiated when the system pumps the vented chamber directly to the Low Vacuum mode (see Chapters 2 and 5).

FIGURE 3-18 LOW VACUUM PREFERENCES
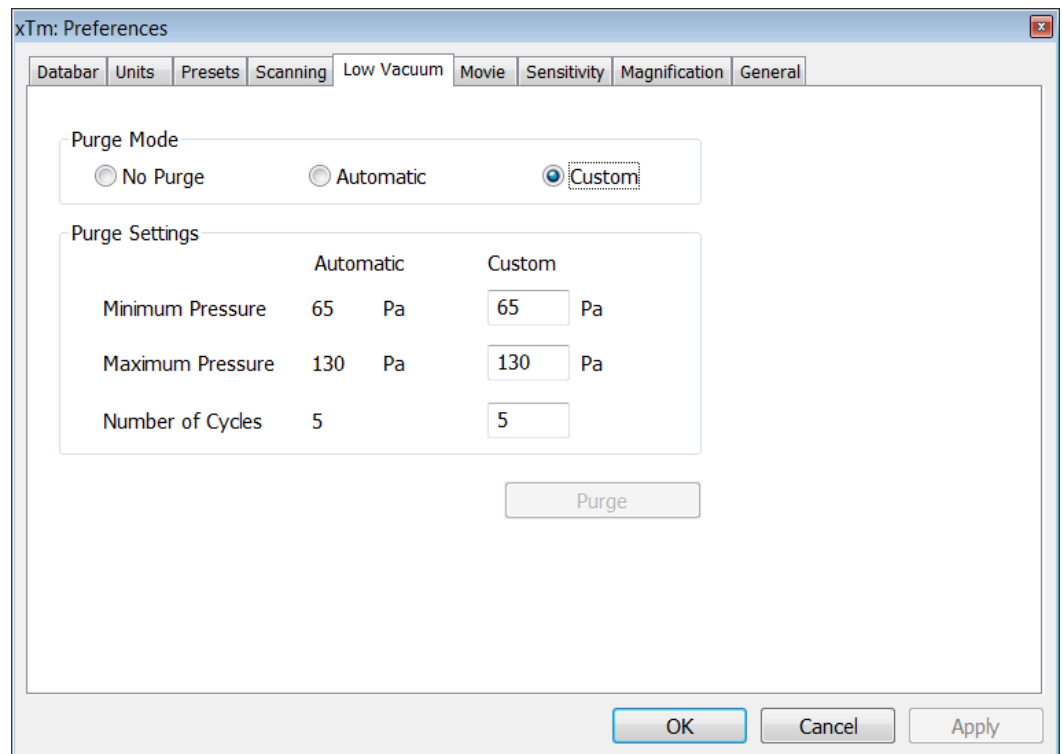
Purge Mode module radio buttons:

*   **No Purge** – The purging is switched off and the chamber pressure goes directly to the set Low Vacuum mode value. The gas mixture in the chamber slowly changes to the new gas type.
*   **Automatic** – All purging parameters are set automatically, according to the mounted Low Vacuum detector (Cone).
*   **Custom** – The Custom parameters (**Minimum Pressure, Maximum Pressure**, **Number of cycles**) defined in the **Purge Settings** module edit boxes are used. The default values are the same as in Automatic mode.

The **Purge** button enables to start the purging (using the actual Purge Mode and Settings) manually when the system is already pumped to the Low Vacuum; otherwise, the button is disabled. When the purging is running, the Purge button becomes highlighted. Clicking on the highlighted button stops the actual purging procedure and returns the system to operation in Low Vacuum.

Notes:
– The new Purge Mode or Settings is applied immediately after clicking the **OK** or **Apply** button, even if the purging cycle is already running.
– During the purging procedure, the chamber pressure is not ready for SEM operation (the vacuum status is Pumping). Therefore, clicking the Purge button automatically switches off the accelerating voltage.
– The Purge Settings is not remembered separately for each user. If it is of any importance, please check these Preferences before starting the Low Vacuum operation.

General Tab

contains variety of user settings of both UI behaviour and microscope operation, which are of less importance and/or does not logically belong to other Preferences section.

FIGURE 3-19 GENERAL PREFERENCES
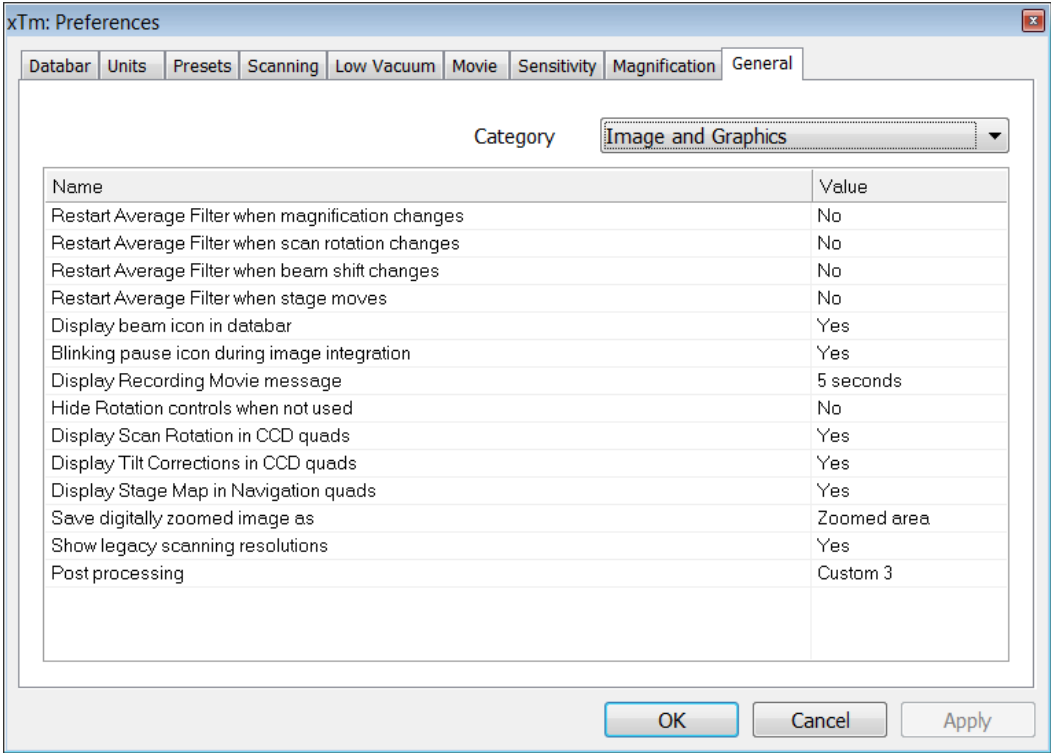
Each item of the General Preferences is represented by single line displayed in the property editor. Clicking on the corresponding **Value** displays a drop down list with the settings available for that item.

Note:
Some changes become visible after the next UI start.
Some of the items are model dependent and some of them are intended for options.

Categories
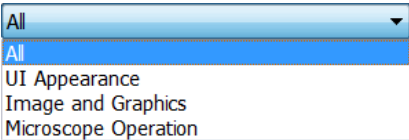
To make navigation among the number of preferences easier, they are divided into three groups. Selecting appropriate group from the **Category** drop down list will display in the below property editor only the items belonging to this group. Selecting Category **All** will display all items at once.
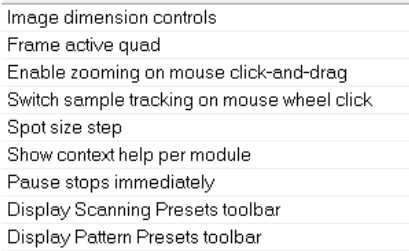
UI Appearance

- **Image dimensions control** (Magnification / HFW)
  Selects a way of the magnification representation and control.
- **Frame active Quad** (Yes / No)
  Switches on / off additional highlighting of the active Quad
- **Enable zooming on mouse click-and-drag** (Yes / No)
  Enables / disables the zoom function linked to the left mouse button
- **Switch sample tracking on mouse wheel click** (Yes / No)
  switches the tracking movement control linked to the mouse wheel between click-and-move and click-and-drag modes
- **Spot Size Step** (0.1 / 0.01 / 0.001)
  enables to set the accuracy of the spot size setting.

- **Show context help per module** (Yes / No)
  Toggles question mark display in the module header on / off.
- **Pause stops immediately** (Yes / No)
  The Pause function acts instantly / waits for the complete scan.
- **Display Scanning Presets toolbar** (Yes / No)
  Enables to display 6 preset scanning parameters at the toolbar.
- **Display Pattern Preset toolbar** (No / Yes)
  Enables to show 6 preset patterns at the toolbar.

Image and graphics

Restart Average Filter when magnification change
Restart Average Filter when scan rotation changes
Restart Average Filter when beam shift changes
Restart Average Filter when stage moves
Display beam icon in databar
Blinking pause icon during image integration
Display Recording Movie message
Hide Rotation controls when not used
Display Scan Rotation in CCD quads
Display Tilt Corrections in CCD quads
Display Stage Map in Navigation quads
Save digitally zoomed image as
Show legacy scanning resolutions
Post processing

- **Restart Average Filter when magnification change** (Yes / No)
- **Restart Average Filter when scan rotation change** (Yes / No)
- **Restart Average Filter when beam shift change** (Yes / No)
- **Restart Average Filter when stage moves** (Yes / No)
  The above four items enable to choose whether the image averaging should be restarted when the indicated parameter changes. Restarting the Average Filter causes the image to blink and get noisier; on the other hand, the averaging slows down the imaging response to the changed parameter.
- **Display beam icon in databar** (Yes / No)
  Adds an beam icon to the first position in the Databar.
- **Blinking pause icon during image integration** (Yes / No)
  If Yes is selected, the blinking Pause symbol is displayed in Quads which are being stopped. Otherwise, the Pause symbol appears only after the image acquisition has actually stopped.
- **Display Recording Movie message**
  (No / 1 second / 2 seconds / 5 seconds / 30 seconds)
  During the Movie Recording, some information may be displayed in the recorded Quads. This selection controls if and how long such information shows up.
- **Hide Rotation controls when not used**
  (No / 10 seconds / 30 seconds / 60 seconds)
  Specifies if and when the on-image Scan / Compucentric Rotation control should be automatically switched off.
- **Display Scan Rotation in CCD quads** (Yes / No)
- **Display Tilt Corrections in CCD quads** (Yes / No)
  The above two items specify if the Scan Rotation / Dynamic Focus and Tilt Correction indicator and value should be permanently displayed in the CCD image(s); only non-zero values are displayed.
- **Display Stage Map in Navigation quads** (Yes / No)
  shows saved positions in any navigation image, which is available (Nav-Cam, Navigation Montage, Image Registration, Navigation Alignment).
- **Save digitally zoomed image as** (Entire image / Zoomed area)
  When saving an image, this option enables to save only the zoomed area or the entire scanned area.
- **Show legacy scanning resolution** (Yes / No)
  enables to display old format screen resolutions in the toolbar dropdown list (see Chapter 3).
- **Post Processing** (**Standard** / None / Custom...)
  Sets the default Post Processing setting.

Interactive Databar
Lower stage when venting the chamber
Change magnification when pumping
Switch off CCD automatically
Pause beam quads when switching off HV
Allow Beam Shift in Get mode
Blank beam during long stage moves
Reverse Joystick movement
Auto switch stage measurement system
Chamber illumination
Venting valve opening time
Default quad for Nav-Cam image
Allow short dwell times at low magnification
Unpause CCD quads when venting the chamber

Microscope Operation

- **Interactive Databar** (On / Off)
  Turns image databar fields to be active (when possible) / inactive.

- **Lower stage when venting the chamber**
  (No / By 5 mm / By 10 mm / Full down)
  Specifies if the stage should automatically move to a lower Z-axis values when user Vents the chamber. This is recommended settings, because it greatly diminishes the chance of hitting the pole-piece when closing the chamber doors after mounting a higher specimen.

- **Change magnification when pumping**
  (No / Set to 100× / Set to 200×)
  Specifies if the magnification should be automatically set to a low value when the chamber is being pumped (presumably after replacing the specimen).

- **Switch off CCD automatically**
  (No / 1 minute / 10 minutes / 30 minutes / 1 hour / 2 hours / 6 hours)
  Specifies if and when the CCD should be automatically switched off. The countdown starts when releasing (un-pausing) the CCD image and continues regardless of the operator activity

- **Pause beam quads when switching off HV** (Yes / No)
  Specifies if the SEM image Quads should be automatically paused when switching off the High Voltage

- **Allow Beam Shift in Get mode** (Yes / No)
  Enables / disables automatic using of BeamShift when a user requires very small point-to-point movements (double-click in the image at high magnifications). When enabled, the Stage menu item Auto Beam Shift Zero allows selecting if the BeamShift should be automatically reset each time the point-to-point stage movement is required.

- **Blank beam during long stage moves** (Yes / No)
  If Yes is selected, the electron beam is automatically blanked during long software controlled stage movements. This may protect extremely sensitive samples from exposure to the beam in undesired areas.

- **Reverse Joystick movement** (Yes / No)
  Normally the joystick movement direction corresponds to the stage movement, so the imaging moves in the different direction. This setting changes the stage response to the joystick movement direction.

- **Auto switch stage measurement system** (Yes / No)
  Automatically switch the stage measurement systems off when not used to avoid light interference with 3rd party equipment (EDS detectors etc.).

- **Chamber illumination** (Yes / No)
  If Yes and the in-chamber Nav-Cam is installed, inner chamber illumination is on when the chamber is vented.

- **Venting valve opening time** (value [s])
  Sets the period for which the venting valve is opened during chamber venting. Default value is 180 s.

- **Default quad for Nav-Cam image**
  (quad 1 / quad 2 / quad 3 / quad 4)
  Sets the quad at which the navigation image will be placed.

- **Allow short dwell times at low magnification** (Yes / No)
  Enables fast scanning conditions (dwell time < 200 ns) at low magnifications, when an imaging could be distorted.

- **Unpause CCD quads when venting the chamber** (Yes / No)
  Specifies if the CCD quads should be automatically released (unpaused) when venting the chamber.

The Movie Tab

provides two groups of controls: **Timer** to set-up the movie frame-rate and **File** to set-up the path name and format of the resulting movie (see Chapter 5).

Magnification Tab

controls the imaging and stored / printed image databar magnification display. The constant imaging pixel size is set at the toolbar. When storing / printing an image (while in a Single or Quad imaging mode) the databar magnification display may not be correct.

FIGURE 3-20 MAGNIFICATION PREFERENCES
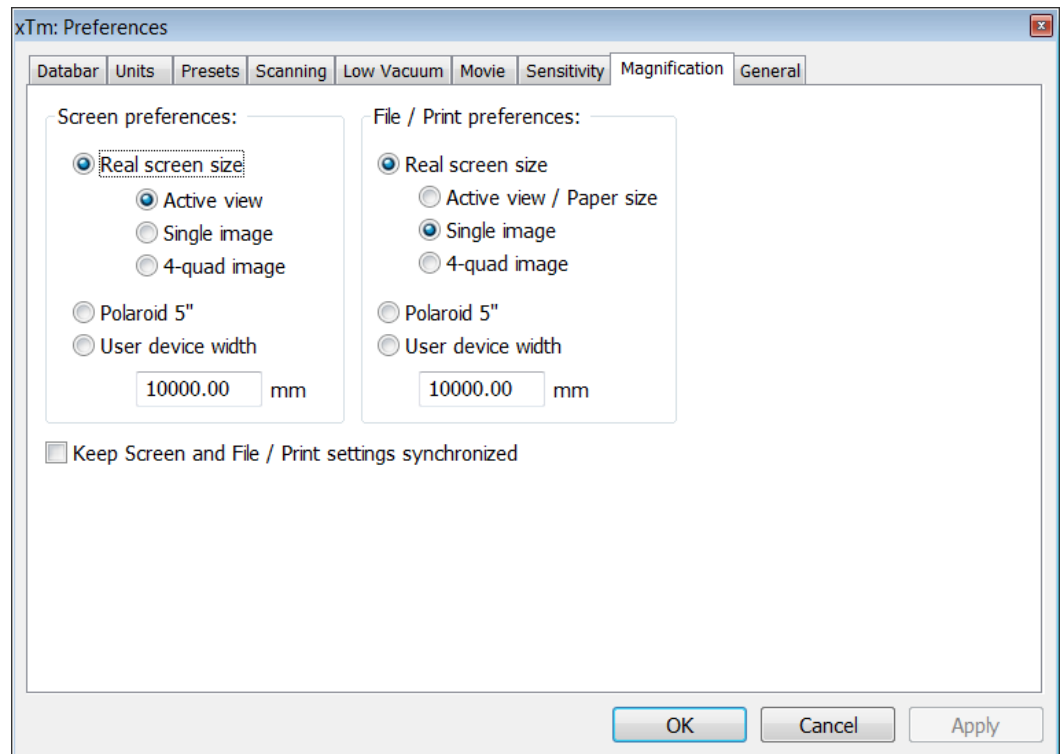
The **Screen preferences** area sets the imaging databar magnification display behaviour while the **File / Print preferences** area sets the storage / printing databar magnification display behaviour. Selecting the radio button activates its functionality:

- The **Real screen size**: the imaging pixel width is handled.

  – The **Active view**: the databar magnification value depends on whether the Single or Quad UI imaging mode is selected. It is displayed in the databar and stored / printed with an image with an icon representing the Single / Quad UI imaging mode.

  – The **Single image**: Single image mode magnification value is displayed in the databar and stored / printed with an image.

  – The **4-quad image**: Quad image mode magnification value is displayed in the databar and stored / printed with an image.

- The **Polaroid 5"** film width is handled. A recalculated magnification value is displayed in the databar and stored / printed with an image.

- The **User device width** (set by a user via the edit box) is handled. A recalculated magnification value is displayed in the databar and stored / printed with an image.

The **Keep Screen and File / Print settings synchronized** check box keeps both settings identical.

FEI User Management Software
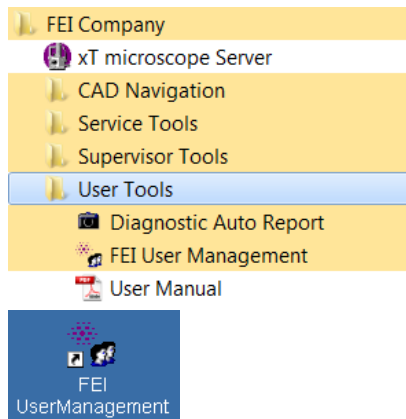
The FEI User management software allows to FEI Account Administrators, FEI Supervisors and FEI Microscope Users to organise user accounts that can possibly be used to run the xT microscope Control software. It allows the creation and removal of user accounts, the setting of user passwords and group membership, as well as the copying and removal of user data.

You can start the software from the system Start menu. This brings up the **Log On** dialogue box, containing **Username** and **Password** text fields, for entering the User Management software.

CONTROL POSSIBILITIES

- **Context menu** – You can reach some context options by right-clicking (see below).
- **Drag and Drop actions** – Instead of using menu options, you can sometimes simply click & drag items from one icon to another (set user group).

FEI ACCOUNT ADMINISTRATORS

As the highest account level, FEI Account Administrators have rights that allow them to create and delete users and change their properties over the following user groups (in order of significance):

- FEI Account Administrator
- FEI Supervisor Users
- FEI Microscope Users
- FEI Non-active Users

Each of these accounts has its own opportunity to operate the **xT microscope Server** and **Control** software. The first FEI Account Administrator is created during the system installation.

FIGURE 3-21 FEI ACCOUNT ADMINISTRATORS CONTROL OVERVIEW
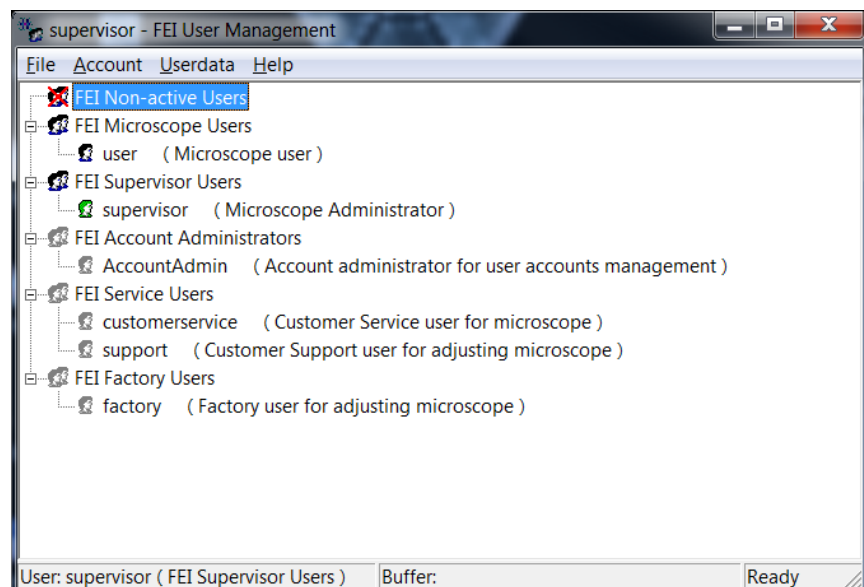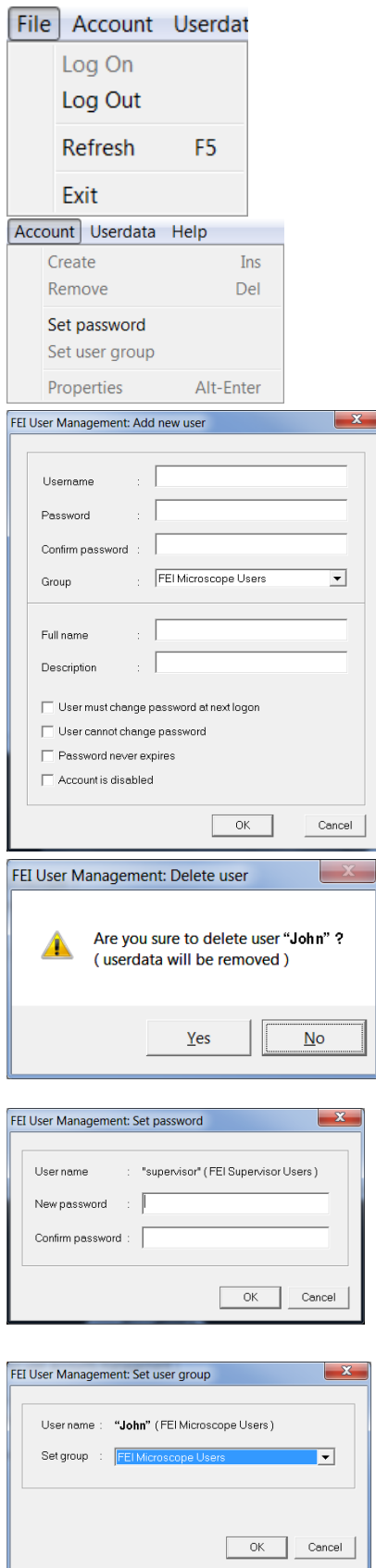
File Menu

contains the following items:

- **Log On:** click to log on (active when user is logged out).
- **Log Out:** click to log off (active when user is logged on).
- **Refresh (F5):** click to refresh the user tree.
- **Exit:** click to exit the FEI User management program.

Account Menu

contains the following items, which are accessible only for **FEI Account Administrators** (with the exception of set password function).

- **Create (Ins):** click to add a new user or supervisor.

- **Remove (Del):** click to remove an existing user. A user must be highlighted first.

If an FEI Microscope User has user data, the account administrator is warned that user data will be removed also. If any additional user is to be removed, that additional user's data is removed without warnings.

- **Set password:** click to make a password for a user who must first be highlighted in the tree.
  An FEI Account Administrator can change the password for any user from a lower level account.

- **Set user group:** click to set the group for a user who must first be highlighted in the tree. When confirmed, a user is moved to selected group. When moving a user from the FEI Microscope Users group to the FEI Non-active Users group, his user data will be removed. A warning is displayed in this case.
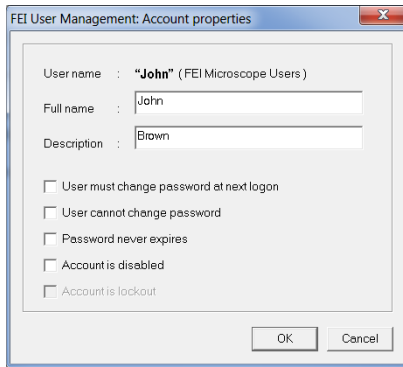
• **Properties (Alt + Enter):** click to see and change the properties for that user who must first be highlighted in the tree.

Userdata menu

contains the following items.
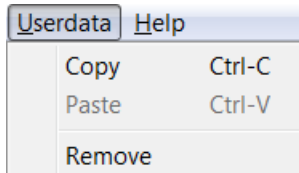
• **Copy (Ctrl + C):** click to copy user data from a user of the same or a lower level group.

• **Paste (Ctrl + V):** click to paste user data into your own account or into the accounts of a lower group level. It is not possible to copy user data inside the FEI Supervisors User group.

• **Remove:** click to delete user data from a selected account of equal or lower group level.

Help Menu

contains the following items:
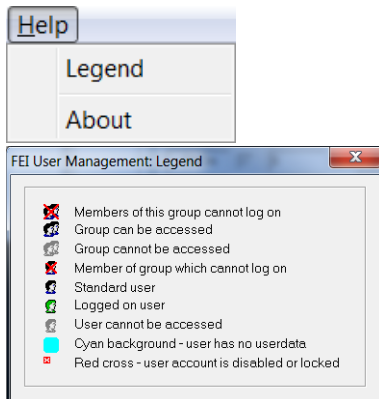
• **Legend:** clicking provides an explanation of icons used in the tree.
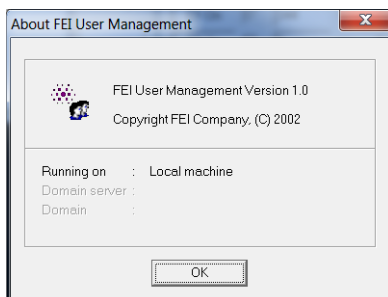
• **About:** displays the FEI User Management software version and copyright.

ACCOUNT LOGGING

This accounting utility monitors user, log on / off actions, session time, filament lifetime and the UI status. It works with two log files located in c:\Program Files\FEI\data\accounting\:

• **accounting.tmp** is a temporary running file during use of the equipment at each user session, updated every 15 seconds so that any power down or operating system crash situation can be time logged.

• **accounting.log** is permanent file to which the previous data are sent when a new session is started. This file is only readable by the FEI Supervisor User or higher level.

These files can only be deleted at factory or service level. Each one is a text – CSV file so it can be loaded into Microsoft Excel for processing. It can also be viewed by the particular FEI utility: c:\Program Files\FEI\Exe\feiaccountinglogviewer.exe

Entering Commands in Summary

USING MOUSE
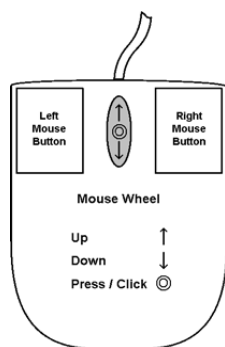
Keyboard + Mouse button	Function
(Shift +) Click *single-arrow cursor*	selects a control element: toolbar pause icon: pauses / activates (all) quad(s)
(Ctrl +) Click *single-arrow cursor*	selects a graphical item within an imaging area (adds another one to the selection)
Click & drag (+ Shift) *single-arrow cursor*	selects an area to zoom in (out)
Shift + Click & drag *hand-cursor*	activates the Beam Shift
Doubleclick	**Electron Imaging:** Get mode: moves a point to the quad center **Optical Imaging:** places 5 mm marker
Right-click & drag *double-arrow cursor*	focuses by dragging the mouse left-right
Shift + Right-click & drag *four-arrow cursor*	corrects an imaging astigmatism by dragging the mouse left-right – X stigmator or up-down – Y stigmator
Ctrl + Click & drag	controls the detector contrast / brightness by dragging the mouse left-right / up-down
Ctrl + Right-click & drag *four-arrow cursor with circles*	activates the Lens Alignment
Shift + Wheel-scroll Up / Down	increases / decreases the magnification finely
Ctrl + Wheel-scroll Up / Down	increases / decreases the magnification coarsely
(Ctrl+) Wheel-click & drag	**Electron Imaging:** Track mode: moves the stage (joystick-like control) **Optical imaging:** moves the stage in Z-axis direction (tilts the stage) by dragging the mouse up / down (left / right)

Note:
The given sequence of the key press and mouse button click is important for some functions.

USING KEYBOARD

TABLE 3-3   WINDOWS SYSTEM KEYS

Key (+ Key)	Function
Enter	equivalent to the OK button in dialogues
Esc	1. equivalent to the Cancel button 2. stops the stage motion at that point **Note:** During particular procedures, Home Stage for instance, use the software Cancel or Stop button!
Tab	switches between entry fields within dialogue boxes
(Shift +) Arrows	1. selects an item within list boxes 2. moves the stage approximately by (40%) 80% of the field of view in corresponding direction
Alt (F10)	underlines menu bar item characters – by hitting it a corresponding menu list is expanded
Alt + Tab	Switches between running applications: each time the Tab key is hit while holding the ALT key pressed a pointer jumps to another application icon. Releasing the Alt key at any time makes application just listed active.
Alt + F4	closes active application or Windows operating system
Del(ete)	deletes a selection, texts or graphics
Ctrl + A	selects all items, texts or graphics within an active window
Ctrl + C (Ctrl + Insert)	copies a selection to the clipboard – temporary memory
Ctrl + V (Shift + Insert)	pastes content of the clipboard at the pointer position – text / to a window – graphics
Ctrl + X (Shift + Delete)	cuts a selection to the clipboard – copies and deletes it

FEI

TABLE 3-4   FUNCTION AND SPECIFIC KEY SHORT-CUTS

Key (+ Key)	Function
F1	Displays On-Line Documentation
Shift + F1	Opens Image Properties window
(Shift +) F2	Starts Photo with the active beam (in all quads with the same beam at once)
Ctrl + (Shift +) F2	Starts / Stops Active Preset Snapshot (in all quads at once)
F3	Toggles Videoscope On / Off
Shift + F3	Starts Home Stage procedure
F4	Starts / Stops Snapshot
Shift + F4	Starts Lens Alignment procedure
F5	Toggles Single / Quad Image mode
Ctrl + F5	Toggles Large Image Window mode
Shift + F5	Toggles Center Cross display
F6	Pauses / Activates scanning
Shift + F6	Toggles Alignment rectangle display
F7	Toggles Reduced area / Full Frame Mode
F8	Degauss
Ctrl + F8	Calls up Direct Adjustment window with Beam / Stigmator Centering
F9	Starts Auto Contrast and Brightness procedure
Shift + F9	Link Z to FWD
F11	Starts Auto Focus procedure
Ctrl + F11	Starts automatic Astigmatism correction function
Shift + F11	Toggles Display Saturation function
(Shift +) F12	Toggles Compucentric (Scan) Rotation tool
Ctrl + 0 - number	Moves stage to X=0, Y=0
Ctrl + B	Toggles Beam Blank function
Ctrl + E	Tilt stage to 0°
Ctrl + F	Sets FWD to 5 mm
Ctrl + H	Sets Horizontal Field Width (HFW)
Ctrl + K	Sets Spot beam mode
Ctrl + M	Sets Full Frame scanning conditions
Ctrl + Shift + M	Starts movie recording dialogue

TABLE 3-4 FUNCTION AND SPECIFIC KEY SHORT-CUTS

Key (+ Key)	Function
Ctrl + N	Toggles Sample Navigation
(Ctrl +) Shift + N	(Previous) Next pattern line
Ctrl + O - letter	Opens Preferences dialogue
Ctrl + P	Opens Print dialogue
Shift + P	Next pattern
Ctrl + R	Restarts scan
Ctrl + (Shift +) S	Saves images (from all quads)
Ctrl + Z	Moves stage to the Last position
Pause key	Starts / Stops patterning
Ctrl + Pause key	Resets patterning
Ctrl + (Shift +) ,	Sets one step slower (slowest) scanning
Ctrl + (Shift +) .	Sets one step faster (fastest) scanning
Ctrl + (Shift+) Tab	(Backward) Steps between quads
Ctrl + Page Up / Down	Left / Right Steps between pages
Ctrl + 1 / 2 / 3 … - letter keypad	Selection of the particular page (the number corresponds to the toolbar page icon sequence)
+ / -	Increases / Decreases magnification 2x
*	Rounds off magnification to the nearest round value
Ctrl + +/-	Scales up / down the imaging 2× (Digital Zoom)
Ctrl + arrow	Moves the digital zoom area

4 | ALIGNMENTS

At the **Alignments** page select an alignment procedure available from the list box. Always follow the instructions given in the **Instructions** module. The **Step** displays the present control step number and the total number of steps. You can find some additional explanation in this chapter.

COMMON RULES

Alignments should be performed in the quad 1. In other case it is not possible to ensure the correct functionality of the Contrast, Brightness and Auto functions used at the Alignments pages.

Before one aligns the Electron column, be sure that the final lens aperture is clean and properly centred.

During adjustment procedures it is allowed to change the magnification, the scanning speed, to use reduced area and to optimize image contrast / brightness. It is also possible to correct astigmatism and to focus an image (for a particular alignment this is forbidden).

During adjustment procedures it is not allowed to change a Vacuum Mode, a Spot size and a High Voltage. Do not use the Beam Shift at any time during the adjustment procedures, as this is set to the zero value at each alignment section. All specimen movements can be made using the stage where appropriate.

BUTTONS AND CONTROL ELEMENTS

The following particular buttons and control elements (see Chapter 3) have the same behaviours for all alignment procedures, when available:

- The **Start** button starts the procedure and proceeds with following dialogues.
- The **Contrast** / **Brightness** adjusters enable to optimize the image quality during alignment.
- The **Auto** button executes the appropriate alignment action automatically for a particular voltage / spot / direction (whatever suitable) with the use of the **Image Recognition** software. If this utility does not recognize image features well, the procedure is aborted and Warning message appears onscreen. In this case change the imaging conditions (better focus, slower scanning, or lower magnification) and try again.
- The **Crossover** button activates the Crossover mode, where the onscreen image shows the electron source tip instead of the sample.

ALIGNMENT LIST

The list of alignments accessible for a Supervisor is represented,
the User alignments list is reduced and is represented by (U) sign.

- **Manual Final Lens Strip Aperture Alignment**
  It is necessary to have the final lens aperture aligned well prior any alignment procedure.
- **5 - Emitter Startup**
  Enables electron gun - Emitter switching On / Off.
- **10 - Source Tilt and Shift**
- **13 - Stigmator Alignment (U)**
- **17 - Stage Rotation Centre (U)**
  Sets the stage rotation center for the correct functionality of the compucentric rotation feature.
- **42 - UHR Stigmator Alignment**
- **43 - UHR Image Shift Correction**
- **44 - UHR Lens Alignment**
- **45 - HR Image Shift Correction**
- **46 - Final Lens Alignment (U)**
- **81 - Crossover Position Calibration**
- **94 - CCD Camera Alignment**
- **104 - Plasma Cleaning**
- **154 - Water Bottle Venting**
  Enables to vent the water bottle in case of refilling.
- **254 - GIS Alignment**
- **Vacuum Actions**
- **E-column: Magnification Correction (U)**
  User magnification calibration (see Beam menu item).

Recommendation

The system alignment should be made whenever necessary.

Some procedures may influence the others, therefore care should be taken to monitor an influence of actions taken.
Alignment procedures should be carried out:

- Whenever needed: **13 / 17**
- Regularly once in two weeks: **10**
- After emergency shutdown: **5**
- Preventive check once per month (in the given order):
  10 / 44 / 42 / 43 / 45

Procedures 10, 42, 43 and 44 are rather extended. Therefore it is allowed to adjust the column just for the conditions which are going to be used. Other steps are possible to skip.

Final Lens Strip Aperture Alignment

This mechanical alignment eliminates an image shift when focusing and it is necessary to accomplish it after each new aperture choice. The position of the final aperture should remain constant and should not be changed further during the alignment procedure. When the aperture is well aligned, the image does not rotate (at low magnification) or move (at high magnification) during focusing.

To select a new aperture:

- Left-hand turn the large ring to move the aperture holder outwards towards the larger aperture.
- Tune its position by the inner knob and the one on the right side, (horizontal plane fine movements).

ALIGNING PROCEDURE

1. Set the accelerating voltage = 30 kV / Spot = 2.5 / WD = 5 mm / magnification = 1000×.
2. Click the **Stage** menu / **Beam Shift Reset** and / **Zero Beam Shift** (see Chapter 3).
3. Find a recognizable feature on the sample surface, center it onscreen and optimize an image as best as possible.
4. Click the toolbar **Lens Alignment** toolbar icon, the scanning sets to the fastest value, the objective lens modulation starts (the imaging rotates about a point, possibly different from the image center), the alignment cross appears in all imaging quads center and the mouse cursor changes.
5. Adjust the aperture position so that the image rotation center is under the alignment cross.
6. Increase the magnification to 20 000× (if necessary to 40 000×) and realign the aperture position (at higher magnification the imaging moves very slightly in a certain direction).
7. When corrected, click the Lens Alignment toolbar icon to switch it off. There should be no image shift when focusing.

Note:
If the mechanical alignment is done, one can run lens alignment via the **Direct adjustments (Ctrl + F8)** window / **Lens Alignment** 2d box (see Chapter 5) or by using the mouse control (Ctrl + right-click & drag). This could be used any time.

5 - Emitter Startup
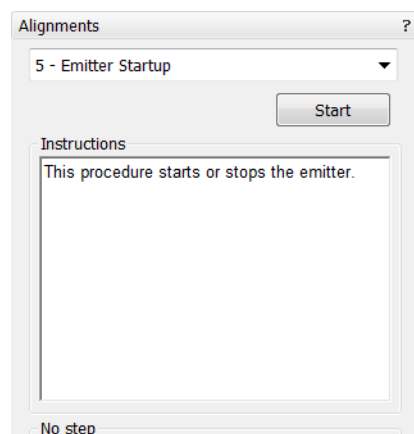
This procedure enables electron source switching On / Off.

In cases of emergency shut down or the microscope mains switch off the Ion Getter Pumps (IGP) keep pumping the FEG source area backed up by the Battery Supply Unit (BSU) (option). However, the main IGP power supply is switched off at this time so it is necessary to turn it on when the mains power is recovered.

The BSU battery provides about nine hours of uninterrupted power when fully charged and having full capacity. If the microscope was without the power longer, it is usually not possible to start the IGP´s by this alignment procedure. It is necessary to call the service to run the bake out procedure first.
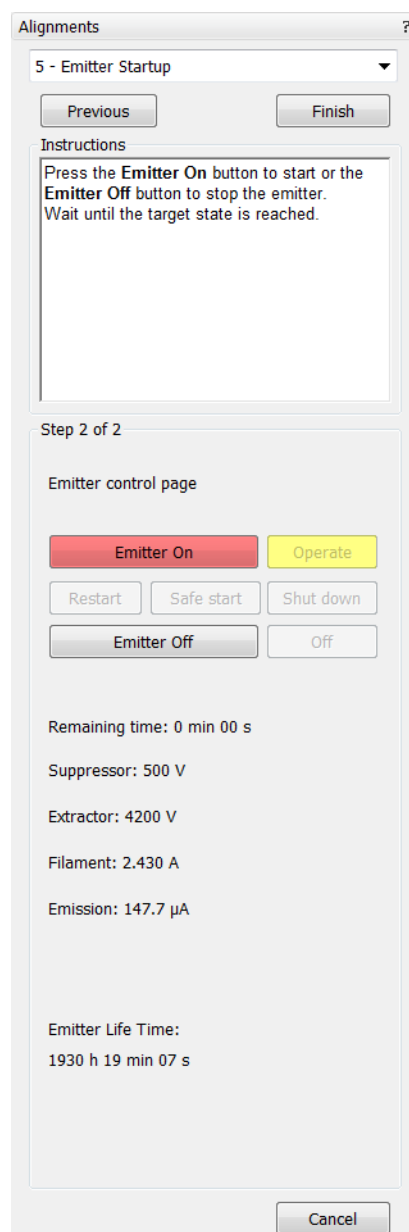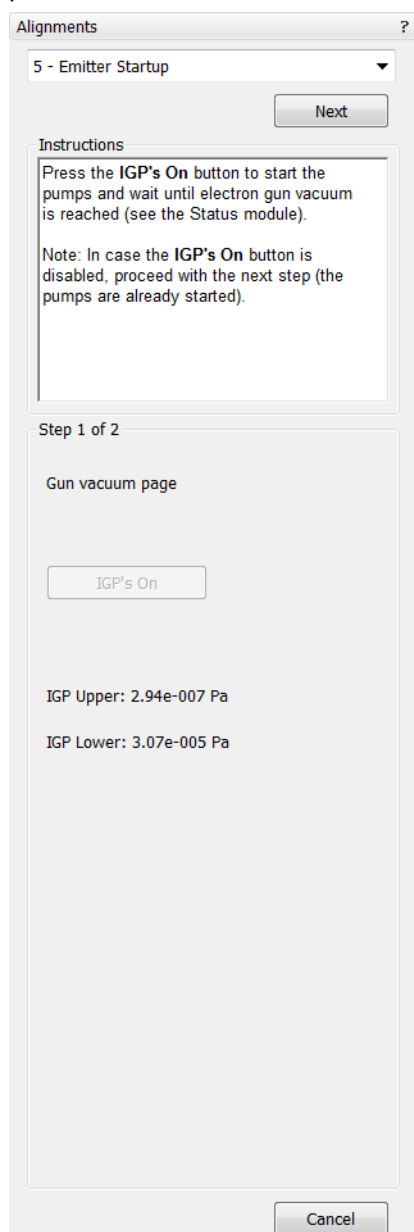
1. The **Gun vacuum page:** if it is **IGP's On** click the Next button.

   If it is **Off** click the **IGP On** button to automatically start the ion pump. This procedure takes a few minutes. If the ion pump start is not successful, call service.

FEI Limited Rights Data

2. The **Emitter control page:** Click the **Emitter On / Off** button to start / stop the emission of electrons.

   Note:
   If the Emitter On button is disabled and the IGP´s are running, restart the xT Microscope Server and try again.

Other informational fields:

• The **Operate** indicates that the emitter is in the operate state
• The **Restart** indicates that the emitter runs-up after a short emission interrupt
• The **Safe Start** indicates that the emitter runs-up with a slow run-up procedure
• The **Shut Down** indicates that the emitter is being switched off
• The **Off** indicates that the emitter is off
• The **Remaining Time** indicates the time needed to complete the required action (Emitter On / Off)
• The **Extractor** shows the actual extractor voltage
• The **Filament** shows the actual filament heating current
• The **Emission** shows the total emission current of the emitter
• The **Emitter Life Time** shows the actual emitter operating life time

10 - Source Tilt and Shift

This procedure adjusts electron source in the whole range of voltages and spots. It is possible to complete it only for the voltages which are going to be used but for complete adjustment it is necessary to complete it for all values. Before starting this alignment it is necessary to complete Final Lens Strip Aperture Alignment.

1. Choose HR (field-free) mode and set **FWD = 5 mm**.
2. **Select a High Voltage** required.
3. Choose Spots progressively (3.9, 2.5, 1, 4, 5, 6, 7) and for each one adjust **Source Tilt** for maximum brightness and **Source Shift** so there is no image shift during focusing.

Note:
The **Intermediate** and **DC Off** buttons are useful only for service actions. Do not use them during the alignment.

Source Tilt Adjustment

Click on **Cross Over** button and with the use of 2D box set the centre of the image under the **Center Cross**. Besides, for Spots 5 and higher it is recommended to switch off the Cross Over mode and fine-tune for the maximum brightness.

Source Shift Adjustment

Click on **Modulator** button and with the use of 2D box set the centre of the image rotation under the **Center Cross**.

To achieve result of both above described adjustments it is possible to just click the **Auto** button. This function utilizes **Image Recognition** software. If this utility does not recognize image features well, the procedure is aborted and Warning message appears onscreen. In this case change the imaging conditions (better focus, slower scanning, or lower magnification).

Note:
For large spots and low voltages Source Tilt and Source Shift adjustments influence each other. Therefore adjustments should be repeated several times to achieve optimal result.

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Source Tilt and Shift Alignment (continued)

Panel 1:

Alignments   ?

10 - Source Tilt and Shift [v]

[Start]

Instructions

This alignment centers the electron beam for several Spotsizes and High Voltages. Press the Start button.

Note:
Use Quad 1 for the procedure.

No step

Panel 2:

Alignments   ?

10 - Source Tilt and Shift [v]

[Next]

Instructions

Optimize the image with Focus, Contrast and Brightness.
Press the Next button to go forward or the Cancel button to quit.

Step 1 of 5

Select a High Voltage:

[30000]
[20000]
[10000]
[5000]
[2000]
[1000]
[500]
[300]

Contrast   63.71
[<]   [___]   [>]

Brightness   40.35
[<]   [___]   [>]

[Cancel]

Panel 3:

Alignments   ?

10 - Source Tilt and Shift [v]

[Previous]   [Next]

Instructions

Adjust C&B if necessary. Click on Modulator. Tune Source Shift so the rotation center matches the image center. Click off Modulator. Press the Next button to go forward, Previous to go back, or Cancel to quit.

Step 2 of 5

Spot = 3.9   (7 Spots remaining)

Source Tilt   Source Shift
[Auto]   [Auto]

[Cross Over]   [Modulator]

Mod. Amplitude   0.5000
[<]   [___]   [>]

[Intermediate]   [DC Off]

Contrast   54.11
[<]   [___]   [>]

Brightness   40.35
[<]   [___]   [>]

[Cancel]

Source Tilt and Shift Alignment (continued)

Alignments	?
10 - Source Tilt and Shift	⌄

[Previous] [Next]

Instructions

Tune Source Tilt for maximum light intensity.
Adjust C&B if necessary.
Click on Modulator. Tune Gun Shift so the rotation center matches the image center.
Click off Modulator.
Press the Next button to go forward, Previous to go back, or Cancel to quit.

Step 3 of 5

Spot = 5.0   (3 Spots remaining)

Source Tilt   Source Shift
[Auto]   [Auto]

[Cross Over]   [Modulator]

Mod. Amplitude   0.5000
[<] [░░░]   [>]

[Intermediate]   [DC Off]

Contrast   42.37
[<] [░░░]   [>]

Brightness   40.36
[<] [░░░]   [>]

[Cancel]

Alignments	?
10 - Source Tilt and Shift	⌄

[Previous] [Next]

Instructions

Press the Next HV button to continue centering with another HV.
Press the Save button to store the previous centering.
Press the Next button to to go to the last step or Cancel to quit.

Step 4 of 5

☑ Next HV

[Save]

[Cancel]

Alignments	?
10 - Source Tilt and Shift	⌄

[Previous] [Finish]

Instructions

Press the Finish button to save and finish.

Step 5 of 5

[Cancel]

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13 - Stigmator Alignment

This procedure eliminates the image shift when stigmating. It is useful in both SEM modes.

1. Adjust **Focus** and the **Contrast** and **Brightness** adjusters if necessary. Switch on the fast scan.
2. Click on the **Stig X / Y Wobbler** and by using the 2D box labeled **Stigmator X / Y Alignment**, eliminate the image shift. **Amplitude** slider sets the wobbler modulating depth.

To achieve result of both (X / Y) above described adjustments it is possible to just click the **Auto** button. This function utilizes **Image Recognition** software. If this utility does not recognize image features well, the procedure is aborted and Warning message appears onscreen. In this case change the imaging conditions (better focus, slower scanning, or lower magnification).

Alignments   ?

13 - Stigmator Alignment ▾   Start

Instructions

This adjustment simply allows you to minimize Stigmator image shift at a specific condition of HV and WD. Click on the Start button.

Note:
Use Quad 1 for the procedure.

No step

Alignments   ?

13 - Stigmator Alignment ▾   Next

Instructions

Stigmator X alignment.
Adjust focus, Contrast and Brightness if needed.
Adjust the x-stigmator correction for minimum image movement.
Click on the Next button to move to the next Step.

Step 1 of 2

Stigmator X alignment

Auto

Stig X Wobbler

Amplitude   0.0115

Contrast   61.25

Brightness   38.20

Cancel

Alignments   ?

13 - Stigmator Alignment ▾

Previous   Finish

Instructions

Stigmator Y alignment.
Adjust focus, Contrast and Brightness if needed.
Adjust the y-stigmator correction for minimum image movement.
Click on Finish to save the procedure and exit or Cancel to leave the Alignment procedure and return to original settings.

Step 2 of 2

Stigmator Y alignment

Auto

Stig Y Wobbler

Amplitude   0.0115

Contrast   61.25

Brightness   38.20

Cancel

17 - Stage Rotation Centre
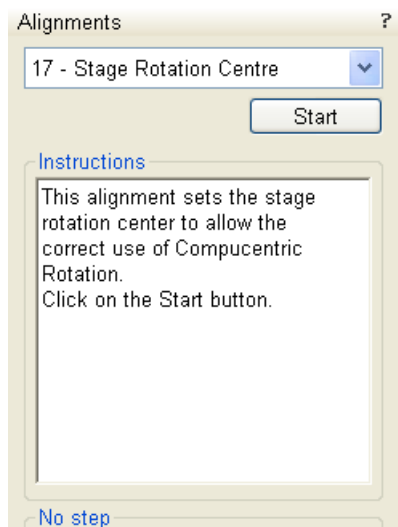
The rotation of the stage has a mechanical center and movement by rotation can be made by changing the value in the text box for R on the Work page. This will move the stage about its mechanical center. In some circumstances this is not desired because rotation about the center of the field of view would be more useful. The following correction is the alignment procedure for the Compucentric Rotation function found in the Stage menu. The offset of X and Y are calculated in this procedure so that the Compucentric Rotation will be correct when computed at any later time.

1. The magnification should be from 500× to 2000×, and the sample should have a recognizable feature close to the center of the stub mounted in the center of the stage (do not use IG stub holder or any other axis holder) at this magnification. Bring it under the screen **Centre Cross** by using the mechanical stage movement. A readout of the X and Y coordinates is displayed on the pages. Make sure the tilt is set to zero.

2. The stage automatically rotates the view 180º. Wait until the stage movement is finished. Bring the recognisable feature back under the screen centre cross by using mechanical stage movement. A new readout of the X and Y coordinates is displayed on the pages.

3. Wait until the stage movement is finished.

Stage Rotation Centre (continued)

Alignments ?
17 - Stage Rotation Centre ▾
Next
Instructions
Optimize the image with Focus, Magnification, Contrast and Brightness. Select the GET function and double-click on a feature to move it under the center cross. Click on the Next button to move to the next Step.
Step 1 of 3
Position X = -0.011744 m Position Y = 0.005670 m
Cancel

Alignments ?
17 - Stage Rotation Centre ▾
Previous   Next
Instructions
Wait for the stage movement to finish. The stage has rotated 180o. Select the GET function and double-click on the feature to move it back under the center cross. Click on the Next button to move to the next Step.
Step 2 of 3
Position X = 0.009900 m Position Y = -0.006029 m
Cancel

Alignments ?
17 - Stage Rotation Centre ▾
Previous   Finish
Instructions
Wait for the stage movement to finish. Click on Finish to save the procedure and exit or Cancel to leave the Alignment procedure and return to original settings.
Step 3 of 3
Cancel

42 - UHR Stigmator Alignment
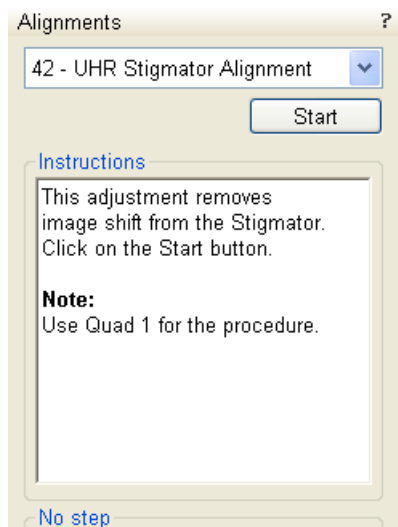
This procedure eliminates the image shift when stigmating in the whole range of voltages and working distances in UHR (immersion) mode. It is possible to complete it only for the voltages and working distances which are going to be used but for complete adjustment it is necessary to complete it for all values. Before starting this alignment it is necessary to complete alignments 10 - Source Tilt and Shift and 44 - UHR Lens Alignment.

1. **Select a Working Distance**. If you want to keep values from the 1. step of alignment as the starting ones for all the next steps, click **Re-align all** button.

2. Optimize an image: focus with the Z-axis stage movement or with the tracking mode in the CCD image quad, use **Contrast** and **Brightness** sliders if necessary.

3. Click on the **Stig X / Y Wobbler** and by using the 2D box labeled **Stigmator Alignment control** , eliminate the image shift progressively for all offered voltages.

4. If you are going to adjust the next WD after finishing all of the steps for the selected WD, check the **Next WD** check button before clicking the **Next** button.

To achieve result of above described adjustments it is possible to just click the **Auto** button. This function utilizes **Image Recognition** software. If this utility does not recognize image features well, the procedure is aborted and Warning message appears onscreen. In this case change the imaging conditions (better focus, slower scanning, or lower magnification).

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UHR Stigmator Alignment (continued)

Alignments   ?

42 - UHR Stigmator Alignment [▼]

[Next]

Instructions

Select the Working Distance
necessary from the list below
Optimize the image with
Focus, Contrast and
Brightness.
Click on the Next button to
move to the next Step or
Cancel (at any time) to leave
the Alignment procedure and
return to original settings.
Press Re-align All to initialize
the tables with the values

Step 1 of 6

Select a Working Distance.

[1.0 mm]

[1.5 mm]

[2.0 mm]

[3.0 mm]

[4.0 mm]

[5.0 mm]

[6.0 mm]

[Re-align All]

Contrast   74.03
[<] [====] [>]

Brightness   38.20
[<] [====] [>]

[Cancel]

Alignments   ?

42 - UHR Stigmator Alignment [▼]

[Previous]   [Next]

Instructions

Focus with the manual stage Z
movement control.
Optimize the image with
Contrast and Brightness.
Click on the Next button to
move to the next Step.

Step 2 of 6

Setting HV = 10.0 kV

Actual HV = 10.0 kV

(Maximum possible = 18.2 kV)

WD = 5.00 mm

Contrast   71.92
[<] [====] [>]

Brightness   38.20
[<] [====] [>]

[Cancel]

Alignments   ?

42 - UHR Stigmator Alignment [▼]

[Previous]   [Next]

Instructions

Stigmator X alignment.
Minimize the image movement.
Click on the Next button to
move to the next Step.

Step 3 of 6

HV = 10.0 kV   (5 HVs remaining)

Stigmator Alignment control

[Auto]

-1.027

0.405

[Stig X Wobbler]

Amplitude   0.0025
[<] [====] [>]

Contrast   71.92
[<] [====] [>]

Brightness   38.20
[<] [====] [>]

[Cancel]

UHR Stigmator Alignment (continued)

Alignments ?	Alignments ?	Alignments ?
42 - UHR Stigmator Alignment ▼	42 - UHR Stigmator Alignment ▼	42 - UHR Stigmator Alignment ▼
[Previous] [Next]	[Previous] [Next]	[Previous] [Finish]

Left panel (Step 4 of 6):
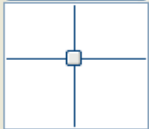
Instructions:
Stigmator Y alignment.
Minimize the image movement.
Click on the Next button to move to the next Step.

Step 4 of 6

HV = 10.0 kV   (5 HVs remaining)

Stigmator Alignment control

[Auto]

-0.086
0.361

[Stig Y Wobbler]

Amplitude   0.0025
[◄] [▬] [►]

Contrast   71.92
[◄] [▬] [►]

Brightness   38.20
[◄] [▬] [►]

[Cancel]

Middle panel (Step 5 of 6):

Instructions:
Press the Next WD button to continue centering with another WD.
Press the Save button to store the previous centering.
Press the Next button to to go to the last step or Cancel to quit.

Step 5 of 6

☑ Next WD

[Save]

[Cancel]

Right panel (Step 6 of 6):

Instructions:
Press the Finish button to save and finish.

Step 6 of 6

[Cancel]

43 - UHR Image Shift Correction

This procedure eliminates the image shift when changing HV in the whole range of voltages and working distances in UHR (immersion) mode. It is possible to complete it only for the voltages and working distances which are going to be used but for complete adjustment it is necessary to complete it for all values. Before starting this alignment it is necessary to complete alignments 10 - Source Tilt and Shift, 44 - UHR Lens Alignment and 42 - UHR Stigmator Alignment.

Alignments ?

43 - UHR Image Shift Correction ▼

Start

Instructions

This adjustment minimizes the image shift during change of kV in Mode 2 (UHR).
Click on the Start button.

Note:
Use Quad 1 for the procedure.

No step

Alignments ?

43 - UHR Image Shift Correction ▼

Next

Instructions

Select the Working Distance necessary from the list below Optimize the image with Focus, Contrast and Brightness.
Click on the Next button to move to the next Step or Cancel (at any time) to leave the Alignment procedure and return to original settings.

Step 1 of 5

Select a Working Distance.

1.0 mm
1.5 mm
2.0 mm
3.0 mm
4.0 mm
5.0 mm
6.0 mm

Contrast   95.37
◄ ▬ ►

Brightness   38.20
◄ ▬ ►

Cancel

Alignments ?

43 - UHR Image Shift Correction ▼

Previous   Next

Instructions

Focus with the manual stage Z movement control.
Optimize the image with Contrast and Brightness.
Use the manual stage X and Y movement controls to bring a feature under the center cross.
Click on the Next button to move to the next Step.

Step 2 of 5

Setting HV = 18.0 kV

Actual HV = 18.0 kV

(Maximum possible = 18.2 kV)
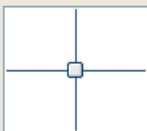
WD = 5.00 mm

Contrast   94.75
◄ ▬ ►

Brightness   38.20
◄ ▬ ►

Cancel

UHR Image Shift Correction (continued)

Alignments	?
43 - UHR Image Shift Correction	▾

[Previous] [Next]

Instructions

Do not Focus.
Control the 2D adjuster to bring the feature back under the center cross.
Click on the Next button to move to the next Step.

Step 3 of 5

HV = 18.0 kV   (6 HVs remaining)

WD = 5.00 mm

ShiftCorrAngleSX/Y

Contrast   94.75
[<] [▭] [>]

Brightness   38.20
[<] [▭] [>]

[Cancel]

Alignments	?
43 - UHR Image Shift Correction	▾

[Previous] [Next]

Instructions

Press the Next WD button to continue centering with another WD.
Press the Save button to store the previous centering.
Press the Next button to to go to the last step or Cancel to quit.

Step 4 of 5

☑ Next WD

[Save]

[Cancel]

Alignments	?
43 - UHR Image Shift Correction	▾

[Previous] [Finish]

Instructions

Press the Finish button to save and finish.

Step 5 of 5

[Cancel]

44 - UHR Lens Alignment

This procedure aligns UHR Lens in the whole range of voltages and working distances in UHR (immersion) mode. It is possible to complete it only for the voltages and working distances which are going to be used but for general adjustment it is necessary to finish it for all values. Before starting this alignment it is necessary to complete alignment 10 - Source Tilt and Shift.

To achieve result of above described adjustments it is possible to just click the **Auto** button. This function utilizes **Image Recognition** software. If this utility does not recognize image features well, the procedure is aborted and Warning message appears onscreen. In this case change the imaging conditions (better focus, slower scanning, or lower magnification).

Alignments	?
44 - UHR Lens Alignment ▼	
	Start

Instructions

This Alignment centers the beam through the UHR lens aperture, to remove image shift.
Click on the Start button.

Note:
Use Quad 1 for the procedure.

No step

Alignments	?
44 - UHR Lens Alignment ▼	
	Next

Instructions

Select the Working Distance necessary from the list below
Optimize the image with Focus, Contrast and Brightness.
Click on the Next button to move to the next Step or Cancel (at any time) to leave the Alignment procedure and return to original settings.

Step 1 of 5

Select a Working Distance.

- 1.0 mm
- 1.5 mm
- 2.0 mm
- 3.0 mm
- 4.0 mm
- 5.0 mm
- **6.0 mm**

Contrast	95.37
◄ ▬ ►	

Brightness	38.20
◄ ▬ ►	

	Cancel

Alignments	?
44 - UHR Lens Alignment ▼	
Previous	Next

Instructions

Focus with the manual stage Z movement control.
Optimize the image with Contrast and Brightness.
Click on the Next button to move to the next Step.

Step 2 of 5

Setting HV = 20.0 kV

Actual HV = 20.0 kV

(Maximum possible = 25.8 kV)

WD = 6.00 mm

Contrast	94.96
◄ ▬ ►	

Brightness	38.20
◄ ▬ ►	

	Cancel

UHR Lens Alignment (continued)

Panel 1 (Step 3 of 5):

Alignments   ?

44 - UHR Lens Alignment ▾

[Previous]   [Next]

Instructions
```
Final Lens Centering.
Minimize the image movement
Click on the Next button to
move to the next Step.
```

Step 3 of 5

HV = 20.0 kV   (6 HVs remaining)

CorrAngleSX/Y

[Auto]

0.000316

-0.000435

[Modulator]

Mod. Amplitude   0.5000
◄ ▭ ►

Contrast   94.96
◄ ▭ ►

Brightness   38.20
◄ ▭ ►

[Cancel]

Panel 2 (Step 4 of 5):

Alignments   ?

44 - UHR Lens Alignment ▾

[Previous]   [Next]

Instructions
```
Press the Next WD button to
continue centering with another
WD.
Press the Save button to store
the previous centering.
Press the Next button to to go
to the last step or Cancel to
quit.
```

Step 4 of 5

☑ Next WD

[Save]

[Cancel]

Panel 3 (Step 5 of 5):

Alignments   ?

44 - UHR Lens Alignment ▾

[Previous]   [Finish]

Instructions
```
Press the Finish button to save
and finish.
```

Step 5 of 5

[Cancel]

45 - HR Image Shift Correction

This procedure eliminates the image shift when changing HV in the whole range of voltages in HR (Field-Free) mode. Before starting this alignment it is necessary to complete alignment 10 - Source Tilt and Shift.

Alignments ?

45 - HR Image Shift Correction

Next

Instructions

The sample should be set at the Eucentric working distance and Focusing only performed with the manual stage Z movement control.
Bring a recognisable feature under the centre cross on the screen with the Stage movements.
Click on the Next button to move to the next Step.

Step 1 of 3

Contrast   93.26

Brightness   38.20

Cancel

Alignments ?

45 - HR Image Shift Correction

Previous   Next
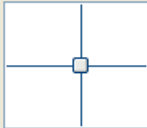
Instructions

Optimize the image with Contrast and Brightness.
Control the 2D adjuster to bring the feature back under the center cross.
Click on the Next button to move to the next Step.

Step 2 of 3

HV = 30000 V   (7 HVs remaining)

ShiftCorrAngleX/Y

Contrast   50.74

Brightness   33.59

Cancel

Alignments ?

45 - HR Image Shift Correction

Previous   Finish

Instructions

Press the Finish button to save and finish.

Step 3 of 3

Cancel

46 - Final Lens Alignment

Alignments   ?

46 - Final Lens Alignment ▼

Start

Instructions

This Alignment centers the beam through the final lens aperture, to remove image shift.
Mode: HR
Specimen: Tin Balls
Click on the Start button.

Note:
Use Quad 1 for the procedure.

No step

Alignments   ?

46 - Final Lens Alignment ▼

Next

Instructions

HR Mode.
Working Distance is 5mm.
Focus with Stage Z movement only.
Click on the Next button to move to the next Step.

Step 1 of 3

Contrast   38.87
◄ ▭ ►

Brightness   33.59
◄ ▭ ►

Cancel

Alignments   ?

46 - Final Lens Alignment ▼

Previous   Next

Instructions

Final Lens Centering.
Activate the Lens Modulator.
Tune AlignCorrAngleX/Y to minimize the image shift.
Click on the Next button to move to the next Step.

Step 2 of 3

HV = 30000 V   (7 HVs remaining)

AlignCorrAngleX/Y

Modulator

Contrast   40.06
◄ ▭ ►

Brightness   33.59
◄ ▭ ►

Cancel

Alignments   ?

46 - Final Lens Alignment ▼

Previous   Finish

Instructions

Press the Finish button to save and finish.

Step 3 of 3

Cancel

   FEI

81 - Crossover Position Calibration

This procedure calibrates the green cross position indicating the ideal crossover center. The calibration is necessary for the proper Source Tilt Auto Alignment performance.
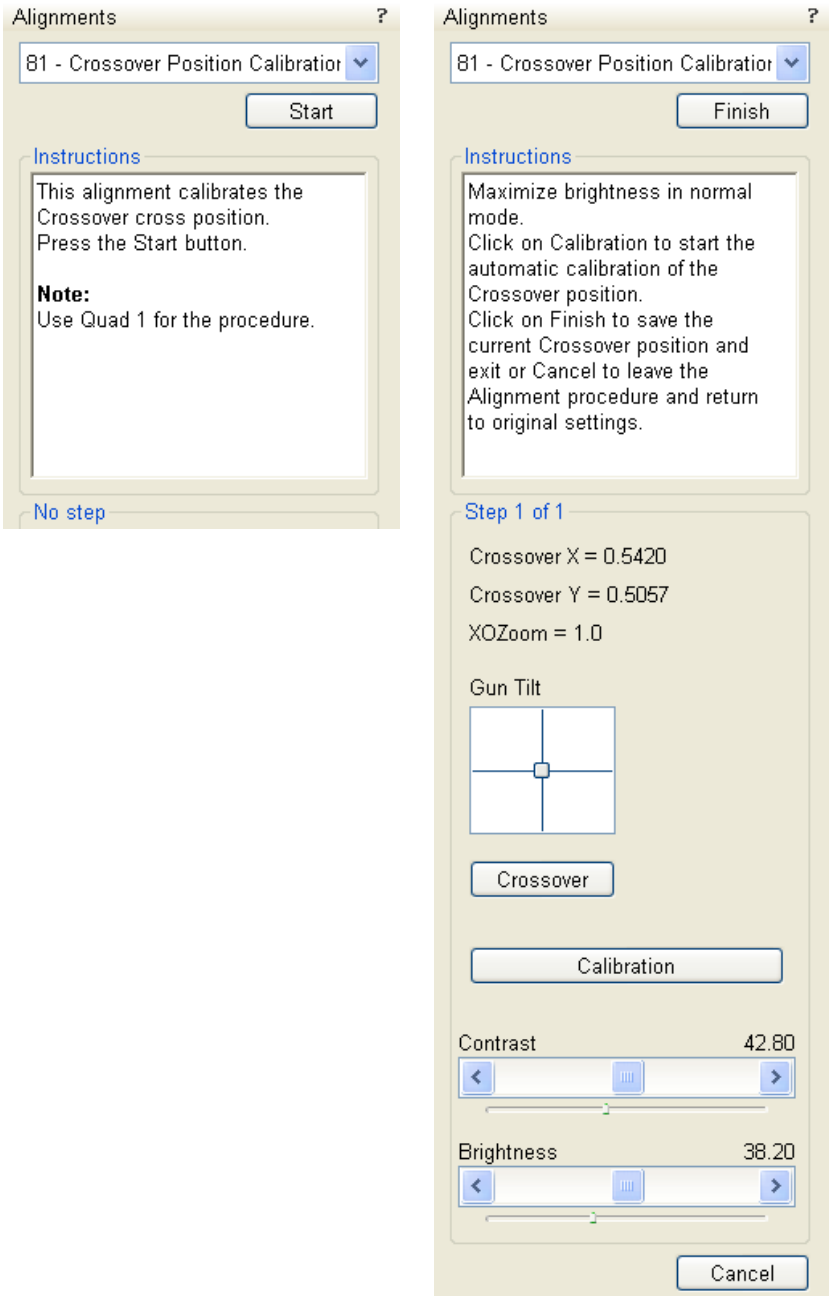
94 - CCD Camera Alignment

This procedure optimizes the CCD camera imaging performance.

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104 - Plasma Cleaning Alignment

When repeated **Sample Cleaning…** procedure is not efficient (see Chapter 4), click the **Start Chamber Cleaning** button, (the procedure **Duration** is much longer).

W A R N I N G !

Do not use Chamber cleaning procedure when EDS / WDS / EBSD system is mounted! If you need to clean system with EDS detector mounted, use 1 mm collimator and do not exceed 30 minutes once a week at most.

Alignments ?	Alignments ?
104 - Plasma Cleaning ▼	104 - Plasma Cleaning ▼
Start	Finish
Instructions	**Instructions**
This procedure controls the sample and/or chamber plasma cleaning. Click **Start** button to open the plasma cleaning control page. *Warning*: Always fully retract EDX before plasma cleaning. Use FEI approved collimator!	Set the Chamber cleaning duration and click **Start Chamber Cleaning** to initiate the procedure. Procedure can be interrupted at any time with the same button and system will return to chamber pumped state. Clicking **Cancel** or **Finish** will *not* interrupt running procedure! Preset Sample cleaning duration time for
No step	Step 1 of 1

Chamber Cleaning

Duration: 5 min
◄ [III]   ►

Elapsed time: 00:00

Start Chamber Cleaning

Last executed:

2011-Sep-27 15:36:34, duration: 00:01:01

Preset Sample cleaning duration time for
Sample Cleaning function.

Sample Cleaning

Duration: 60 s
◄ [III]   ►

Cancel

154 - Water Bottle Venting

Alignments   ?

154 - Water Bottle Venting   ▼

Start

Instructions

This procedure vents the water bottle to allow refilling.

No step

Alignments   ?

154 - Water Bottle Venting   ▼

Finish

Instructions

Click the button to vent the water bottle.

This action connects water bottle to auxiliary gas inlet for a while.

Step 1 of 1

Vent water bottle

Cancel

Vacuum Actions

Alignments   ?

Vacuum Actions ▼
Vacuum Alignments
Start / Stop IGPs
Pump / Vent Actions
Plasma Cleaning

- Start / Stop IGP's
- Pump / Vent Action
- Plasma Cleaning

Alignments   ?

Vacuum Actions ▼

Start or Stop IGP's.

Stopping IGP's can cause the FEG source to be switched off.
Stop FEG source before Electron IGP's are stopped.

Electron:

| Upper IGP: ON | Upper IGP: OFF |
| Lower IGP: ON | Lower IGP: OFF |

FEG emission:

| Switch OFF |

Finish

Alignments   ?

Vacuum Actions ▼

There's no action available for current system and your user rights.

Finish

Alignments   ?

Vacuum Actions ▼

Warning:
- Always fully retract EDX before plasma cleaning.
- Use FEI approved collimator!

Set the Chamber cleaning duration and click **Start Chamber Cleaning** to initiate the procedure.

Procedure can be interrupted at any time with the same button and system will return to chamber pumped state.

Note: Clicking **Cancel** or **Finish** will **not** interrupt the running procedure!

Preset Sample cleaning duration time for **Sample Cleaning** function.

Chamber Cleaning:

Duration (min)   5
◄ ▐ ▌ ►

| Start / Stop Chamber Cleaning |

Elapsed time: 00:00

Last executed:

2012-Feb-24 08:53:05, duration:

Sample Cleaning:

Duration (s)   60
◄ ▐ ▌ ►

Finish

E-Column: User Magnification Correction
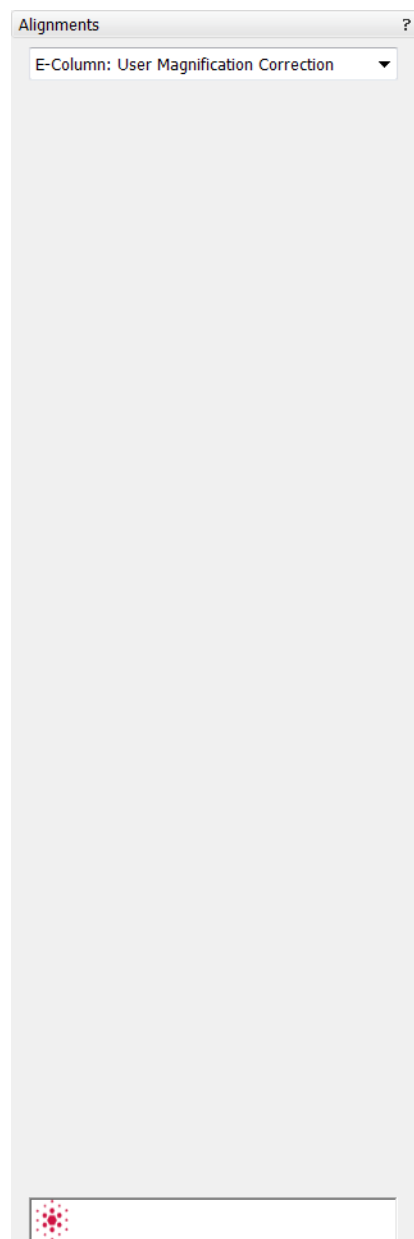
This utility is intended to enhance factory calibration accuracy under particular, user selectable conditions.

Note:
Switch the **Beam** menu / **Magnification Correction** item on only for calibrated conditions, otherwise it could worsen magnification accuracy.
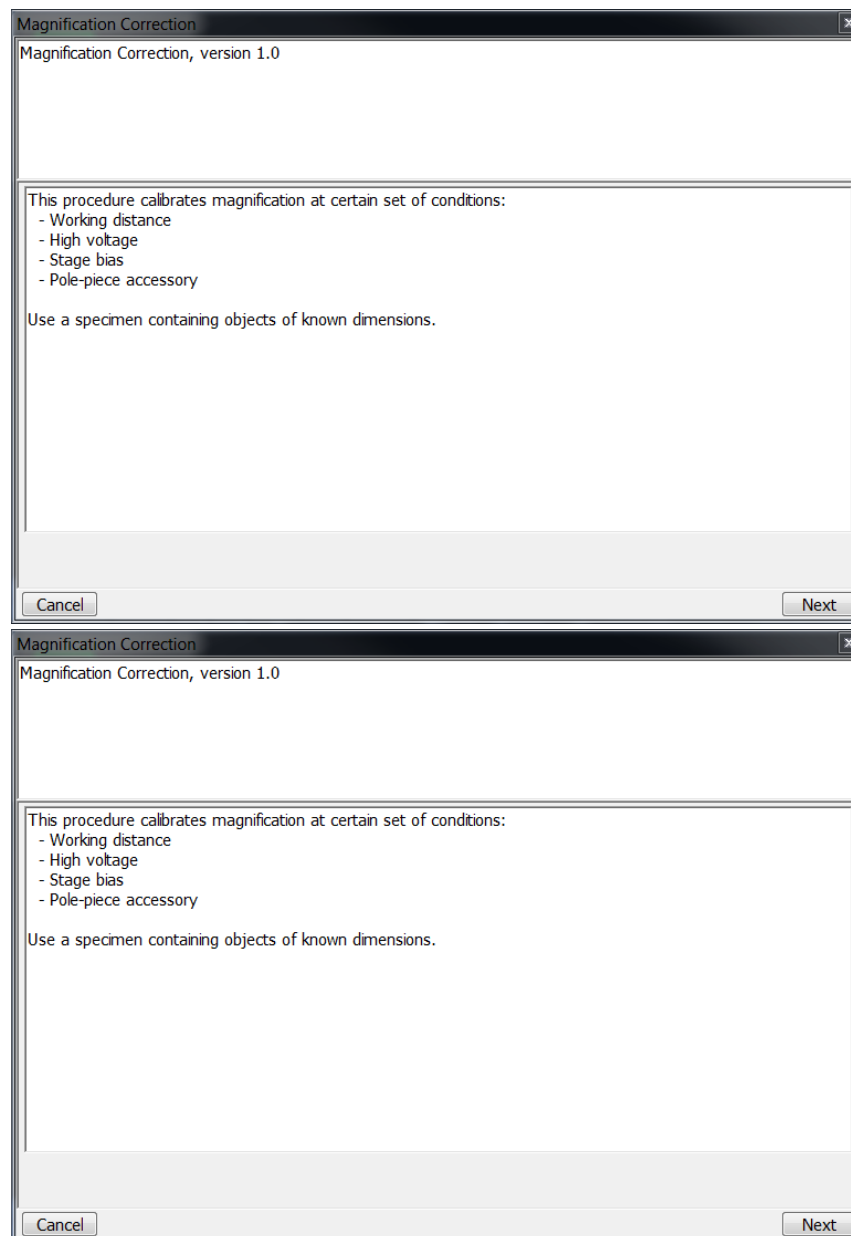
5 | OPERATING PROCEDURES

This chapter describes how to use the Microscope system from an application point of view. The following subjects are covered:

- Specimen Preparation and Handling
- Obtaining an Image
- Optimising an Image
- Detector types and usages
- X-ray Analysis for Different Vacuum Modes
- Capturing and Handling a Single Image
- Saving Multiple Images (Recording Movies)
- Beam Deceleration
- Measurement and Annotation Functions

Caution!

These procedures assume you are familiar with the xT microscope server and xT microscope Control software (see Chapter 3), which are necessary to start and operate the microscope.

Specimen Preparation and Handling

The specimen material for high vacuum must be able to withstand a low pressure environment (without outgassing) and the bombardment by electrons. It must be clean and conductive. Oil and dust may contaminate the chamber environment, which could hinder or even prevent evacuation to the level needed for standard SEM operation.

Note:
Always wear lint- / powder-free clean room gloves when reaching into the specimen chamber to minimise oils, dust, or other contaminants left inside the chamber.

NEEDED ITEMS

- Class 100 clean-room gloves
- Specimen stubs and conductive adhesive material
- Tools: tweezers, 1.5 mm hex wrench
- Prepared or natural specimen

NATURAL SPECIMEN

If no coating is desired the Low Vacuum mode can be used to stabilise the specimen for observation. This mode is useful if there is a suspicion that a coating might alter the specimen.

COATED SPECIMEN

If the specimen is nonconductive (plastic, fibre, polymer or other substance with an electrical resistance greater than 10^{10} ohms) the specimen can be coated with a thin conductive layer. This conductive layer reduces beam stir due to sample charging and improves imaging quality.

For successful imaging, rough surfaced specimens must be evenly coated from every direction. Biological, cloth and powder specimens may require carbon or other conductive painting on portions of the specimen that are hard to coat.

Coating reduces beam penetration and makes the imaging sharper. It may mask elements of interest for X-ray analysis (thus the use of carbon for geological and biological specimens).

For more information on specific preparation techniques, see *Scanning Electron Microscopy and X-Ray Microanalysis, 2nd ed.* by Joseph Goldstein et al., Plenum Press, New York, 1992.

MOUNTING SPECIMEN TO HOLDER

Wafers and PGA devices have individual sample-mounting procedures. If you are using a wafer piece or other sample, attach the specimen to the specimen holder using any suitable SEM vacuum-quality adhesive, preferably carbon or silver paint. The specimen must be electrically grounded to the sample holder to minimize specimen charging, make sure the specimen is conductively attached to the holder.

Note:
The sample holder is not directly grounded to the chamber ground because it is connected to the BNC feed allowing to measure the specimen current.

C a u t i o n !
Store samples and sample holders in a dry and dust free environment. Dust on samples can get drawn into the electron column, degrading imaging and requiring service response.

Microscope Control

It is assumed, that the microscope is in the Full operation state (see Chapter 2).

OPERATION PRE-CHECK

To ensure correct operation in any Vacuum mode, check the following list before continuing. After obtaining a preliminary image, you can then experiment with your settings.

TABLE 5-1   NOVA NANOSEM SETUP CONDITIONS

Adjustment	E-Beam Settting
Vacuum mode	**HiVac:** conductive samples **LoVac:** nonconductive, mixed or contaminating samples
Accelerating Voltage	Select voltage relative to specimen type: - low kV for surface imaging, beam-sensitive samples and slightly charging samples - high voltage for conductors, high resolution, compositional info (BSE, X-ray) For example: - biological sample HV = (1–10) kV - metal sample HV = (10–20) kV
Spotsize **(for imaging)**	**HiVac** and **LoVac:** 3 or 4
Scan rate	**HiVac:** fast (dwell time about 0.1 µs) **LoVac:** slow (dwell time about 3 µs)
Free Working Distance (FWD)	Set the highest specimen point to approximately 5 mm. (yellow mark in CCD image Quad) and hit Ctrl + F (set FWD to 5 mm function).
Eucentric Position	5 mm
Magnification	Set to lowest – from 100× to 200×
Standard Detector	**HiVac:** ETD (SE) **LoVac:** LVD
Filtering	**HiVac:** Average (2-4 frames for fast scans) **LoVac:** Live
Contrast & Brightness	With contrast at minimum value adjust brightness to just show a change in intensity to the screen. Increase the contrast to produce a reasonable image on screen. Increases in brightness and decreases in contrast produce softer images. The reverse produces sharper images.

INSERTING / EXCHANGING SPECIMEN AND / OR DETECTOR
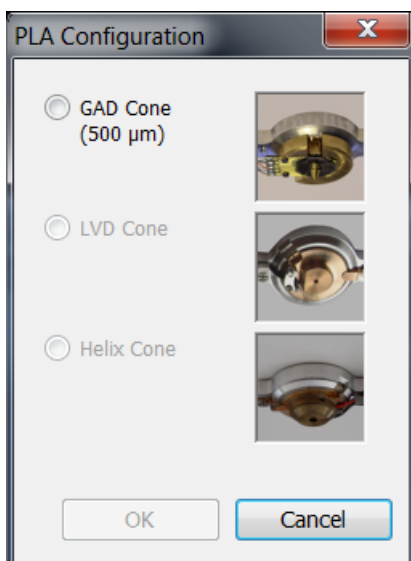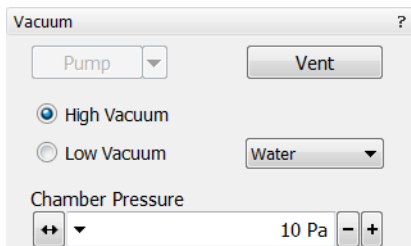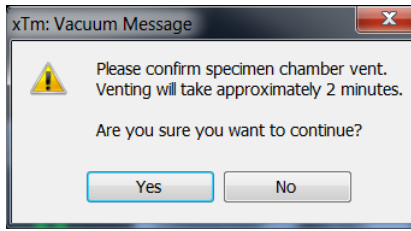
1. Click the **Vacuum** module / **Vent** button. The confirmation dialogue appears.

   After an automatic accelerating voltage switch off (or manually the **Column** module / **HV** button), the vacuum system switches off the pumps and opens the appropriate valves to vent the system. After a specified venting time the venting valve will close.

   Note:

   If the venting valve closes before the chamber is at the atmospheric pressure (the door is not possible to open), click the Vent button once more to open it again.

   If you vent the chamber in order to change a detector, wait until the **Status** module vacuum icon (chamber part) is grey. Otherwise there is a risk of a incorrect detector determination, and as a result the PLA (see Chapter 2) is not recognised by the system.

2. When vented, open the specimen chamber and, using lint-free gloves or tweezers, place a specimen into the specimen holder. Secure the specimen stub with an appropriate hex-wrench unless a spring-clip holder has been used.

3. Install any additional detector if it is not already done (see below).

4. Adjust the Eucentric Position (see below).

   Check the stage position and the Tilt before closing the chamber door! Use the Adjuster Tool for the Nova NanoSEM 650 model. The sample height must be between the 5 and 1 mm planes (from 5 to 1 mm below the Final lens pole).

5. Close the specimen chamber door.

SELECTING VACUUM MODE

When a specimen and appropriate detector(s) are installed correctly, continue the procedure (see above):

6. Check the **High Vacuum** module / **Low Vacuum** or **High Vacuum** mode radio button.

   For the Low Vacuum mode select the appropriate gas from the drop down list and the target **Chamber Pressure** that the system pumps to.

   Under normal operation, the system will know the PLA size for the detector installed. This will allow the system to set automatic pressure range limits for the aperture installed, thus avoiding vacuum errors when setting chamber pressure. In some cases a user will be prompted for **PLA Configuration**.

7. Click the **Vacuum** module / **Pump** button. While pumping, choose the highest specimen point and bring it to the 5 mm Working Distance (yellow line in CCD Quad).

8. Wait for the vacuum status **Pumped** (**Status** module / green icon).

WARNING!

The system can be damaged by using the Low Vacuum mode without an appropriate PLA. Do not select a PLA Cone which is not actually mounted onto the objective pole piece (see Chapter 2).

OBTAINING IMAGING ON SCREEN
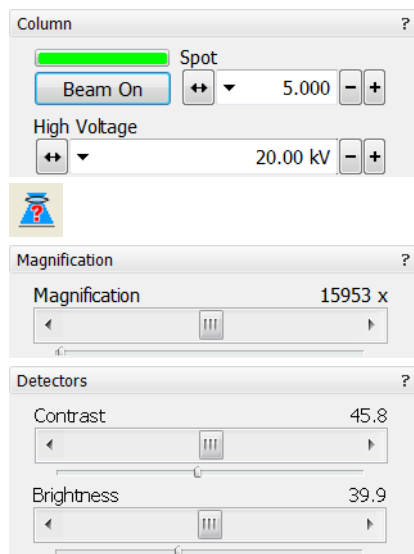
Continue the procedure (see above):

9. Select an appropriate detector (see below) and resume the chosen quad.
10. Click the **Column** module / **Beam On** button to ramp up the accelerating voltage. An imaging appears in the active quad.
11. Focus the imaging and **Link Z to FWD** (see Chapter 3).
12. Adjust to a suitable magnification, optimize the imaging using the **Contrast & Brightness, Focusing, Astigmatism Correction** etc. (see below).

Imaging Optimising

PRINCIPLES OF SEM IMAGING

All scanning beam microscopes screen with the same fundamental technique. The primary beam is scanned across the specimen surface in a regular pattern called a raster. Normally, this raster consists of a series of lines in the horizontal (X) axis, shifted slightly from one another in the vertical (Y) axis. The lines are made up of many dwell points and the time of each dwell point can be shortened or prolonged (dwell time). The number of points per line can be increased or decreased as well as the number of effective lines (resolution). The result is a picture point (pixel) array. Low or high resolution imaging can be obtained by changing these factors. The larger the pixel array, the higher the imaging resolution. The imaging is created pixel-by-pixel in the computer memory and displayed on a monitor screen.

The signal emitted by the specimen surface as it is illuminated with the primary beam is collected by the detector, amplified and used to adjust the intensity of the corresponding pixel. Because of this direct correspondence, the pixels displayed on the monitor are directly related to the specimen surface properties.

The raster consists of many (typically one million) individual locations (pixels) that the beam visits. As the beam is scanned, the signal emitted by the sample at each beam position is measured and stored in the appropriate digital memory location. At any time after the beam scan, the computer can access the data and process it to change its properties, or use it to generate a display.

MAGNIFICATION

Magnification is calculated as the displayed dimension (L) divided by the sample scanned dimension (l).

If the observed sample point size is made smaller while the monitor size remains constant, the magnification increases. At low magnification, one gets a large field of view. At high magnification, you point only a tiny sample area.

It is possible to set a corresponding data bar magnification readout in the Quad Image and Single Image modes and in the saved image (see the **Preferences… / Magnification** tab).

FIGURE 5-1   MONITOR IMAGING AND SCANNED SAMPLE

$$\text{Magnification} = \frac{L \ (Viewed \ length)}{l \ (Scanned \ length)}$$

7 000x	29.6 µm
100x	500 nm
500x	1.00 µm
1 000x	5.00 µm
5 000x	15.0 µm
10 000x	30.0 µm
30 000x	150 µm
100 000x	300 µm
300 000x	1.50 mm
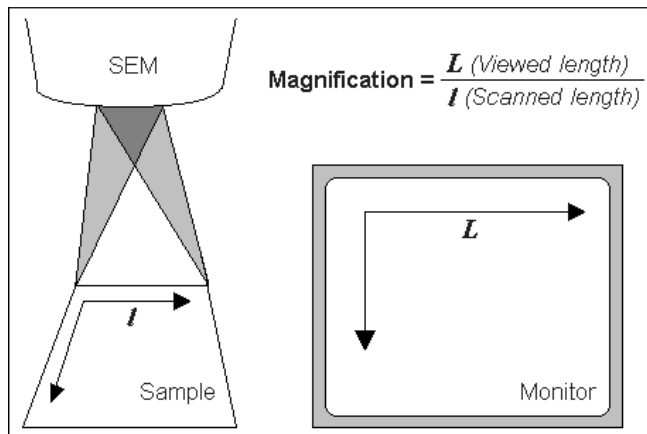
Changing Magnification

- The **Toolbar** list box is used to select from a predefined values.
- The **Keyboard** control (**+** / **-** / *****): the numeric pad plus key (+) / the minus key (-) increases / decreases the magnification 2× and rounds the value. The star (*) key rounds the magnification value (e.g. 10 063× becomes 10 000×).
- The **Mouse wheel** control: Coarse / fine control can be operated by the Ctrl / Shift key and scrolling the mouse wheel up / down to increase / decrease the magnification.
- The **Selected Area Zooming In / Out** is a quick way of zooming in / out on an area of interest. Click inside the imaging area & drag to make a dotted box over the area of interest (the cursor changes to a magnifying glass with a + sign). Release the mouse button and the selected area increases to fill the whole quad (window) with respect to the sides ratio. Clicking & dragging + Shift consecutively reverses the above described technique (the cursor changes to a magnifying glass with a - sign). The escape button cancels the operation at any time.
- The **Magnification** module (see Chapter 3)
- The **Digital Zoom** module (see Chapter 3)

SCAN SPEED AND FILTERING

To make a good imaging it is necessary to find a balance between scan speed, charge, sample damage and signal to noise ratio.

A noisy imaging can be improved by decreasing the scan speed. If charge or sample damage are the limiting factors it is better to use a faster scan speed in combination with an **Average** or **Integrate** filter (see Chapter 3).

CONTRAST AND BRIGHTNESS

The contrast and brightness can be set manually either by adjusting the **Detectors** module controls (see Chapter 3) or using the MUI (option).

1. Select a medium speed scan in an active quad.
2. Reduce the contrast to zero and adjust the brightness to a level so that the last gray level can be seen, by eye, before the screen goes black.
3. Increase the contrast so that the imaging appears.
4. If necessary, adjust the brightness level to improve the imaging.

Using Videoscope (F3)

This mode could facilitate contrast and brightness optimization to obtain full grayscale imaging level range.

Three yellow horizontal lines (placed over the quad) indicate white (top line), gray (middle line) and black (bottom line) levels. The oscillogram signal amplitude / central position reflects a contrast / brightness of the just scanned line. If the oscillogram is cut by the bottom / top line, the signal level is clipped in black / white. This should be avoided because the imaging details are lost in the clipped areas.

Tuning the oscillogram exactly between the top and bottom lines for a feature of interest (with the use of the reduced area) results in the full detailed imaging. The signal clipping may be used to obtain harder contrast conditions when more black and white is needed. The signal amplitude lowering decreases the contrast, i.e. the imaging looks softer.

1. Select a slow scan in an active quad.
2. Activate the Videoscope (**F3** / **Scan** menu).
3. Reduce the contrast to zero and adjust the brightness level to the lower dashed line (black).
4. Increase the contrast so that the signal level just touches the upper dashed line (white).
5. If necessary, adjust the brightness level once more so that the average signal level is roughly in the middle.
6. The high and low peaks should just touch the dashed lines.

Note:
Use also the following functions to optimize the Contrast / Brightness (see Chapter 3): **Auto Contrast Brightness** (F9), **User Auto Contrast Brightness**, **Display Saturation** (Shift + F11).

FOCUSING

Find a feature of interest with distinct edges on a specimen. Use a combination of contrast, brightness and magnification adjustments to maximize the imaging quality.

1. When the mouse cursor is over an imaging area, **right-click & drag** (the mouse cursor changes to a double-ended arrow). Move the mouse from side to side until the selected quad imaging is sharp, then release the mouse button.
2. The focus function (cursor) is active over the whole screen without any interference with other controls. If the full mouse motion is not sufficient to get the focus: release the mouse button at one side of the screen, move the mouse cursor to the opposite one and right-click & drag again (over an imaging area) to continue focusing.
3. If this is a new specimen first time focusing, run the **Link Z to FWD** function (see Chapter 3).

Focusing at a higher magnification makes the result more precise. For example, for an output at the 2000× magnification focus at 4000× – 8000× magnification.

To avoid scanning too long and contaminating or even damaging the sample before you take the final image, move away from the feature of interest with the X and Y stage controls, and focus until the image is sharp on an adjacent area.

Focusing with MUI (option)

Use **coarse** and **fine** focus knobs. The imaging immediately responds to the MUI.

Note:
Use also the following functions to focus
(see Chapter 3): **Reduced area** (F7), **Auto Focus** (F11).

CORRECTING ASTIGMATISM

This optical aberration is caused by different focal lengths for rays of various orientation, resulting in a directional imaging blur (X and Y rays are not focused to the same plane on the edges).

There are special coils serving to correct this imperfection, which is usually better visible at higher magnifications (3000× or more). You need to correct astigmatism when you change the imaging conditions.

1. Focus an image.
2. Bring the imaging just slightly out of focus. The imaging appears to become sharper in one direction whereas in perpendicular direction blur increases (blurring or stretching).
3. Bring the imaging just slightly out of focus in the other direction to observe the opposite directional blur.
4. Focus to the midpoint between the two directions, where the blur is visible.
5. Use the **Beam** module / **Stigmator** 2D control.

   The **Mouse**: shift + right-click & drag while in the selected quad. This results in a 4 arrowed cross appearing on the screen with the cursor position at its center. Move the cursor around the screen to achieve maximum sharpness. When you are satisfied, release the mouse button.

   The **MUI** (optional): adjust imaging sharpness with the stigmator **X** and **Y** knobs until the best result is achieved. The computer beeps when the stigmator limits are reached.
6. Repeat steps 1–5 as necessary.

If astigmatism is severe and the cross is close to the edge of the screen when nearing correction, release the mouse and reposition the cross in the center of the screen. Then repeat the procedure above to perform further astigmatism correction. You can use reduced area advantageously (see Chapter 3).

If astigmatism cannot be corrected, there may be some other reason, usually the final lens aperture is dirty (see Chapters 4 and 6), the magnification may be too high for the beam spot size (see below) or the sample is charging (apply conductive layer or use the Low Vacuum mode).

Note:
For normal astigmatism correction use the automatic procedure
(Ctrl + F11).

DIRECT ADJUSTMENTS (CTRL + F8)

This is tabbed window for fine-tuning the beam geometry to achieve the best focus and brightness.

Beam tab
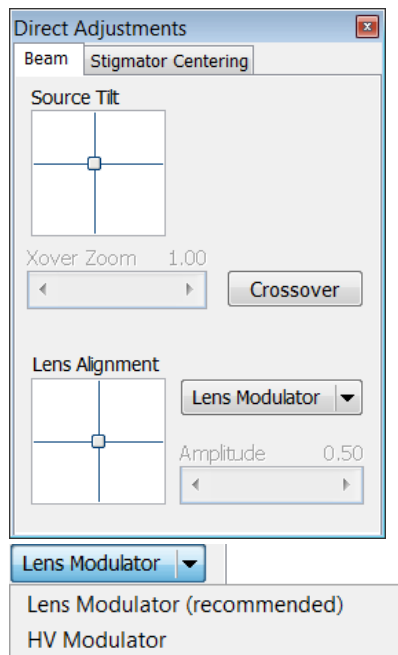
- The **Source Tilt** 2D box corrects an imaging illumination drop by changing an effective angle of the beam coming from the gun area into the electron column.
- In the **Crossover** mode (activated with the button) the imaging shows the electron source tip instead of the sample surface.
- The **Xover Zoom** slider set the Crossover image magnification.
- The **Lens Align** 2D box minimizes the objective imaging shift during focusing. The 2D control indicates an actual beam position setting relative to the final lens aperture.
- The **Lens Modulator** / **HV Modulator** button starts automatic objective current / accelerating voltage oscillation (periodically under- and over-focuses imaging in a narrow range) to facilitate the process.

    Try to bring the rotation center to the screen center (if the magnification is too high, the rotation could seem like a linear motion instead of a rotation).

    When the accelerating voltage is above 3 kV, Lens Modulator is automatically selected and recommended, otherwise the HV Modulator is.

- The **Amplitude** slider sets the modulation amplitude.

Stigmator Centering tab
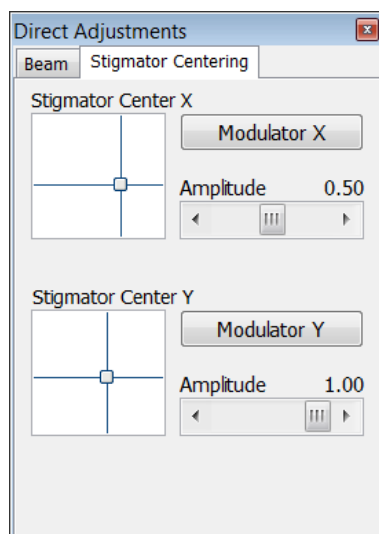
- The **Stigmator Center X** / **Y** 2D box sets the coils for correcting astigmatism to bring the beam into the center. The crosshair indicates the actual stigmator setting. This minimizes imaging shift during astigmatism correction.

    Try to bring the rotation center to the screen center (if the magnification is too high, the rotation could seem like a linear motion instead of a rotation).

- The **Modulator X** / **Y** button starts automatic oscillation of the current of coils for correcting astigmatism (periodically changes under- and over- stigmator setting in a narrow range) to facilitate the process.

    Try to bring the rotation center to the screen center (if the magnification is too high, the rotation could seem like a linear motion instead of a rotation).

- The **Amplitude** slider sets the modulation amplitude.

DIGITAL IMAGING ENHANCEMENT / IMAGING MIXING / COLORING

The Enhanced Image module offers various digital imaging enhancements.

Note:

When saving the image with the digital enhancements applied, be sure to choose the correct file format (see below).

LUT (Look-Up-Table) Tab
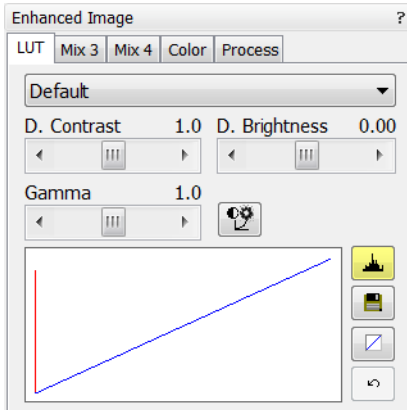
enables to monitor and modify a grey level distribution (histogram).

- The **Presets** list box enables to select the Digital Contrast, Digital Brightness and Gamma values using pre-defined or custom presets.
- The **D. Contrast** continuous adjuster sets a digital contrast in the range from -10 to +10 (negative values lead to an inverse imaging).
- The **D. Brightness** continuous adjuster sets a digital brightness in the range from -2.0 to 2.0.
- The **Gamma** continuous adjuster corrects image brightness non-linearly in the range from -10 to +10.
- The **Auto Levels** button sets the three above mentioned parameters automatically acording to the imaging / image quality.
- The **Graph** window graphically displays (blue line) the applied modification. Original / modified values are on the horizontal / vertical axis.
- The **Histogram** button switches on / off the grey level distribution (corresponding to the active quad image) display. The left / right side corresponds to black / white original image pixels. The height of the red line is proportional to the number of pixels with the corresponding grey value.
- The **Save** button saves the actual setting as the custom preset.
- The **Default** button restores the default values.
- The **Undo** / **Redo** button cancels / applies again the last changes.

Mix 3 / Mix 4 Tab
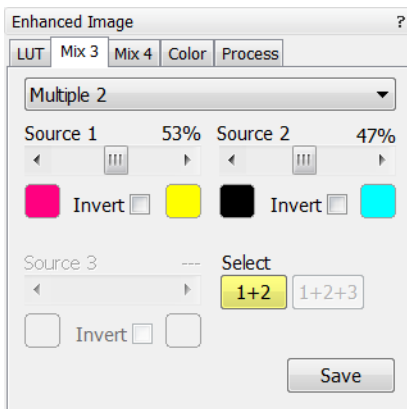
The Mix feature operates in quad 3 / quad 4 and is enabled only if the **Detector** menu / **Mix** is selected for a quad 3 / 4. It uses the processed images (Average / Integrate, Digital Contrast, Digital Brightness, Digital Zoom), not the raw detector signals. Any combination of live and paused images can be mixed together, providing all mixed images have the same pixel resolution. However, there are some logical limitations and behaviours:

- The Average and Integrate filters are disabled.
- Pause / Activate influences the mixed imaging only, not its sources. The Mix quad is always paused immediately regardless of the actual scanning status.
- The CCD image is not mixed.

Note:

In the Mix 3 tab the Source 3 controls and the Select 1+2+3 button are disabled.

- The **Presets** list box enables to select the mixing ratios and colors using pre-defined or custom presets.
- The **Source 1 / 2 / 3** linear continuous adjuster tunes the mixing ratio of quad 1 / 2 / 3 imaging. The adjuster % values influences correspondingly the resulting image and the other ones change automatically to reach the 100% sum.

- Clicking the **Color** control areas (below each Source adjuster) enables to select a color, replacing the source image black (left) / white (right) one. The image grey scale is linearly transformed to a new color spectrum before it is mixed with other image(s).
  Note:
  Color imaging (see below – the Color tab) is converted to greyscale one before mixing.
- The **Invert** check boxes inverts the corresponding source spectrum. It has the same effect as exchanging the left and right colors selection.
- The **Select 1+2** / **1+2+3** button selects between quads 1+2 or quads 1+2+3 mixing modes.
- The **Save** button saves the actual setting as the custom preset.

Color Tab

enables to colorize a grey scale imaging. An imaging already colored with the use of the Mix 3 / Mix 4 tab cannot be colored again, the Color tab is disabled.
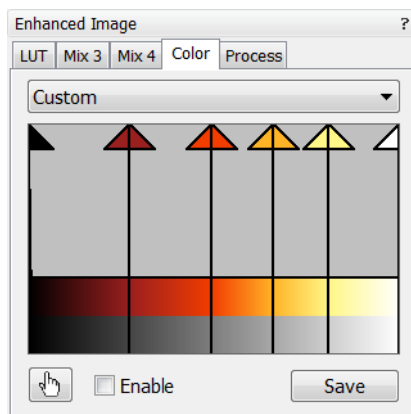
- The **Presets** list box enables to select the color profile using pre-defined or custom presets.
- The **Coloring Control** area displays the selected quad histogram and enables to create a color profile.
  Right-clicking into the histogram area adds the vertical borderline with a divided triangle at the top (right-clicking onto an existing one removes it). Clicking & dragging a borderline changes its position along the histogram. Clicking onto the left / right part of the triangle selects the left / right border color. The imaging grey scale between two borderlines is linearly transformed to a new color spectrum.
- The **Hand** button enables to select and color a particular image grey level. Clicking it opens the color selection dialogue: select a color and click the OK button. The mouse cursor changes to the hand image. Click the feature image you want to highlight. New borderline is added into the histogram with a rectangle at the top. The selected grey level is marked with the chosen color. You can move this borderline and change its color the same way as a borderline with a triangle at the top. By dragging the rectangle left / right side the highlighted grey level range could be changed.
- The **Enable** check box switches on / off actual color settings for the active quad image.
- The **Save** button saves the actual setting as the custom preset.

The Process Tab

Here a user can set parameters, which adapt image when clicking the **Apply** button, or when selecting the **Tools** menu / **Image Post Processing** (Ctrl + F7). The **Undo** button, or the **Tools** menu /**Undo Image Post Processing** (Ctrl + Shift + F7) reverts the corrections back.

- The **Denoising strength** (0 / 1 / 2 / 3 / 4) removes dust and scratches from the image.
- The **Sharpening strength** (0 / 1 / 2 / 3 / 4) influences the image sharpness.
- The **Undo** / **Redo** button cancels / applies again the last changes.

The Custom settings could be saved.

Note:

This functionality works only with greyscale images (not colored via Color tab), images which are paused or with loaded saved ones.
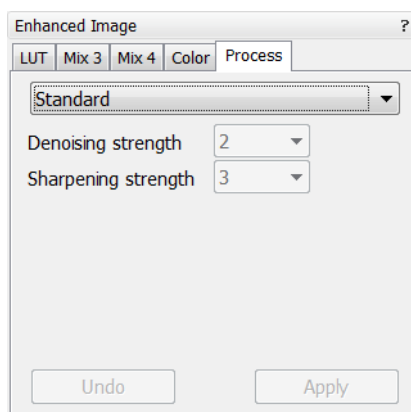
BEAM SPOT SIZE / BEAM CURRENT
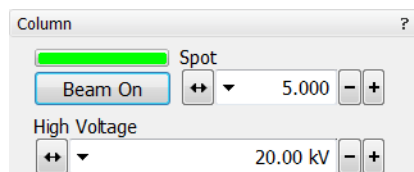
The actual focused area of the electron beam on the specimen is referred to as **Spot**, which has assigned numbers that range from 1 to 7. Both the focused beam area and the beam current increases with the increasing spot number. There are 11 pre-set spot size numbers selectable from the corresponding toolbar list box.

The beam current depends also on the actual High Voltage and the selected final lens aperture. Its values could be found in the **Help** menu / **Beam Current Table…**

Adjusting Spotsize for Imaging

Spotsize is considered to be close to ideal when the edges of the beam just touch when adjacent lines are scanned. If the spotsize is too large, overlaps occur and the imaging appears out of focus. If the diameter is too small, electronic noise appears.

Deciding which spotsize is correct for a particular magnification can be determined when you achieve good focus and astigmatism correction easily at the chosen magnification.

TABLE 5-2   SPOTSIZE USE RECOMMENDATION

Spotsize	Best Use
1, 2	Very high resolution (mag >200 000×); Mode 2 + TLD
3, 4, 5	Standard imaging, SE, LVD, Helix
5, 6, 7	BSE, CL, X-ray analysis, EBSP

When you change spotsize, adjustment of the **Detector** module / **Contrast** and/or **Brightness** may be necessary to optimize the imaging. An alternate approach is to click the toolbar **Auto Contrast & Brightness** icon.

SEM Modes

The electron column can be operated in three different final lens modes and in the Beam Deceleration mode.

Final lens modes

These modes can be selected in the **Beam** menu / **SEM Mode** or directly from the toolbar.
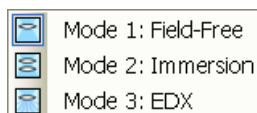
- **Mode 1: Field-Free**

    This is the default survey mode essential for navigating and reviewing samples at lower magnifications and for observation of ferromagnetic samples. The immersion lens is switched off and the default detector is the ETD in Secondary Electron operation.

- **Mode 2: Immersion**

    This mode is used for ultra-high resolution imaging of the sample. The immersion lens is switched on and the default detector is the TLD in Secondary electron operation.

C a u t i o n !

Never switch to the Immersion lens mode with a magnetic specimen in the chamber!

- **Mode 3: EDX**

    This mode is used for EDX / WDX analytical tasks with EDX detector w/o magnetic collimator. The Immersion Lens is not so powerful as in Mode 2 but can act as an electron trap for backscattered electrons to improve X-ray collection.

Selecting Mode 2 and 3 have their's own Beam menu presets.

BEAM DECELERATION
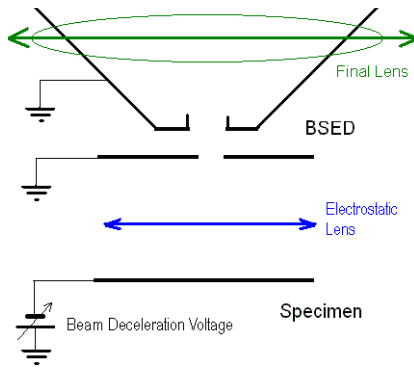
The Beam Deceleration mode (BDM) method is based on a negative voltage **Stage Bias** (**bias**) applied to a stage (i.e. a sample). The electrical field between the sample and the nearest surface over (a column bottom or a detector) is formed, acting as the additional electrostatic lens. Its power is described by the Immersion Ratio (imRatio) parameter (see below).

Detection Principles

The Beam Deceleration influences both primary and signal electrons.

As the sample is at the negative potential according to the ground and detectors, the initial SE and BSE energy (when leaving the surface) is accelerated by the Stage Bias before the detection. The higher is the Immersion Ration, the lower is the difference between SE and BSE energies when detected.

Signal electrons are accelerated upwards and deflected towards the column axis. The SE have a low initial speed and they are usually absorbed into the detector central hole, equally like the BSE heading upright. Conversely the BSE heading nearly parallel to a surface (which normally cannot be detected) are driven to a detector.

By changing the Stage Bias an output angle distribution of electrons leaving a surface could be obtained.

FIGURE 5-2   TYPICAL TRAJECTORIES OF SECONDARY (RED) AND BACK SCATTERED (GREEN) ELECTRONS
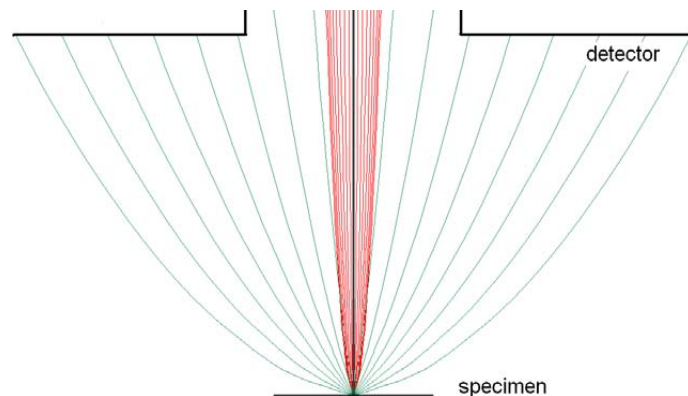
Detectors most convenient for the Beam Deceleration are BSE ones, placed closely under or directly inside the column. Their efficiency depends on their active area: the smaller is the inner diameter of the active area, the better. The standard ETD could also be used, but its efficiency is low.

Beam Deceleration Applications

- The BDM enables detection of the BSE when the electron energy is under the detection limit of the detector.
- The BDM expands the electron energy range under the minimum HV limit.
- The BDM improves the microscope resolution at low accelerating voltages. A conventional microscope resolution is limited by a chromatic aberration at low electron energies. The higher is the Immersion Ratio, the smaller are the aberrations and a loss of resolution at low electron energies is well compensated.
- The BDM enables to detect electrons heading nearly parallel to a surface which accentuates a surface roughness.

Application Restrictions

- In the LoVac mode the chamber environment is rather electrically conductive and the BDM is not available.
- The sample tilt causes an electrical field deformation, which adds not correctable aberrations (a chromatic aberration and an image distortion). An acceptable sample tilt is about a few degrees, for a higher immersion ratios preferably less.

FIGURE 5-3 SIGNAL DISTORTION AND IMAGE ABERRATIONS FOR TILTED AND ROUGH SAMPLE (TIN BALLS) AT HIGH IMMERSION RATIO
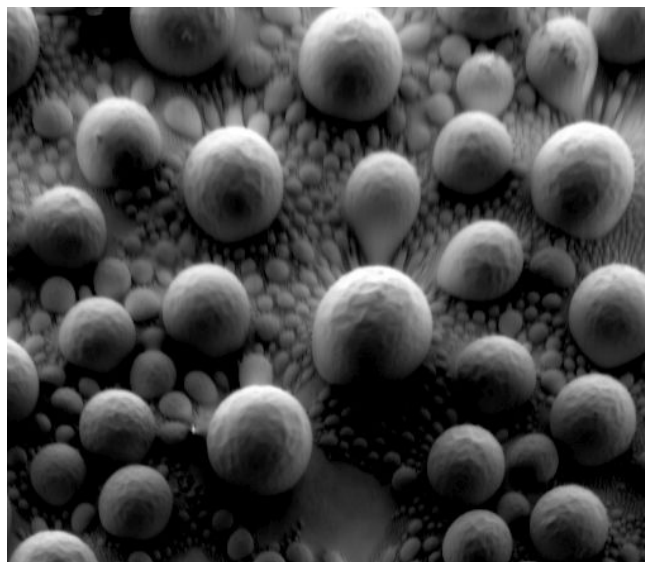
Beam Deceleration Module

The **Beam Deceleration** module is accessible from the **Beam Control** and **Detectors** pages. It has following features:

- The **On** button switches the BDM on / off. This is available only in the HiVac mode and with the Beam On. When switching the beam off, the BDM switches off automatically.
- The **Stage Bias** (bias) reflects the negative voltage applied to a stage. Minimal value is 50 V, maximal is 4 kV.

When the BDM is on, a hook mark is placed behind the HV. In this case this value represents energy of electrons reaching a sample surface (it is also stored within the TIF file header).

The imRatio = (HV + bias) / HV.
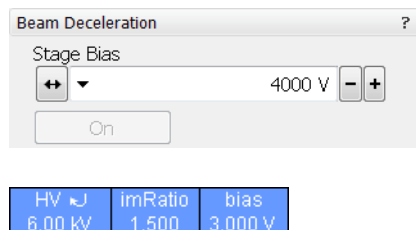
Beam Deceleration Mode Imaging Procedure

1. Put the sample into the chamber and pump to the HiVac.

In the BDM a sample becomes the electrode. Its position, size, tilt and surface roughness influence an imaging quality. At optimal conditions the sample should be symmetrical, planar, have a size comparable with the detector size, and placed perpendicular to the column axis. In other conditions a distortion, an astigmatism and a blurring caused by the chromatic aberration appear. This is even worse when the Immersion Ratio is higher.

2. Select the suitable HV and find an area of interest. Set the Eucentric Position (see below) and tune an imaging with the **Beam** menu / **Lens Alignment** and the **Beam** module / **Stigmator** 2D control functionality (see Chapter 3). In various quads select the SE and BSE to observe different imaging simultaneously.

3. Click the On button. Gradually raise the Stage Bias, the SE / BSE image is getting dark / light.

At low magnifications an ETD image should become dark symmetrically around the window center, in other case the sample could be tilted.

When a dark area is shifted with an Stage Bias change, the sample is possibly not parallel with the detector. With the use of the Compucentric stage rotation / stage tilt try to keep the dark are in the center of the screen.

Note:
An image shift when changing the Stage Bias could be caused by imaging near the sample edge or any other edge.
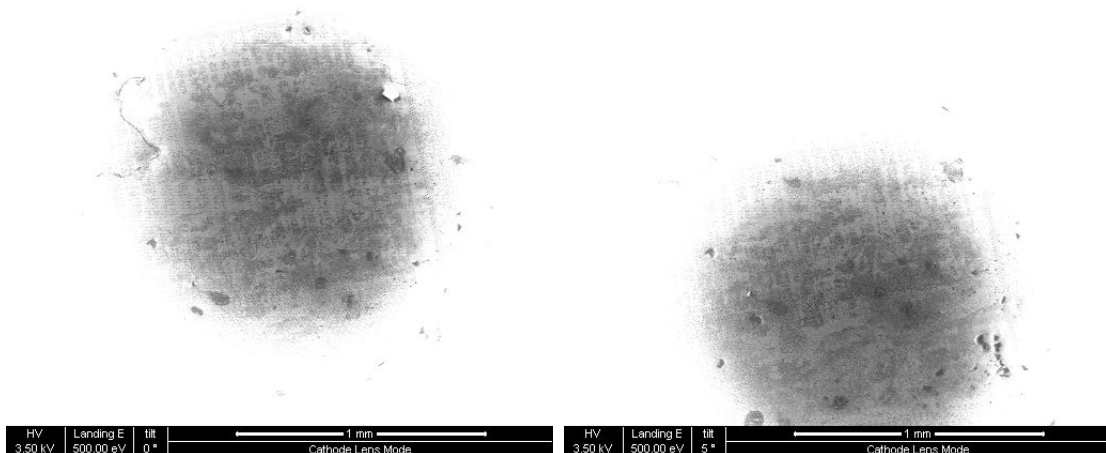
4. Set the Stage Bias considering the sample material (charging compensation, material contrast) and to optimize the signal. Set the brightness, contrast and WD according to the requirement.

5. Tune the **Beam** menu / **Lens Alignment** and the **Beam** module / **Stigmator** 2D control functionality (both factors remembers the HV and Stage Bias last used).

6. Repeat steps 4. and 5. to get the best result.

Standard Detectors
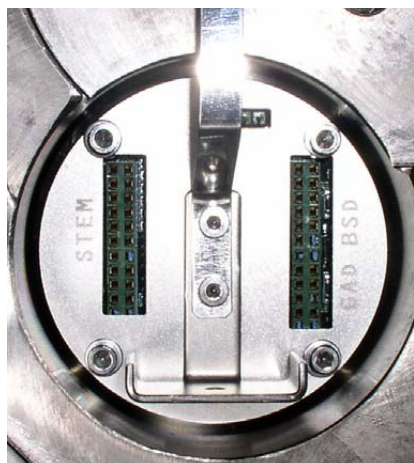
DETECTOR CONNECTION

Detectors are connected to the feed-through connector panel. Connectors have engraved names and they are used to connect following detectors:

- The **STEM** connector: STEM I, STEM II
- The **GAD** connector: GAD
- The **BSD** connector: CBS

The LVD and the Helix detectors are connected to another connector placed to the left beside the final lens pole.

DETECTOR SETTINGS MODULE

Detector exchange and modification of its conditions via **Navigation** page / **Detector Settings** module are immediate.

During the patterning (option) process the Detector Menu is still in use, but modifications will not become active until Patterning has stopped or has been interrupted. A typical circumstances under which changes could be made while patterning is when Snapshot or image acquiring are used during a patterning session. These facilities can be set up in advance. When patterning is stopped, the last scan detector and scan conditions will be active.

GASEOUS DETECTORS IMAGING PROCEDURE
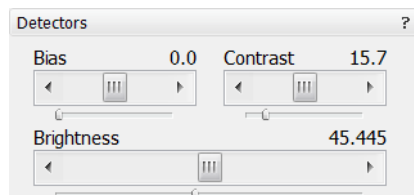
1. After the pumping and purge process click the **Beam On** button.
2. The **Bias** (detector voltage) adjuster in the Detector module is automatically adjusted to 70% of maximum value. Adjust it if necessary to increase a signal or to stop possible discharges. The **Contrast** adjuster (electronic gain) is set to the value last used.
3. At the lowest possible magnification, adjust the Contrast / Brightness if necessary, until the bright circle of the used cone can be seen in the imaging center.
4. Increase magnification and adjust Bias / Contrast / Brightness more precisely.

Discharges between Gaseous Detectors and Sample

Excessive voltage may cause a "breakdown" between the detector and the sample, chamber, pole-piece etc. This could damage the sample (at ground) but does not damage the detector. This condition is indicated by white flashes or streaks across the imaging, and on some systems a large discharge could make the system unstable or cause the chamber to vent and switch off the HV. There are several factors that could cause detector voltage breakdown:

- The Bias is set too high.
- A sample is too close to the detector.
- Gas pressure is low (depending on the detector and the environment).
- Air in the chamber (water vapour purge cycle not complete)
- A sample is not grounded to the stage, or the stage is not fully grounded (BNC plug not connected).

INFRARED CCD CAMERA
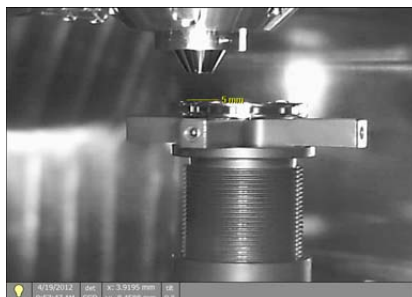
Imaging obtained with this camera assists in overall sample and stage orientation by enabling to view the inner space of the specimen chamber (an optical quad). It protects the objective pole piece and retractable detectors against collision when moving (especially in the Z-direction) or tilting the stage. IR LED's are used to light the specimen chamber interior.

EVERHART THORNLEY DETECTOR (ETD)

It is a scintillator photo-multiplier type detector collecting electrons generated by the primary beam interaction with the specimen surface. It is permanently mounted in the chamber over and to one side of the sample. It works in **Mode**s:

*   Secondary Electrons (SE)
*   Backscattered Electrons (BSE)
*   The Deceleration Mode is available, when it is on (see below)
*   Custom

ETD Settings

The **Detector Settings** / **Mode** list box enables to choose a **SE** / **BSE** mode (the **Grid Voltage** is set to +250 V / -150 V) or a **Custom** mode, for which the Grid Voltage could be set by the adjuster in a range from -240 to + 260 V. When the voltage is negative (use a range of -25 to - 240 V), SE are repelled from the ETD detector and only BSE are detected.
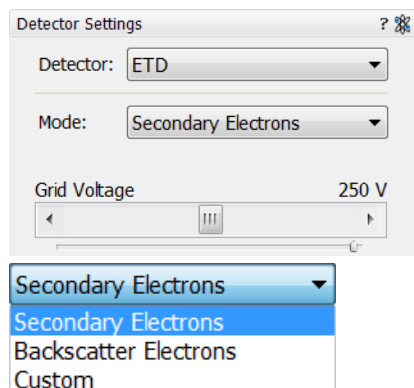
THROUGH LENS DETECTOR (TLD)

The TLD works in all SEM modes, but it is primarily designated to high resolution imaging in the SEM Mode 2 at which one can choose **Mode**s:

*   Secondary Electrons (SE)
*   Backscattered Electrons (BSE)
*   Charge Neutralization: suction tube voltage is set to zero
*   Down-hole visibility: suction tube voltage is set to 100 V
*   Custom
*   Deceleration Mode is available, when the Deceleration Mode is on (see below)

TLD Settings

*   The **Suction Tube Voltage** adjuster enables to modify electron collection. When the voltage is negative, low energy SE's are repelled from the detector and only BSE's are detected. When the voltage is positive, low energy SE's are collected by the detector. The Suction Tube Voltage capability is from -250V for only BSE's to +250V for SE's collection.
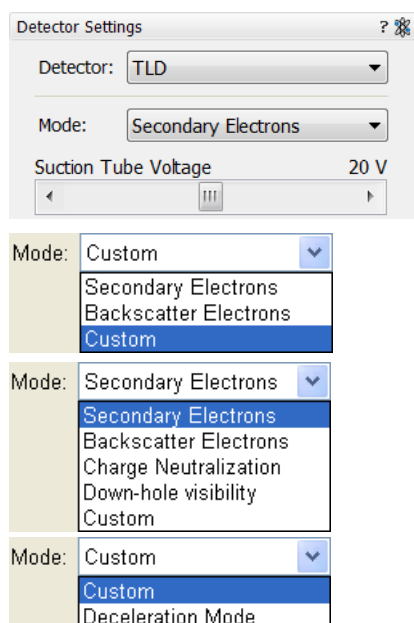
LOW VACUUM DETECTOR (LVD)

This detector is standard and optimal for general imaging at Low Vacuum mode in the whole pressure range from 0.08 to 1.5 Torr (10 - 200 Pa). The LVD detector limits the field of view to about 1 mm at the 5 mm working distance. The minimum working distance is limited to about 3 mm.

The LVD detector can be used in all SEM imaging Modes, but is primarily intended and gives better signal in modes 1 and 3. Its signal contains both secondary and backscattered electrons.

FIGURE 5-4   LOW VACUUM DETECTOR (LVD)

Installing / Unisntalling LVD

C a u t i o n !
Always use gloves when handling the detector and the chamber components.

1. Plugs the detector's PCB (Printed Circuit Board) into the signal proper connector (see above).
2. Hold the detector cone by its aluminium handle and put it gently on the bayonet base of the objective lens.
3. Turn it to the left to fix it in the bayonet lock joint.
4. Remove the detector the same way - first dismount the cone, then unplug the PCB connector.

LVD Settings

After pump down and purge process switch on the accelerating voltage, use mode 1 preferably. The modified **Detectors** module / **Bias** slider is automatically adjusted to the value used the last time. Adjust Bias if necessary to increase signal or to stop possible discharges. At the lowest possible magnification, adjust the Contrast and Brightness if necessary, until the bright circle of the LVD cone can be seen in the center of the image. Increase magnification and adjust Contrast and Brightness more precisely.
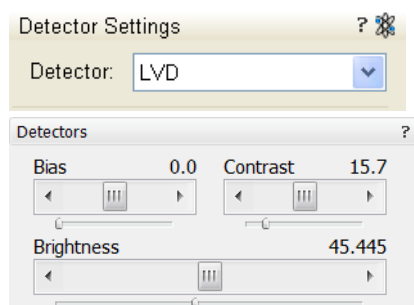
Capturing and Handling Single Image

After obtaining a good image quality, the image could be paused and saved. It is possible to save an image using the File menu or using the Scandium database software (option) image saving function.

Setup the file name label and harddrive destination for the image to be saved using the next available label / number prior to the capture session. Set the databar information important for the archiving (see the **Preferences…** / **Databar** tab).

The conditions for a good image quality are:

- Slow scan speed (longer dwell time) of the beam.
- Select a pixel resolution from the drop down list box to suit the detail in the image, i.e. no tearing pixelated edges.
- Increase the magnification at least 2× above the desired value, focus and correct the astigmatism (using the reduced area), then return the magnification back.
- Use the Videoscope to set the Contrast and Brightness accurately, otherwise use the Auto Contrast Brightness procedure.
- Use Pause / Snapshot / Photo / Active Preset Snapshot / filtering functions (see Chapter 3).

IMAGE TYPES

A computer perceives an image as a two-dimensional array of numbers – bitmap. Each array element is called a pixel and is represented as an integer value. Frequently, the pixel is represented as an unsigned 8-bit integer in the range [0, 255], with 0 / 255 corresponding to black / white and shades of gray distributed over the middle values. A 16-bit representation produces up to 65 536 different shades of gray (it is not possible to distinguish onscreen), which may be crucial for obtaining accurate data in analysis.

The raw scanned image is always a greyscale bitmap. The colors are possible to add digitally as a result of particular features. The UI is able to display and save images with a various bit depth:

- The **Greyscale** 8 / 16 bit image offers 256 / 65 536 levels of grey.

  Live / Averaged and Integrated images are scanned as 8 / 16 bit ones. For the Mix quad images a selection between the 8 or 16 bit mode is possible.
- The **Color** 24 bit image offers 256 levels of each primary color (red / green / blue).

  Digital colors coming from the Display Saturation feature, from the Image Enhancement module / Color tab, from the Mix quad with color mode set changes an image bit depth so there is no way to save it without them. When user wants to obtain the image without these color enhancements, it is necessary to turn off the respective UI functions.

  An image is possible to be saved with / without colored digital overlaid graphics (Measurement and Annotation) (see the respective checkbox in the Save As dialogue). Other types of overlaid graphics over an image are never saved (icons, controls, etc.).

Digital File Formats
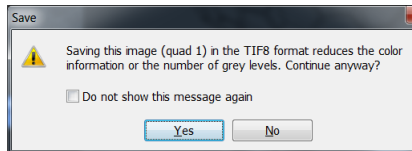
The image captured can be saved in various digital formats, depending on the resulting color and bit depth needed. Generally there is no reason to save an image with a higher bit and color depth than available in an original one. Over against saving an image with a lower bit and color depth than available leads to the loss of information. The message is displayed in this case onscreen.

* The **TIF** 8 / 16 – greyscale image type
* The **TIF** 24 file – color image type

   TIF file contains active processing information, which could be utilized for a databar setting (see the **Preferences… / Databar** tab).

* The **JPG** file is a compressed file format employing a lossy compression algorithm resulting in the small file size with a little loss of information, depending on the particular image appearance and the compression level (factory preset to 80%). The 8 / 24 bit depth is automatically selected when saving the greyscale / color image file.
* The **BMP** file is a not compressed file format. The 8 / 24 bit depth is automatically selected when saving the greyscale / color image file.

SAVING / OPENING / PRINTING

The following universal file handling functions could be used:
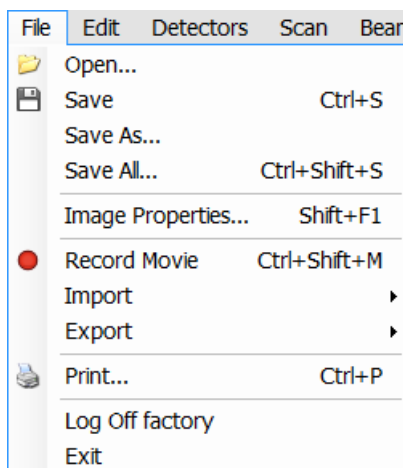
Image Capturing

1. Select the area of interest and set the **Magnification**, the **Scan condition**, the image pixel **Resolution** and the Databar information that are required in the saved image (see above).
2. Make the best image using any suitable method you are familiar with.
3. Use the **Pause (F6) / Snapshot (F4) / Photo (F2) / Active Preset Snapshot (Ctrl + F2)** function. The scan makes one screen / quad pass (or several passes when the number of integrated frames is larger) and pauses.

Image Saving

* **Save (Ctrl + S)** stores the image to the predetermined location with the last used filename including an incremental number.
* **Save As…** opens a dialogue for saving images (this provides an opportunity to change the file name, its location, and the possibility to save also Databar and overlaid graphics). Both functions can be linked to the Snapshot / Photo function (see the **Preferences… / Scanning** tab).
* **Save All...** behaves the same way as Save As functionality, but enables to save images from all four quads at once.
* **Open…** opens a single image file into the selected quad. The dialogue displays, by default, the location used in the last Save As… utilization.

Image Printing

1. Capture the image (see above) or open a saved one.
2. Click the **File** menu / **Print… (Ctrl + P)**, the printer setup dialogue appears so that the choice of printer and settings can be established to print the selected quad.
3. Complete the print setup and click the **OK** button to activate the printer and print an image.
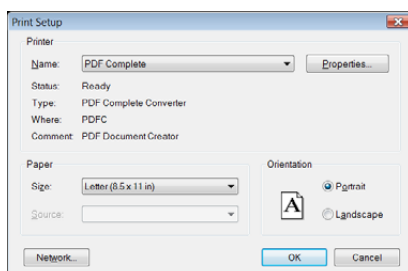
Recording Movies (Saving Multiple Images)

This function captures dynamic experiments performed with the microscope and creates the digital video files (AVI). Up to 4 imaging quads (not the optical one) can be recorded simultaneously with a synchronized start. It is possible to switch between single and quad image window while the video is recording. The movie has the following embedded features:

- Resolution 512 × 442 or 1024 × 884
  (768 × 512 or 1536 × 1024 for wide screen)
- Databar image optionally included in the video
- Average or Integration changeable during recording
- Scan speed changeable during recording
- Reduced area pauses recording of all quads
- Remaining time indicator
- Single frame TIF images recordable during video sequence
- Compressed AVI (*.avi) formats
- Start, Stop and Pause onscreen indicators
- Preferences set-up dialogue

Note:
For the quad(s) with the **Enhanced Image** module / **Color** tab / **Enable** check box ticked, the **Movie** recording is paused, the colored TIF files are stored anyway if selected (see below).

MOVIE TAB PREFERENCES DIALOGUE

The **Preferences…** (**Ctrl + O**) / **Movie** tab provides two modules, one to set-up conditions for timing (labeled **Timer)**, the other to set-up save conditions for the resultant movie (labeled **File)**.

FIGURE 5-5 MOVIE PREFERENCES
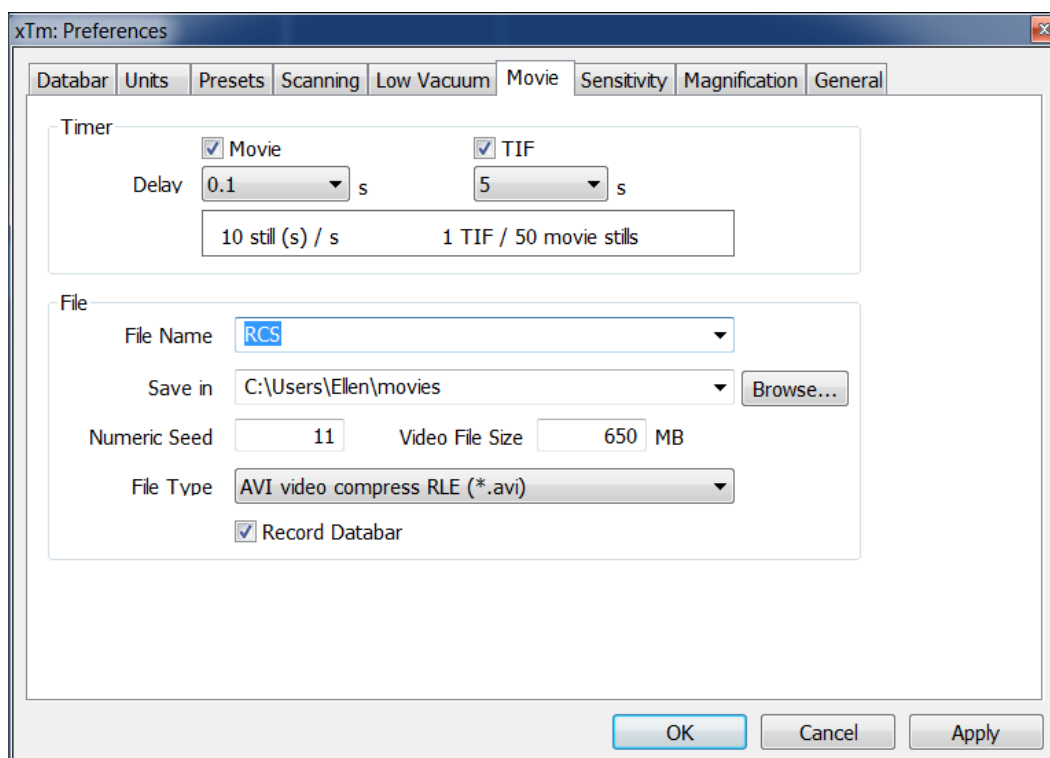
Timer module

The parameters in this section can be changed when the digital video is inactive, but are disabled during recording. The digital video is recorded asynchronously to the scanning.

- The **Movie** check box – AVI (Digital Video) timer:
  After the **Delay** time, the image of each active quad is stored immediately (even in the middle of the frame) as a new frame in the video stream.
- The **TIF** check box:
  After the **Delay** time, images series of each active quad are stored at the end of the running scan (the system waits) in TIF format.
- In the read only area additional information are given about the number of stills (frames) per time unit (seconds, minutes).

If both TIF and Movie check boxes are ticked, AVI and also TIF files are stored. In this case the AVI file is not reconstructed from TIF files, which means the directly recorded movie can be different from the movie reconstructed from TIF files.

Note:

TIF files are better to save in many cases as they can be built into a faster AVI and the databar display can be customized when building an AVI file (see below).

If both AVI and TIF are recorded, the AVI may be jerky due to delays when writing TIF files to a disk. TIF delay must always be longer than or equal to the Movie delay.

File module

Names of Movie [TIF] files are composed as follows:
File name, (quad name), **Numeric seed**, [- series number].avi [tif]

For example: *MovieName (Quad1) 015 [- 00023]. avi [tif]*
[The series number always has five digits form with leading zeros.]

- The **File Name** – a generic file name must be entered here, otherwise the Movie tab cannot be closed. Do not use punctuation, dashes or other not alpha-numeric characters, otherwise the movie maker is not able to build an AVI.
- The **Save in** – a path to an existing directory must be entered here, otherwise the Movie tab cannot be closed. Use the **Browse** button to find the location.
- The **Numeric Seed** – enter any number from 1 to 999 which is converted to the three digit form with leading zeros. The numeric seed is automatically incremented, after the recording has stopped, or the video file size limit has been reached.
- The **Video File Size** – the maximum AVI video file size (lower than 2 000) in MB must be entered here, otherwise the Movie tab cannot be closed. After reaching this size, the video file is closed and a new one is automatically created, without interruption of the recording process. A warning dialogue appears if the hard drive lacks sufficient free space.
- The **File Type** – the list box with supported video compression format types. Try to change the format if the resulting movie files are too big or if the system is overloaded during the movie recording.
- The **Record Databar** check box allows the databar to be included in the video (tif files).
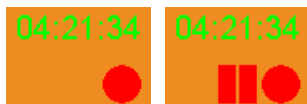
MOVIE PROCEDURE

The **red dot** button starts the recording of all active quads at the same moment – no video / images are stored for paused quads. When a quad is paused during the video recording, the storing of the video frames is interrupted but the video streams keep synchronization for the next recording.

When the red dot representing 'Start' is clicked, it turns to a **red square**, representing 'Stop'. Clicking the red square then stops the recording of the video in all quads and closes all video files.

The red dot with the timer (displayed in the top right-hand corner) indicates that recording is active in this quad. The Pause symbol indicates that the record is running but the data from this quad are not stored (the quad is paused).

The timer indicates the time estimation (in the hh:mm:ss format) remaining to the end of the video. This is calculated from the average disk space consumption and the disk free space.

Record Movie Procedure

1. Open the **Preferences…** / **Movie** tab. In the **Timer** module tick the **Movie** or **TIF** check box and select the desired **Delay** time (the period between stored frames).
2. In the **File** module fill in the **File Name** and give the **Save in** directory path. Fill in the **Numeric Seed** value and the **Video File Size**. Select the **File Type** and choose whether to record the databar with the **Record Databar** check box.
3. Pause those quads which you don't want to record. Set up the imaging parameters in the live quad(s).
4. Select the **File** menu / **Record Movie** (a tick mark) or click the toolbar / red dot button. When the scan resolution is higher than 1024 × 884 the dialogue appears.
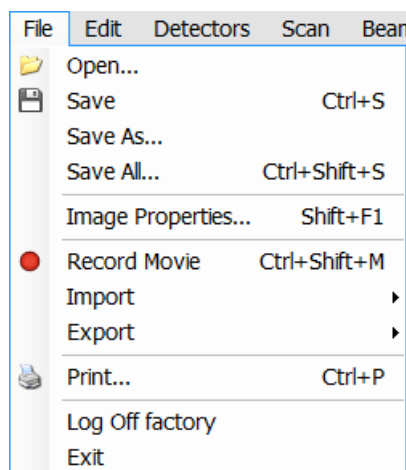
5. Choose either of the offered **Resolution** values at which the movie starts to record.
6. Select the **File** menu / **Record Movie** again or click the toolbar / red square button to stop the movie recording.
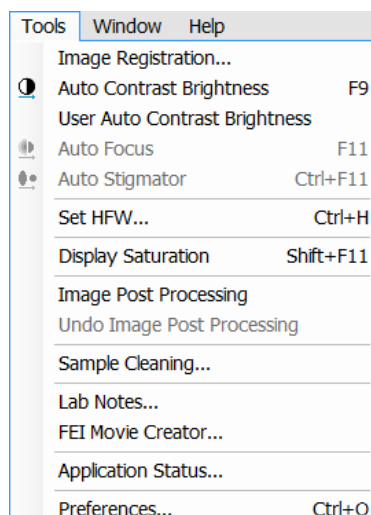
FEI MOVIE CREATOR

This is a separate program that creates a movie from a sequence of TIF images. Click the **Tools** menu / **FEI Movie Creator…** to activate the tabbed dialogues.

The following items are common for all tabs:

*   The **Databar Preview** displays the databar created in the **Databar** tab.
*   The **Status** displays the progress of movie creation process.
*   The **Create Movie** button opens the **File** tab and starts the movie creation process from the TIF files to a single AVI file.

- The **Stop** button stops the creation process.
- The **Close** button closes the **FEI Movie Creator** program.

File Tab

FIGURE 5-6   FEI MOVIE CREATOR TAB: FILE
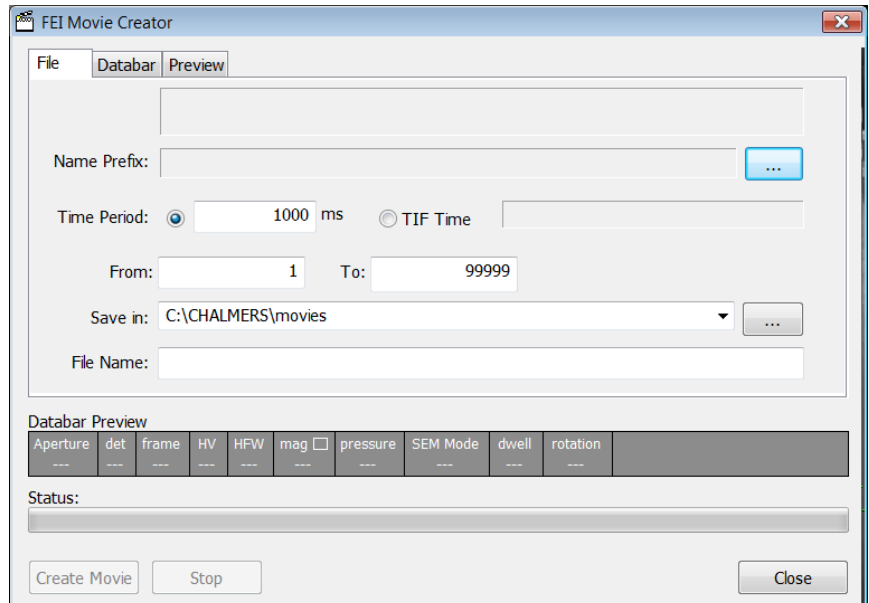
- The **Name Prefix** – click the **…** button to browse the TIF files (with the desired sequence prefix) directory. It is not necessary to choose the first file in a row.

FIGURE 5-7   BROWSE DIALOGUE
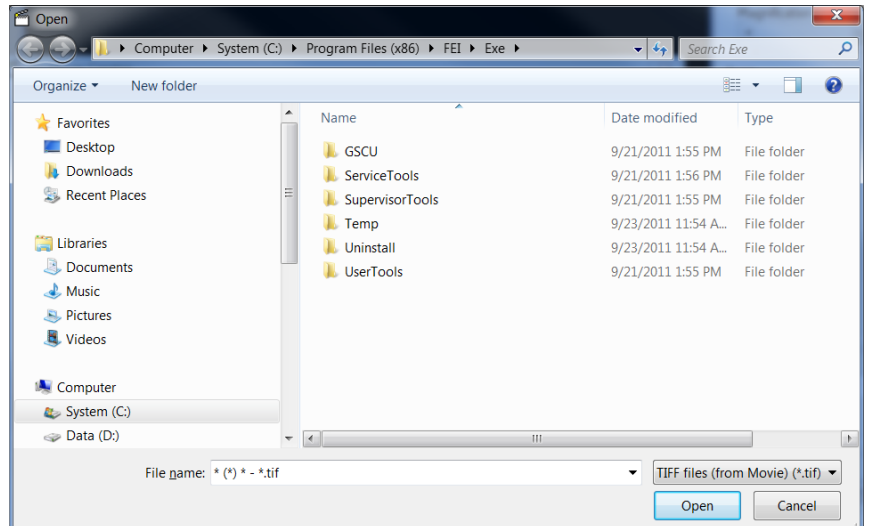
- The **Time Period** – select the **ms** radio button to select a custom timing for the movie playback. One may experiment (200 ms is good for most movies to speed it up). Select the **TIF Time** radio button to select a real timing for the movie playback.
- The **Grey Movie** button suppresses the colors in the resulting movie.
- **From** / **To** – enter the number of the starting / ending frame. This field is filled automatically with the first / last frame available.
- **Save in** – enter the path where the AVI file should be saved. Click the **…** button to browse it.
- **File Name** – enter the resulting AVI file name. This field is filled automatically with the first image file name.

Databar Tab

Settings made in this dialogue does not affect the databar or units settings used in the UI.

Note:
The **Databar Preview** does not show any item until you enter the **File** tab / **Name Prefix** field.

FIGURE 5-8   FEI MOVIE CREATOR TAB: DATABAR
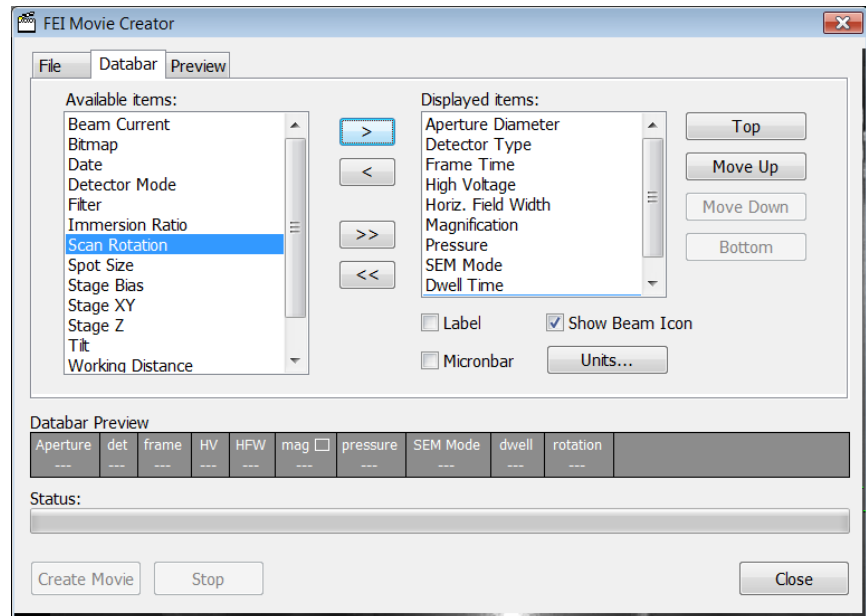
- The **Available** / **Displayed items:** lists – all items that can be entered in the databar / are already present in the databar.
- **> / >> (< / <<)** buttons adds one / all item(s) from the Available list to the Displayed list (removes one / all item(s) from the Displayed list back to the Available list).

  Since there is a finite amount of the databar space, the area expands or contracts as other items are added to or removed from the Databar. The item exceeding the allowable space is ignored.
- **Move Up / Move Down / Top / Bottom** buttons move a position up / a position down / to the top / to the bottom in the **Displayed** list (a position to the left / a position to the right / to the left / to the right in the **Databar Preview**).
- The **Label** / **Show Beam Icon** / **Micronbar** check boxes set the display of the appropriate items in the Databar. The Micronbar scales to the magnification.
- The **Units…** button sets the Units of Measure / Pressure / Temperature used in the movie Databar display.

Preview (tab)

Once the movie is set-up, opening the Preview tab automatically displays the first image of the movie sequence.

FIGURE 5-9 FEI MOVIE CREATOR TAB: PREVIEW
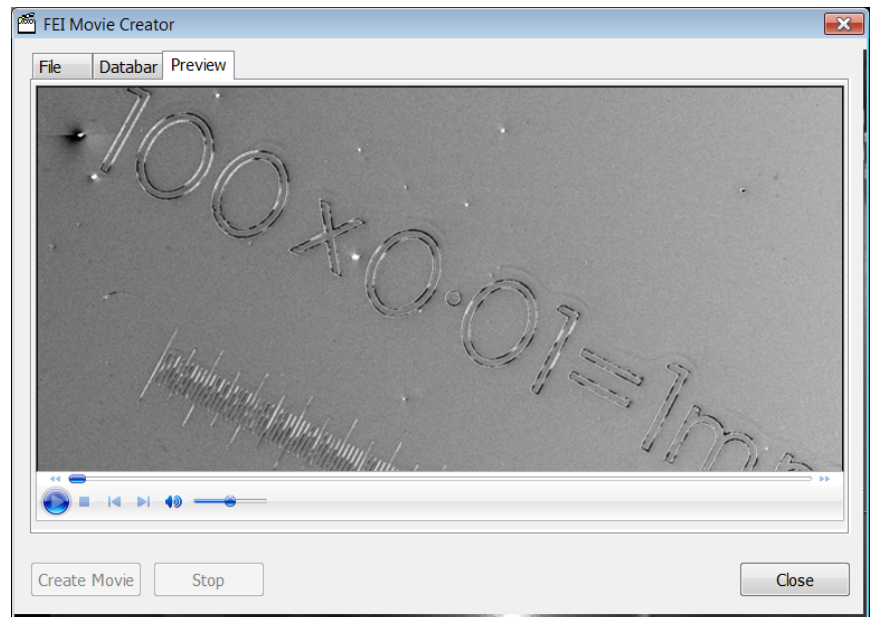
- The **Start** / **Pause** / **Stop** button starts / pauses / stops the movie play back. By dragging the adjuster one can run forward or backward through the movie.

PLAYING A MOVIE

The AVI file movie can be played in the Windows Media Player or any another more advanced movie editing program recognising the *.avi file type.

Stage Control

EUCENTRIC POSITION

Establishing the eucentric position is an important part of setting up a sample for observation or modification.

At the eucentric position, the stage tilt and the beam axes intersect. When the stage is tilted or rotated in any direction, this point remains focused and almost does not shift. At the eucentric position, one can use various system components in a safe and optimal way (e.g. GIS, EDX…).

Eucentric position should be adjusted after loading any new sample, as the sample loading clears all position information.

Note:
For electron imaging of non-tilted sample the eucentric position adjustment is not necessary. But it is still required to run the Link Z to FWD procedure (see Chapter 3).

FIGURE 5-10 EUCENTRIC POSITION PRINCIPLE

1) The point of interest is focused below the Eucentric point (see 2).

2) Tilting the stage moves the point of interest out of the beam.

3) The point of interest is focused at the Eucentric point (see 4).

4) Tilting the stage does not move the point of interest out of the beam.

⚛ FEI™
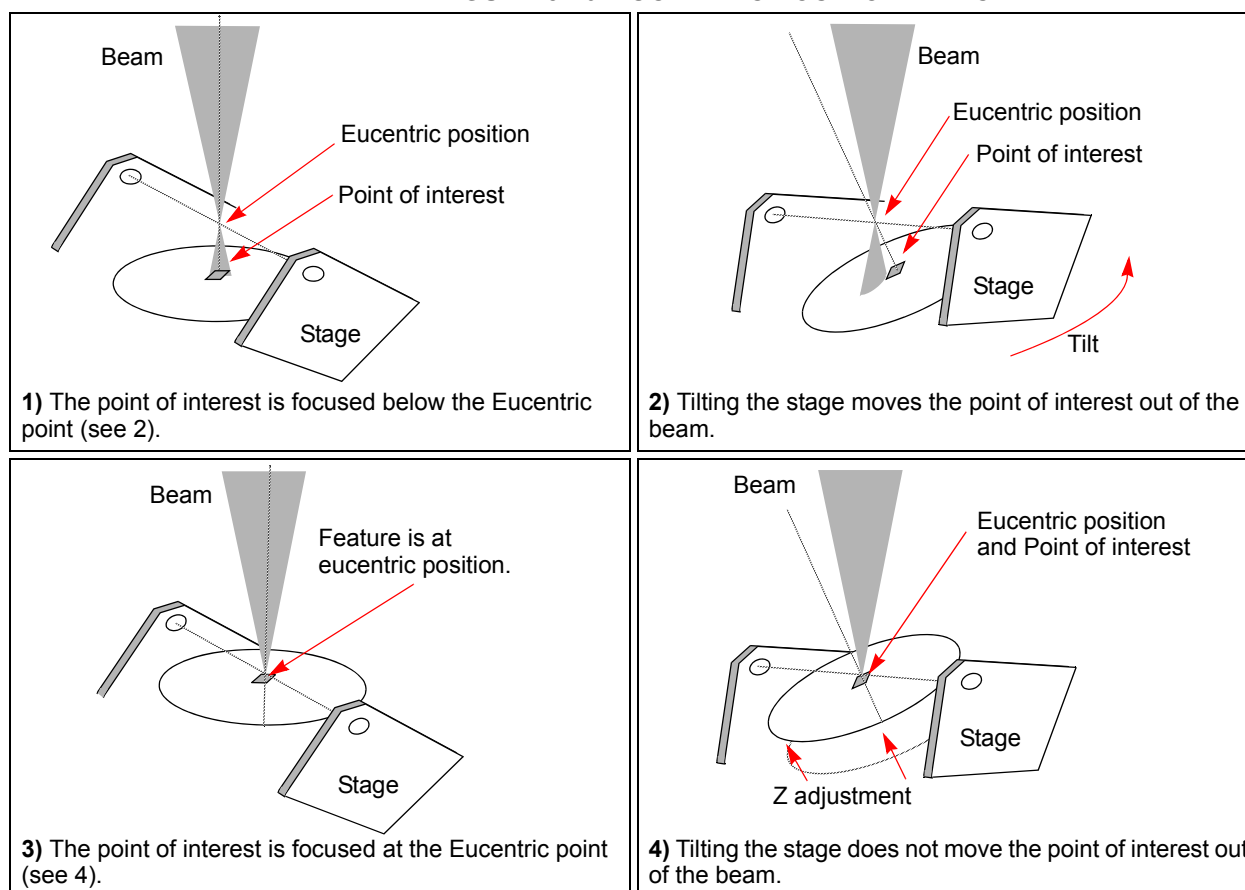
Sample Top Surface Positioning

The distance between the observed sample and the stage rotation head surfaces must be properly set to bring the stage to the eucentric position. This procedure also prevents the specimen to touch the final lens when moving the stage in the Z-axis direction.

With the standard specimen holder it is possible to move the sample (its top surface) along the Z-axis up / down if required (holder movement). This allows a flexibility to load large height specimens onto the stage.

1. Load a specimen onto the specimen holder.
2. Adjust the Z, so that the highest specimen point is approximately 5 mm below the lens.
3. Close the chamber, and pump it down.
4. Switch on the beam, focus the specimen top surface and run the Link Z to FWD function (see Chapter 3). The FWD is now recognised by the system as the **Stage** module / **Coordinates** tab Z value.

The Z coordinate can now be changed via the software Z control around the eucentric position and further, but not less than 1 mm from the lens for safety reasons.

Eucentric Position Setting Procedure

1. Apply the **Stage** menu / **Auto Beam Shift Zero** function.
2. Display the **Window** menu / **Center Cross** (**Shift + F5**).
3. Focus an image. **Link Z to FWD** and go to 5 mm WD.
4. Set stage tilt to 0°.
5. Using the Z-control, coarsely focus the image.
6. Set the magnification to 1000×, find a recognizable feature and center it under the yellow cross by moving the stage.
7. Watching the feature, change the stage tilt to 10°.
   Using the Z-control, bring the feature back under the cross.
8. Change the stage tilt to -10°, and bring the same feature back under the cross using the Z-control.
9. Change the tilt to 0°. The feature should not shift significantly.
   If the shift is > 5 µm, repeat steps from No. 6 to No. 9.

SOFTWARE CONTROL

The **Navigation** page / **Stage** module controls the stage movements that locate the position of the specimen by reference to coordinate points. It consists of **Map** / **Coordinates** / **Tilt Correction** tabs.

Map tab

In the map area the stage schema is represented displaying all stored locatable positions, which are listed in the **Location** list box for selecting.
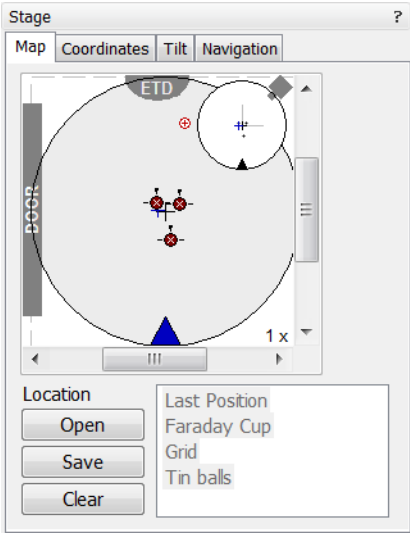
FIGURE 5-11 MAP AREA ELEMENTS
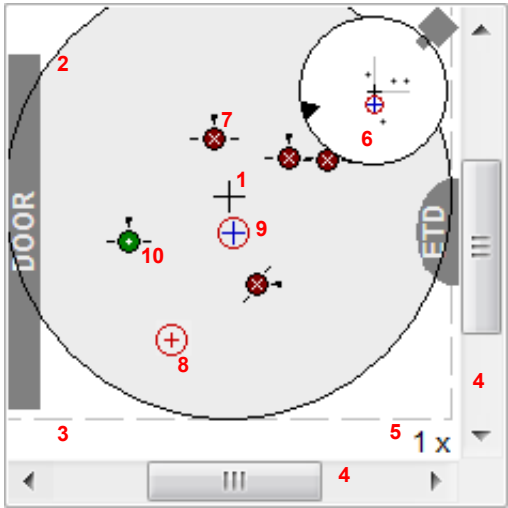
TABLE 5-3 MAP AREA ELEMENTS

No.	Function
1.	**Black +:** mechanical stage center.
2.	**The darker rim:** the sample holder outline.
3.	**Light grey dashed line:** physical limit of the stage movement along X and Y axes.
4.	**X / Y scroll bar:** to move the stage schema area in an X / Y (stage) direction at different magnification factors.
5.	**Magnification** factor of the map area (1× – 100×).
6.	**Radar view:** **Black triangle:** the moveable rotation angle controller. **Grey perpendicular lines:** denote rotation position. **Grey +:** stored positions as on the map.
7.	**White × on a red background:** a stored location with the rotation noted by the black key position.
8.	**Red + in a red circle:** the actual stage position.
9.	**Blue +:** a new location not stored.
10.	**White + on a green background**: indicates a stored position highlighted in the location list.

Radar view

The small circle in the stage schema top right corner conveys the stage rotation at any time by the black triangle and perpendicular lines position. To rotate the stage, click the circle perimeter triangle &.drag it round and release the mouse button at the desired position – the stage rotates accordingly.

Location area

The **Location** list shows the **Current Position** and the **Last Position** (the stage position before any movement) as default. When expanded, it shows the positions list with a scrollbar.

Double-clicking anywhere in the circle area marks a new location (**9**) and moves the stage to it.

The position selected becomes the actual active position and it is highlighted in the list and also on the map (**8**).

Clicking a position name allows a user to edit it. Pressing the **Enter** key or clicking a different item confirms the new name, pressing the **Escape** key restores the old name.

- The **Open** button opens a stored Stage Map file (stg).
- The **Save** button saves a Stage Map file.

  When closing the UI the system registry automatically keeps the Stage Map file with the specific User name to be loaded after the log-in procedure.

- The **Clear** button clears the existing Stage Map file including the Location list.

It is possible to load / save stg file also with the use of **File** menu / **Import** / **Export** functions (see Chapter 3).

Map Menu

Right-clicking over the Map area, provides the drop down menu.

FIGURE 5-12 THE MAP DIALOGUE
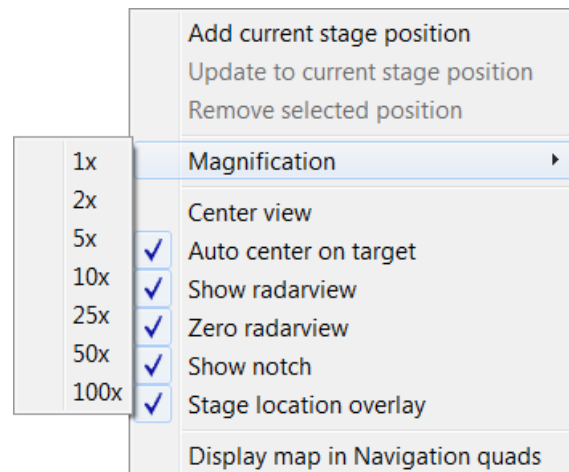
- Clicking the **Add current stage position** item adds a new Location list entry, using the actual active position. The new entry is named **Position X** (**X** = 1, 2, 3…). If a name already exists (because a user loaded a Map list from a Stage Map file), the value is heightened until a unique name is obtained.

  The **Coordinates** tab / **Add** button has the same functionality.

- Clicking the **Update to current stage position** item stores the (edited) coordinate values under the selected name (an overwriting confirmation dialogue appears).

The **Coordinates** tab / **Update** button has the same functionality.

- Clicking the **Remove selected position** item deletes the selected location(s) from the map and from the Location list.

  The **Coordinates** tab / **Remove** button has the same functionality.

- Clicking the **Magnification** item provides menu allowing the **Map** area magnification factor (**5**) to be selected. Scroll bars (**4**) appear if necessary to move over the whole Map area.

- The **Center view** item brings the selected location to the center of view.

- When the **Auto center on target** item is ticked and the Magnification factor is used, the active location remains in the center of view.

- The **Show radar view** item switches the radar view display in the map area On / Off.

- The **Zero radar view** item resets the stage rotation to 0°, which is represented by the black triangle 12 o'clock position.

- The **Show notch** item switches the blue triangle display in the map area On / Off, giving a quick view about the stage rotation.

- The **Stage location overlay** item toggles the detector and chamber door position display in relationship to a sample.

- The **Display map in Navigation Quads** item switches the stored positions display in navigation images.

Coordinates tab

Three modes are possible via the list box:

- The **Actual** mode (default) displays actual position coordinates in the edit boxes.

- The **Target** mode activates when clicking a stored position or when editing a coordinate value.

- The **Relative** mode is used to move stage by a given value and to repeat it several times if needed.

Clicking the **Go To** button drives the stage to a new location. This only acts on just edited coordinates (with a tick mark). Hitting the Enter key after editing of any coordinate value works as the Go To button short-cut. Double-clicking a stored location moves the stage to the desired position immediately.

During the stage motion the **Go To** button changes to the **Stop** button, which stops the stage immediately.

Coordinates X, Y, Z, R, T

Edit boxes for **X**, **Y**, **Z**, **R** and **T** coordinates are filled with the selected or actual position values. The value changed is automatically ticked.

Caution!

*Danger of hitting the pole piece! The **Link Z to FWD** procedure did not pass (see Chapter 3). The red arrow next the Z axis alerts the positive Z-axis stage moving direction is up. It means raising a value in the Z axis edit box causes moving the stage up towards the pole piece.*

After running the **Link Z to FWD** procedure the symbol and the stage moving direction changes. The black arrow next the Z axis indicates the positive Z-axis stage moving direction is down.

The units of measure follow the **Preferences…** / **Units** setting, unless the **Stage** menu / **User Units** function is active, in which case UU is displayed for X and Y.

The software **locks** prevent inadvertent stage movement of selected axes during particular applications. The edit boxes for locked axes are
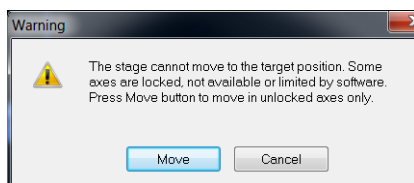
disabled and the stage does not move in these directions. When any or all axes are locked the **Status** module displays a closed lock instead of an open one. By default all axes are unlocked.

When any axis is locked and the stage movement is required in that direction (trying to move to the stored position), the warning dialogue appears.

When the **Compucentric Rotation** check box is ticked, the **R** coordinate operates as the Compucentric Rotation function.

Note:
The R coordinate is permanently locked and its homing is disabled when the heating or cooling stage is plugged in.

Tilt tab

When the appropriate check box is ticked, the function becomes active.
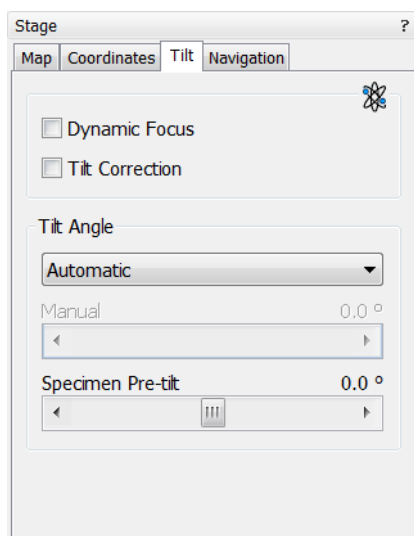
- The **Dynamic Focus** check box ticked – the focus automatically changes as the beam scans from the image top to its bottom, trying to follow the tilted specimen working distance change.
- The **Tilt Correction** check box ticked – the flat specimen foreshortening compensation is on (in one direction, at a known tilt angle, when the tilt axis is parallel to the stage XY plane).

  Because the image is a two-dimensional representation of a three-dimensional object, certain distortions occur. For instance, a square grid image appears rectangular when you tilt the specimen. This function corrects the aspect ratio and restores the square appearance.

- The **Tilt Angle** list box enables to choose between 3 modes.

  In the **Automatic** mode the **Tilt Angle** is equal to the stage tilt plus the **Specimen Pre-tilt** linear adjuster value (a Tilt Angle correction in case the specimen is not parallel to the stage XY plane).

  In the **Automatic (Cross Section)** mode 90° is added to enable observing of the cross section perpendicular to the sample surface.

  When in the **Manual** mode, the linear adjuster enables to manually set the Tilt Angle from -90° to +90°. It is useful when the Dynamic Focus with Automatic Tilt Angle does not give satisfactory results (or cannot be used at all because the specimen is tilted in direction different from the stage Tilt).

When switching from Automatic to Manual mode, the actual Tilt Angle is not changed. When switching to Automatic mode, the Tilt Angle is set to the actual stage tilt.

If the Dynamic Focus is on and the Tilt Angle is not zero, an indicator is displayed in the optical quad.
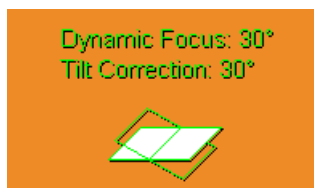
Notes:
Both Dynamic Focus and Tilt Correction work properly only if the specimen (scanned area) is tilted around the X-axis (in the same direction as the stage Tilt). Therefore they cannot be used with Automatic Tilt Angle in combination with a not zero Scan Rotation. If the specimen is tilted in a different direction, you have to align the tilt axis horizontally using the Scan Rotation and then optimize the image focus by tuning the Manual Tilt Angle.

Both functions are also disabled (check box cleared) in the Crossover mode.

Due to the limited range of the dynamic focusing, the overall conditions should be in certain limits. If the dynamic focus would be out of the range, the checkbox becomes disabled. To enable it again, you can try one or more of these actions: decreasing the Tilt Angle, increasing the
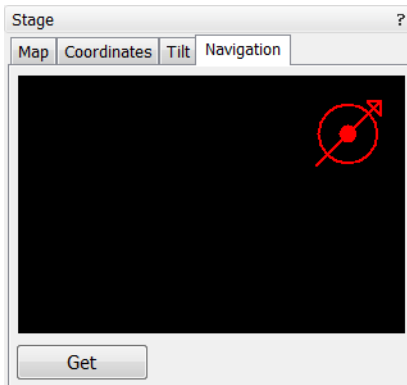
magnification or the working distance, decreasing accelerating voltage or switching the Tilt Correction on (this helps especially at high tilt angles).

Navigation Tab

Click the **Get** button to capture a selected quad imaging into the Navigation tab. Drawing a green bordered box (by clicking & dragging) inside it depicts an observed area from that point on.

By clicking & dragging the box inside the navigation image an observed area could be changed (affecting the selected quad). By clicking & dragging its boundary a box size could be changed, or it is also possible to draw a new one.

STAGE RELATED FUNCTIONS

Stage Movements – Keyboard Shift

The stage can be moved by 80% / 40% of the field of view in perpendicular direction by pressing / Shift + pressing the appropriate keyboard arrow key.
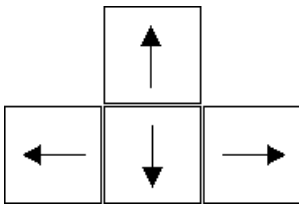
Stage Movements – Track mode

This function allows continuous directional stage movements at a variable speed (see **Preferences…** / **General** tab / **Switch sample tracking on mouse wheel click** item):

- The **Wheel-click & drag** mode – the yellow **dot** appears onscreen in a selected imaging quad at the mouse cursor point. Move the mouse to the direction intended for an observation – a yellow **arrow** appears onscreen denoting the direction opposite to the stage motion. The motion speed raises with the distance between the arrow and the dot, the direction can be changed by moving the mouse. When you come to the place of interest, release the mouse wheel – the action stops.

- The **Wheel-click & move** mode – the mouse wheel does not need to be held, just click the desired direction to start the Track motion and click again to stop it.

In the optical quad clicking the mouse wheel activates the stage Z movement, which can be seen live.

- **Wheel-clicking & dragging** the mouse up / down moves the stage up / down (Z-coordinate).
- **Ctrl + Wheel-clicking & dragging** the mouse left / right tilts the stage in positive / negative direction.

The direction is indicated by a yellow arrow, either pointing up / down from the horizontal line or left / right from the vertical line.
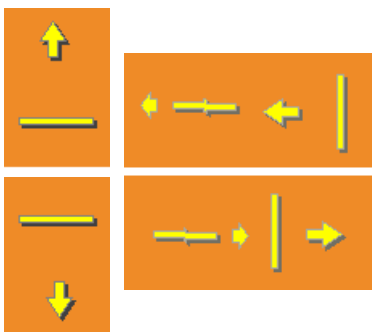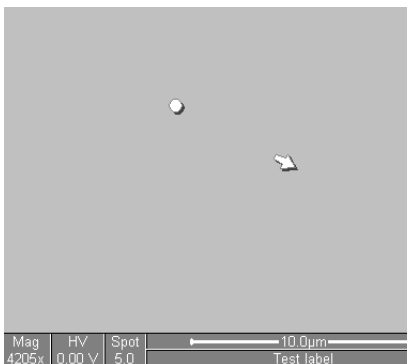
Stage Movements – Get mode

This function brings an image point of interest to the screen center.

Double-click an image point. The object is mechanically centered onscreen by moving the stage, which is suitable for lower magnifications. When working at higher magnifications, beam shift could be also employed (see the **Preferences…** / **General** tab). In this case the object is electronically centered onscreen by moving the electron beam. When the beam shift comes to a limit in any direction, its value resets and the necessary stage movement adapts the observed point position.
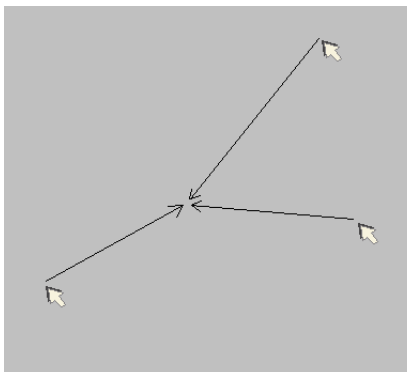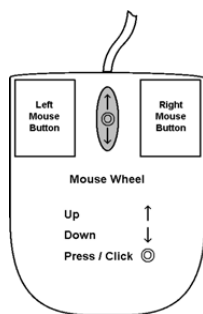
Beam Shift

When you want to employ the beam shift only (which is suitable for higher magnifications), shift + click an image point. Drag the **Hand** cursor to move the imaging area in any direction.

When the limit of the beam shift has been reached, either the **Stage** menu / **Auto Beam Shift Zero** or the **Beam Shift Reset** function needs to be applied (see Chapter 3). In this case the beam shift is reset and the observed point position is adapted by the stage movement.

Releasing the mouse button stops the action.

xT Align Feature…
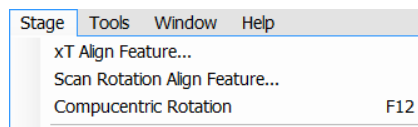
This utility is designed specifically for long features, extending off the screen at the magnification required for an observation. It applies the mapping process bringing the long feature either to the horizontal or vertical axis to make the navigation easier. This can be performed at any point within the stage field limits and takes into account the stage rotation offset.

Note:
xT Align Feature works best at the eucentric position (see above). Longer distances result in a greater accuracy.

C a u t i o n !

Watch the obstacles significantly extending from the sample plane, as these may interfere with equipment under the lens.

1. Select a long feature of interest on the sample.
2. Click the **Stage** menu / **xT Align Feature…** Choose either **Horizontal** or **Vertical**, which relates to the desired final sample orientation. Click the first point along the feature, the **P1** coordinates update.
3. Click the second point along the feature, the **P2** coordinates update. Right-clicking anywhere in the imaging area deletes points, enabling to define them again.
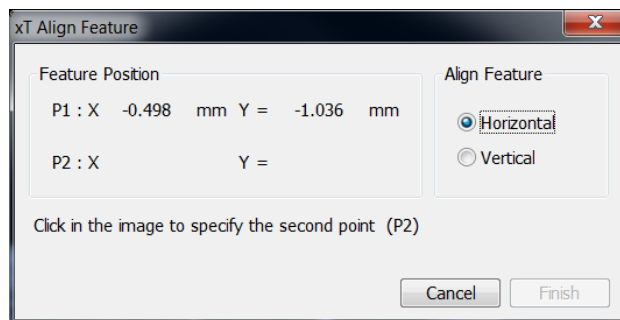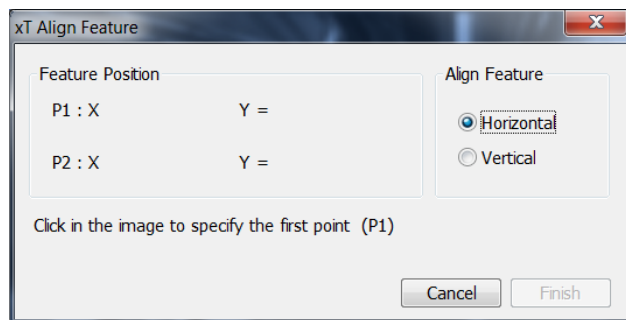
4. Drag any point to change its position, if needed. Click the **Finish** button to orientate the feature either **Horizontal** or **Vertical**, as selected previously. Click the **Cancel** button any time to cancel the function.
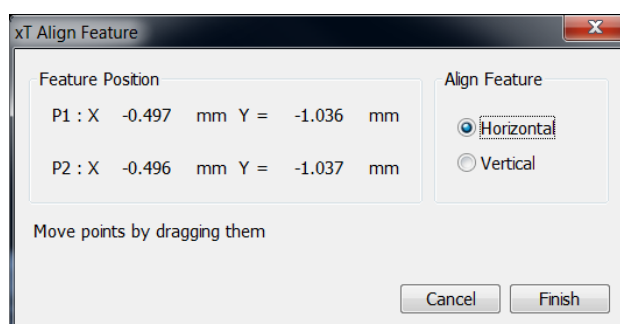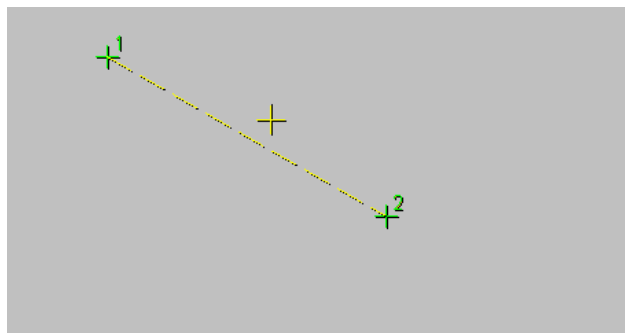
Scan Rotation Align Feature

This procedure helps to navigate along a feature that is rotated disadvantageously. Unlike the xT Align Feature… the rotation is performed by scan coils instead of the stage.

1. Click the **Stage** menu / **Scan Rotation Align Feature**. Choose either **Horizontal** or **Vertical**, which relates to the desired final sample orientation. Click the first point along the feature, the **P1** coordinates update.
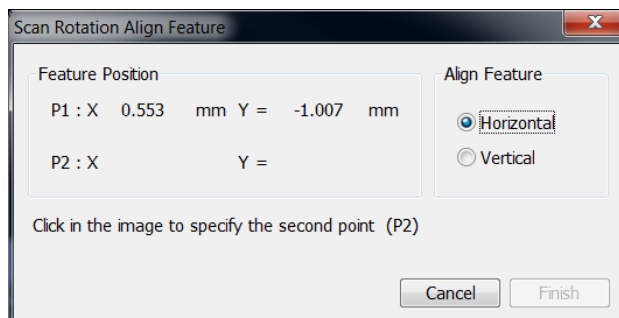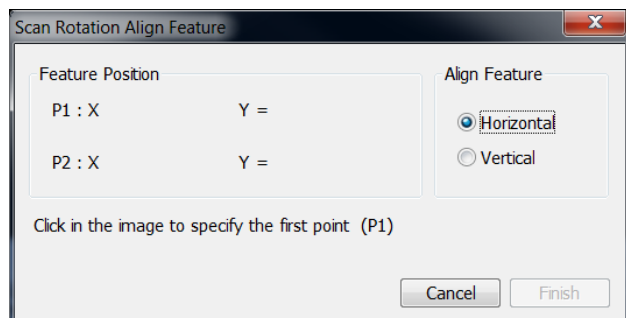
2. Click the second point along the feature, the **P2** coordinates update. Right-clicking anywhere in the imaging area deletes points, enabling to define them again.

3. Drag any point to change its position, if needed. Click the **Finish** button to orientate the feature or click the **Cancel** button any time to cancel the function.
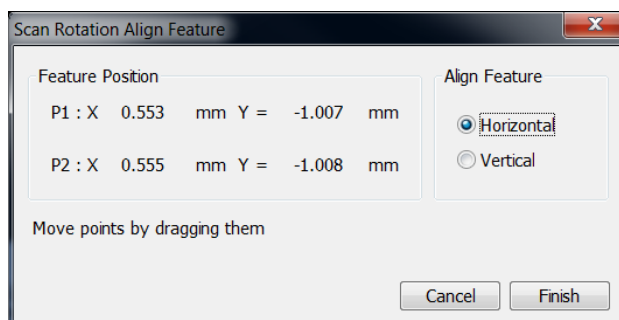
Compucentric Rotation (F12)
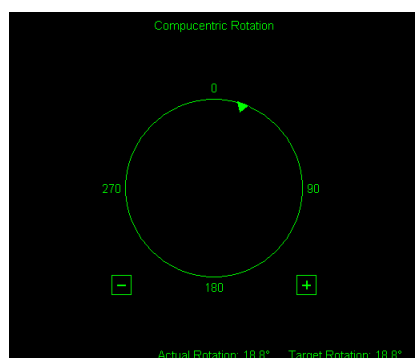
Clicking the **Stage** menu / **Compucentric Rotation** places a green circle in the image window. The green triangle on its perimeter denotes, by its position, the sample rotation relative to its original position when mounted on the stage. Initially, this is in the 12 o'clock position. Click & drag it around the circle to choose a new sample rotation.

The readouts displayed at the image window bottom provide information about the **Actual Rotation** (original position) and the **Target Rotation** (the selected position).

Releasing the mouse updates the stage position to bring the original field of view (rotated to the Target Rotation position) onscreen. With the sample at the eucentric position this can be performed at any sample point irrespective of the mechanical stage center.

Clicking the written angles around the circle perimeter (0° / 90° / 180° / 270°) or the perimeter anywhere drives the stage to that rotation position and the green triangle updates onscreen. Clicking the framed **+** / **–** sign increases / decreases the rotation angle by an incremental value.

User Units

Clicking the **Stage** menu / **User Units** activates user defined units as the basis of the stage coordination system. A tick mark appears next to the label and **UU** in the **Stage** module / **Coordinates** tab next to the X and Y value box. The stage coordinate system reverts to the last defined user unit configuration.

Define User Units…

This procedure assigns user-defined points to stage points. The stage coordination system can be anchored to either 1, 2 or 3 points, depending on the sample management or application.

For example, if you choose a (0,0) position, you can drive the stage relative to that origin using user defined units (0,1 / 1,0 points), which may equal to some repeated sample structures etc.

Particular dialogue buttons

- **Finish:** ends the procedure at the point(s) 1 / 2 / 3 just defined.
- **Details:** displays the resulting coordinates with the possibility to browse them (**Go to** button) and edit values.

1. Select a sample surface feature and view it at an appropriate magnification to check its relation to other structures.
2. Click the **Stage** menu / **Define User Units…** A **Start** dialogue appears. Click the **Define New User Units** radio button.

Redefine User Units – for changing or updating User Units.

Redefine User Units with Shift – as above with the Beam Shift.

Reset User Units so that they are equal to the Stage Units

Show how User Units are now defined – displays the actual definition with the possibility to move the points step by step.

3. Click the sample user point (0,0), its coordinates appear in the **Details…** module.
4. Repeat the step 3 for the sample user point (1,0).

5. Repeat the step 3 for the sample user point (0,1).

6. Check the **Finish** if needed or **Details** the procedure.

xTm: Define User Units - Finish
Current User Units defined on three points.
Warning: The angle between the X and Y axis of the User Units is 25 degrees.

xTm: Define User Units - Details						
	Specimen X , Y		User X , Y			
Set	-7.876 mm	-0.404 mm	0.000 UU	0.000 UU	Go to
Set	-7.055 mm	-0.830 mm	1.000 UU	0.000 UU	Go to
Set	-6.830 mm	-0.445 mm	0.000 UU	1.000 UU	Go to
Current position on specimen:			X -6.830 mm Y -0.444 mm		
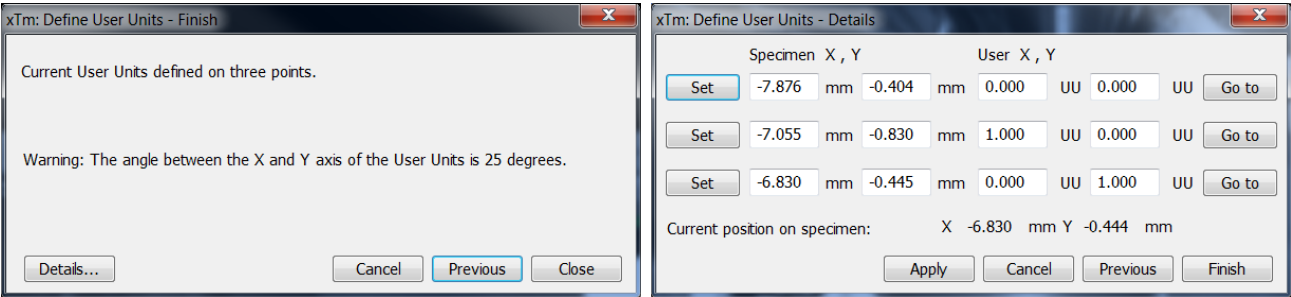
Using 1-, 2- or 3- Point Alignments

TABLE 5-4   ALIGNMENT TYPE DIFFERENCES

Use	1-Point Alignment	2-Point Alignment	3-Point Alignment
Major Use	Aligning to new point directly offset from the existing location	Aligning the stage axes with the specimen X-Y orientation to correct for any distortion	Transforming to nonstandard units on dies or RAM arrays; correcting for any distortion
Change in Scale	None	Scales the axes together	X can be scaled differently from Y
Change in Orientation	None	Rotates both axes with a fixed 90° angle between axes	X and Y orientation can be different

Sample Navigation (Ctrl + N)

Sample Navigation	Ctrl+N
Navigation Montage...	
Navigation Alignment...	
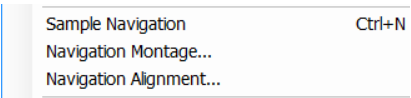
The **Stage** menu / **Sample Navigation** software feature enables to navigate along the sample surface when the field of view is smaller than desired (limited by an aperture for instance). For this purpose various sample Navigation images can be dynamically and independently selected, regardless of its actual content and status (paused, saved, loaded).

As soon as the selected quad is paused, the Sample Navigation icon appears in the upper right quad corner to indicate the functionality. This indicator is green (when the stage rotation and tilt values are equal for both captured and corresponding live imaging) and the paused imaging can be used to navigate along the live one. Otherwise it turns read and indicates no functionality in the respective quad.

A green rectangle showing the actually selected field of view (in the selected quad) appears with the size corresponding to the magnification. In quad(s) using Sample Navigation the Selected Area Zooming and the Get features could be used.

To employ the Sample Navigation there are three possible techniques to acquire (or to use) a Navigation image: Navigation Montage... / Navigation Alignment... / Nav-Cam (option – see Chapter 7).

Navigation Montage...

Navigation Montage	
Target HFW	5.3 mm
Map Size	3 × 3
Estimated Time	0:28 min
Single Image HFW	1.8 mm
☐ Use actual HFW	
☐ Switch off the beam when finished	
Start	Close

Set the **Target HFW** (Horizontal Field Width) range, which influences information fields: the number of tiles – **Map Size**, the **Estimated Time** for the procedure completion and the HFW of each tile – **Single Image HFW**.

The **Use actual HFW** check box ticked causes the system does not use automatically the HFW according to the hardware configuration and sets the user one. This is convenient when the image corners are rounded and imaging does not cover an entire area.

The **Switch of the beam when finished** check box is convenient to use in case a large Target HFW and long dwell times are used to capture the Navigation image, because the process could take a significant time to complete.
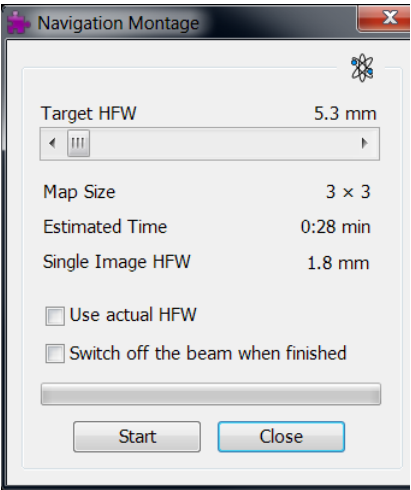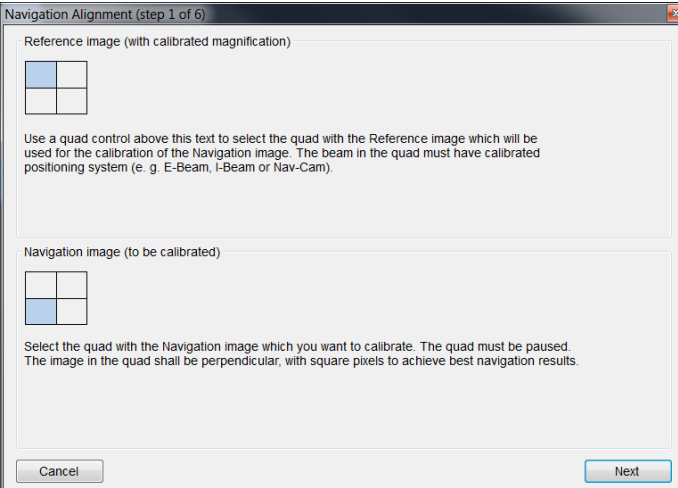
After a process completion the Sample Navigation is then automatically set on.

Navigation Alignment...

This procedure in comparison to the Navigation montage or Nav-Cam (option) enables to use any loaded or paused Navigation image, which is calibrated according to the live Reference image.

Follow instructions given within the process and calibrate 4 image points. If 2 points are sufficient for desired purposes, click the **Compute 2pt alignment** button to finish the process after setting 2 align points.

FIGURE 5-13 NAVIGATION ALIGNMENT

Scan	Beam	Patterning	Stage	T
▮▮	Pause		F6	
	Snapshot			
	Photo		F2	
	Active Preset Snapshot		Ctrl+F2	
	Videoscope		F3	
▫	Reduced Area		F7	
	Full Frame		Ctrl+M	
	Spot		Ctrl+K	
	Line			
	External			
	Beam Blank		Ctrl+B	
	Slow scan		Ctrl+Shift+","	
	Fast scan		Ctrl+Shift+"."	
	Slower scan		Ctrl+","	
	Faster scan		Ctrl+"."	
	Mains Lock			
	Line Integration (Off)		▸	
	Scan Interlacing (Off)		▸	
	Live			
	Average (4 frames)			
	Integrate (1 frame)			
	Scan Rotation		Shift+F12	
	Preferences...		Ctrl+O	

Scan Rotation: 45°

Scan Rotation (Shift + F12)

This function activates the onscreen tool to rotate the scan and align the image. Because it is solely a scan coil function, it has no effect on the stage movements. It is used to orient the image relative to mechanical rotation and detector direction.

Clicking the **Scan** menu / **Scan Rotation** places a green circle in the image window. The green triangle on its perimeter denotes, by its position, the sample rotation relative to its original position when mounted on the stage. Initially, this is in the 12 o'clock position. Click & drag it around the circle perimeter to choose a new sample rotation.

The readouts displayed at the image window bottom provide information about the **Actual Rotation** (original position) and the **Target Rotation** (the selected position).

Clicking the written angles around the circle perimeter (0° / 90° / 180° / 270°) or the perimeter anywhere drives the stage to that rotation position and the green triangle updates onscreen. Clicking the framed **+** / **–** sign increases / decreases the rotation angel by an incremental value.

FIGURE 5-14 SCAN ROTATION
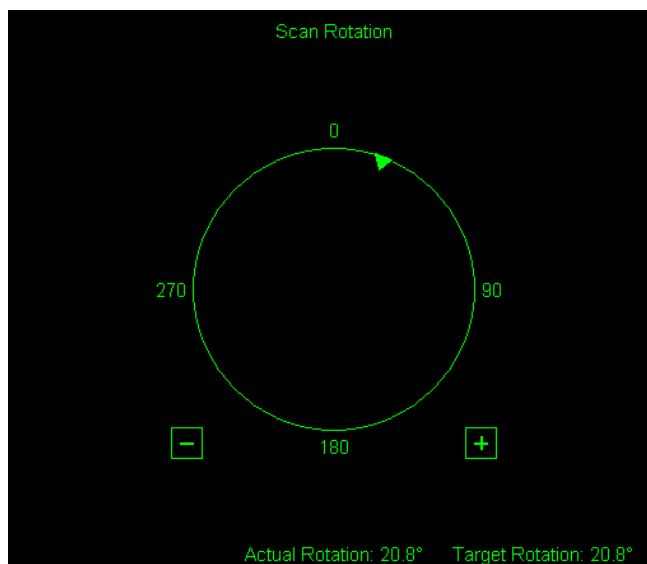
The smaller circle in the top right of an optical quad remains onscreen when the Scan Rotation angle is different from 0°.

Measurement and Annotation Functions
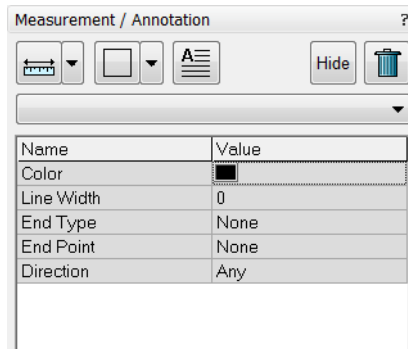
The **Processing** page / **Measurement / Annotation** functions give a user many capabilities to measure distances, angles, diameters and areas as well as locating and labelling items that are of significant interest on the sample area.

TOOLS

Selected measurement or annotation tool is displayed as the tool icon. Clicking the icon activates / deactivates the tool (the active one is highlighted). Clicking the arrow next the icon symbol opens the list of available tools to choose. The appropriate icon is shown from that time on and the item can be drawn on screen. The drawn items are listed in the list box.

- The **Measurements** enable to gain dimension information about a specimen feature by overlaying it with a measurement graphic. By changing the magnification these graphic elements resize accordingly.
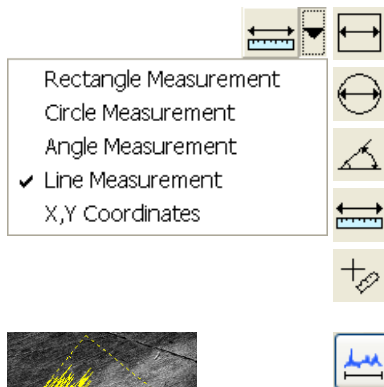
The **Intensity Profile** delineates the imaging profile across a freely selected line.
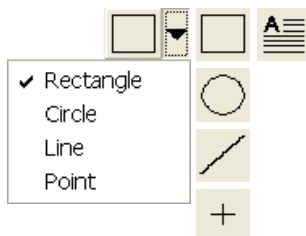
- The **Annotations** enable to graphically label items of interest.
- The **Text** enables to add further information.
- The **Trash can** button deletes selected item(s).

Property Editor

enables to change a property of a selected Measurement / Annotation / Text graphic by a selection from the drop down list or by a direct editing of a text or a value.

Shape Creating

1. Choose the suitable **Measurement / Annotation** graphic tool.
2. Draw the graphic over the area of interest. This can be done by:
   – clicking & dragging the cursor from the top left to the bottom right corner of the rectangle shape.
   – SHIFT + clicking & dragging: the shape starts to grow from the point where you have clicked as from the center.
3. Choose the **Text** symbol and then just click where you require a text in the image. Type the text into the **Property** editor text field. Click the text or press the enter key to confirm it and the text appears onscreen.

Shape Editing

Once a Measurement or Annotation symbol has been drawn, it can be modified. **Selected graphic** is denoted by the addition of resizing handles to the graphic outline (use pointer cursor).

Size and position the graphic correctly over the area of interest. A number of other choices are available in the **Property editor** for each graphics drawn.
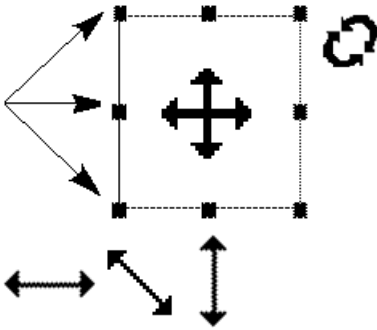
- **Move / Rotate graphic:** click the cursor inside the boundary of the pattern / in the vicinity of a corner & drag it (move / rotate cursor). Pressing the Ctrl + Alt keys while hitting any arrow key moves the pattern in an arrow direction for a fixed distance.
- **Resize graphic:** click & drag the resizing handle until the desired size is reached (horizontal / vertical / diagonal resizing cursor). Pressing the Ctrl key while dragging forces dimensions to be changed proportionally. Precise dimensions could be also entered in the Property editor.
- **Selecting all Items** (in a selected quad)**:** press **Ctrl + A**.
- **Delete selected Item(s):** click the **Trash can** icon or press the **Delete** key.

6 | MAINTENANCE

This section describes the procedures necessary for the maintenance of the microscope that can be carried out by the **Supervisor / User**. For the User maintenance is at a minimum due to Gun and Column design and the long uptime expected from this class of instrumentation. Therefore the more complicated maintenance is normally contained in a service contract to be performed by a qualified service engineer.

At the user level items such as the following can be maintained:

*   Cleaning Procedures Overview
*   The Strip Aperture Module
*   Gaseous Detectors
*   Stage Maintenance
*   Refilling the Water Bottle
*   Rotary Pump Maintenance

C a u t i o n !

- read Chapter 1 (Safety and Handling) before proceeding with any maintenance.
- Parts that operate in vacuum should be handled carefully using clean powder-free gloves. Parts not in use should be stored in suitable containers or packed in aluminium foil.
*- the **EDX window** (if present) **is very fragile** and **must be protected from air burst or vacuum turbulence**. It is recommended to remove the detector before major cleaning activities.*

Note:
Gas back fill (N_2) should be maintained while the specimen chamber is at ambient pressure. However, to avoid gas waste it is recommended that the chamber should be left vented no longer than necessary.

Cleaning Procedures Overview

Frequency of cleaning is, in most cases, determined by necessity due to poor image quality or gross astigmatism level. Recommended cleaning procedures are given below for parts which operate in vacuum and which are subject to possible contamination.

LIST OF APPLIED CLEANERS

- De-ionized or distilled water – H_2O
- Ethanol – C_2H_5OH
- Ethanol p/a (Pro Analysis: 99.8% pure) – C_2H_5OH
- Isopropanol
- Neutral pH cleaning fluid (soap solution)
- CIF* or SOFT SCRUB (fine abrasive household cleaner) or 0.05 µm alumina powder

TABLE 6-1   HOUSEHOLD CLEANERS

Country	Name
Austria	CIF
Australia	CIF
Finland	CIF
France	CIF
Germany	CIF
Italy	CIF
Japan	CIF
Netherlands	CIF
Switzerland	CIF
UK	CIF
USA	Soft Scrub

WARNING!
The cleaning solvents ethanol and isopropanol are highly flammable! Do not use open flames and do not smoke while cleaning. Ventilate the room properly.

CLEANING COLUMN PARTS

All column parts are polished before the instrument is delivered. For this reason only occasional light polishing is required to remove contamination that may build up on components in the column and specimen chamber as part of normal operation. Any part that is exposed to the electron beam should be highly polished, and free of contamination and / or scratches that can charge and thus degrade the image.

Parts that can be removed by the general Supervisor / User and polished include the following:

• LVD and Helix detectors

C a u t i o n !
Gold plated parts should not be polished with abrasives.

MATERIALS AND TECHNIQUE

To polish components, place a lint-free cloth on a flat surface (a glass block is ideal) and apply a small amount of Soft Scrub or CIF and distilled water to the cloth.

Place the part to be cleaned on the polish and rub with a circular motion until all contamination has been removed. For inner surfaces, use a cotton swab or wooden dowel as an applicator. A toothpick can be used for small holes.

Lint-free nylon (not cotton) or latex surgical gloves should be worn while handling parts to avoid contaminating just-cleaned surfaces. Tweezers should be used to hold small parts.

After the part has been polished, remove the Soft Scrub/CIF cleaner by washing in hot water. Inspect the part under a stereo microscope at 20× magnification to ensure that there is no remaining contamination or polish residue. Wash the part in de-ionized or distilled water in a beaker with an ultrasonic cleaner for several minutes. Transfer the part to a clean beaker with alcohol or isopropanol and clean ultrasonically again for several minutes.

Note:
Do not use an ultrasonic bath to clean the LVD or Helix detectors.

When the components are dry (a compressed air 'duster' can speed drying), reassemble and return to the column. If a part is stained, heat it with hot water and immediately rinse with alcohol and dry using compressed air.

Cleaning Tips

Parts exposed to the electron beam require periodic polishing. This will ensure maximum performance of the instrument for many years.

Do not use metal polishes such as POL or WENOL to clean parts as these can leave outgassing material. Be aware that threaded surfaces should not be polished as these do not have contact to the beam and are a source of outgassing if polish is trapped. Wash threads with alcohol or isopropanol if absolutely necessary.

After cleaning, inspect all parts for residue and stains using a light microscope.

Down time can be reduced by purchasing detector assemblies and having them cleaned and stored in a safe place, where they can be ready to be installed into the microscope.

Strip Aperture Module

The objective apertures are holed on a Molybdenum strip which is mounted on a metal holder. The strip has 5 aperture positions and 1 mm alignment hole in the frame. The strip comes aligned in a metal module which is connected to the end of the Aperture rod by a screw. The module is considered as a consumable and therefore would be normally replaced when heavily contaminated. In some cases it is possible plasma cleaning with any available plasma cleaner (in this case follow the equipment instructions). There is also a heater in the rod to assist cleaning / anti-contamination. All screws are made of Titanium not to have any magnetic effect.

FIGURE 6-1   STRIP APERTURE MODULE

REMOVING THE APERTURE ROD

1. With the high voltage off, vent the specimen chamber to the atmospheric pressure (the Aperture rod is in the same vacuum space as the specimen chamber).
2. If connected remove the heater cable from the outer end of the rod.
3. Unscrew the end of the Aperture rod and carefully remove it from the microscope.

Note:
Preparation to clean or replace apertures should be immediately available as the specimen chamber has to stay at atmospheric pressure for the duration of maintenance.

REPLACING THE APERTURE MODULE

The new Aperture Module comes in a fluorine ware container and is ready to be used.

1. Unscrew the Titanium screw holding the old module onto the rod. Keep the screw in the hole of the rod and let the module fall away.
2. Open the new module pack and let the new module sit with the connection end uppermost to the edge of the container base.
3. Pick up the new module with the Titanium screw end and fasten, making sure of a good fit.

REPLACING THE APERTURE ROD

1. Check that there are no fibres on the rod 'o' ring. Do not grease the 'o' ring.
2. Replace the Aperture rod back into the Aperture Adjuster assembly on the column and turn the end screw mechanism until the holder is hand tight.
3. Pump the microscope specimen chamber
4. Reconnect the heater cable to the outer end of the rod if necessary.
5. Set the aperture at a 30 micron hole so that alignment can be performed.

APERTURE AVAILABILITY

These apertures are the present used and come in two size types.

1. Mo Strip Aperture (30, 30, 40, 50, 100 µm)
   This type can be used for general applications including EDX.
2. Mo Strip Aperture (10, 15, 20, 30, 30 µm)
   This type can be used for ultra high resolution applications.
3. Strip Aperture (20, 30, 30, 40, 50, µm)
   This type can be used for high resolution applications, such as low voltage.

Note:
These apertures are on purpose made for the 7 position Aperture Adjuster assembly, although they will fit the earlier 4 position design not all apertures can be accessed.

Gaseous Detectors

WARNING!
Before removing the LVD, disconnect the microscope from the mains and apply the LOTO procedure (see The Safety Manual for a detailed description).

CLEANING THE HELIX OR LVD

This section will describe how to remove and disassemble the Helix assembly for cleaning.

1. Vent the chamber.
2. Turn the detector bayonet lock counterclockwise to the stop and pull it out from the final lens tip.
3. Disconnect the detector cable from the connector placed the specimen chamber.

The PLA is a part of the Helix detector and can be cleaned by inserting carefully a toothpick (or a similar soft pointed pick) into the hole and twisting gently.

Stage Maintenance

STAGE MECHANICS

Checking the condition of the stage should be a weekly exercise as many differing samples may be exchanged in this time period. Some samples may be powders or composite materials that inadvertently drop particles on or in the stage. If a silicon wafer breaks in the chamber it can shatter into hundreds of pieces. In this case the stage should be thoroughly cleaned before attempting movement again.

Cleaning Stage parts

Abrasives and solvents must not be used on the moving stage parts. Cleaning with a vacuum is the ideal method. If not available, cleaning should be done by using dry nitrogen gas bursts around the stage mechanics to blow out any foreign materials. Make sure the final lens and detectors are protected from the turbulence. Do not use sharp metal objects to scrape away debris. A fine pair of plastic tweezers can be used to pick up difficult particles. Spillages on the stage should be wiped up using a lint-free cloth, followed by vacuuming or blowing with clean gaseous nitrogen.

SPECIMEN HOLDERS

Recommended cleaning procedures are given below for parts which operate in vacuum and which are subject to possible contamination. Frequency of cleaning is, in most cases, determined by necessity (image quality or astigmatism level).

Cleaning

1. Clean these parts using a lint free cloth and a mild abrasive domestic cleaner (see list of preferred cleaners at the end of this chapter).
2. Rinse in tap water.
3. Clean in an ultrasonic cleaner for 5 minutes using distilled water.
4. Clean in an ultrasonic cleaner for 5 minutes using alcohol p/a or isopropanol.

Caution!
Do not place parts together in the beakers. Wash separately as damage can occur to the metal surfaces.

5. Rinse in alcohol p/a.
6. First blow dry with a compressed air canister, then dry thoroughly under an infra-red lamp (15 min. to 1 hr.) at a temperature of between 80 °C and 100 °C. Do not bake in an oven!

Refilling Water Bottle

The water bottle in the instrument typically needs to be filled about once a month if the instrument is used on a regular basis at a Low Vacuum mode. The water reservoir is located on the left side of the microscope console, behind the cover. To fill the bottle, do the following:

1. Run the **154 - Water Bottle Venting** alignment procedure (see Chapter 4).

C a u t i o n !
*Be aware of the gas type connected to the gas inlet before the **Vent water bottle** button is clicked! If you are not sure, disconnect the gas pipes from the gas inlet coupling.*

2. Disconnect the quick-coupler and pull out the water bottle.

3. Remove the rubber plug and refill with distilled water (not de-ionized) until 1/3 full.

4. Mount the rubber plug and install the water bottle in the reverse order of that described above.

5. Pump the chamber. Switch to LoVac mode to force automatic purging to flush any air out of the bottle and connecting tubes.

Note:
The first time the system is pumped to LoVac mode after filling the bottle, Auto-purging may be erratic until the bottle pressure has steadied. The removal of all the gas from the liquid must be accomplished before good imaging is possible. This is done correctly when no bubbles are produced in the water when increasing the pressure in the chamber.

Pre-Vacuum Pump Maintenance

The dry pre-vacuum pump is used to directly pump parts of the vacuum system (for instance the specimen chamber after a sample exchange) and for backing the Turbo Molecular Pump (TMP). It also controls the pressure in the specimen chamber when operating in the LoVac mode.

PERIODIC CHECK

The Rotary pump may become very hot while in use, be careful not to touch the main frame of the pump. Venting the chamber will shut off the rotary pump.

C a u t i o n !
When using GIS's (option), do not allow the pre-vacuum pump to emit gases into the work place, as this can be a health hazard.

7 SYSTEM OPTIONS

A range of hardware and software are available as options for Nova NanoSEM systems. This range will be extended when new items become available. Some of the options are:

- The **Helix** Detector
- The **Lens Mounted Annular Gaseous Analytical Detector (GAD)** is similar to the standard low-kV, SSBSED, but features an additional X-ray cone with a 500 micron Pressure Limiting Aperture which seals to the objective polepiece.
- The **Directional Backscattered Detector – Concentric Backscattered Detector (CBS)**
- The **Solid-state STEM I Detector** allows detection of electrons transmitted through the sample. Regular voltage range is from 30 kV down to around 5 kV, which is of course dependent on the sample thickness.
- The **Retractable Annular STEM II Detector**
- The **SIS Scandium Image Software,** the **SIS webRacer,** the **SIS Scandium Desktop Licence**
- The **Pattern Generation Software –** patterning UI module
- The **Deposition Gasses –** Gas Injection UI module
- The **Keithley Picoammeter**
- The **Joystick**
- The **Thermal Printer Kit**
- The **Manual User Interface USB**: optional, supplementary control console providing direct manual control of microscope parameters such as focus, magnification, contrast, brightness, beam shift and stigmator.
- The **UMB Specimen Holder Kit**, **Set of 20 Specimen Stubs** for SEM's
- The **Mains Matching and Isolation Transformer SEM** provides a galvanic isolated, AC-regulated output voltage of 115 or 230 V, 50 or 60 Hz from the local grid.
- The **High-resolution SEM Course** (Acht)
- The **Nova NanoSEM Course** (Hillsboro)
- The **Advanced SEM Course** (Acht)
- The **On-site Training/Support** (1day)
- The **Set of 3 Apertures** 400 µm, 3 mm Diameter
- The **Mo Strip Apertures & Holder**: 2× 30, 40, 50, 100 µm (Additional)
- The **Mo Strip Apertures & Holder**: 10, 15, 20, 2× 30 µm
- The **Mo Strip Apertures & Holder**: 2× 30, 50, 2× 30 µm

Contact your FEI sales representative for more up-to-date information on system options.

This chapter covers hardware and software that is an option either integrated in, or accessory to the Nova NanoSEM System Series. Items covered here are:

- Manual User Interface
- Joystick
- Optional Detectors
- X-ray Analysis
- Specimen Current Measurement
- Nav-Cam
- Remote Control Imaging
- Quick Loader
- Patterning
- CryoCleanerEC option
- CryoMAT
- Plasma Cleaner
- Electrostatic Beam Blanker
- UMB Specimen Holder Kit
- Stage Mapping

Manual User Interface

The Manual User Interface (MUI) provides knobs to perform functions that can also be performed with the software. It is connected to the USB connector located on the microscope controller.

FIGURE 7-1 MUI

The MUI offers additional flexibility for controlling magnification, beam shift, focus, astigmatism, contrast and brightness.

Joystick

The Joystick provides knobs to perform functions that can also be performed by the software. It is connected to the USB connector located on the microscope controller.

FIGURE 7-2 JOYSTICK

- The Up / Down **lever** motion moves the stage in Y axis.
  The Left / Right **lever** motion moves the stage in X axis.
  The Left / Right **lever** rotation rotates the stage left / right.
- The button **1** is not used.
- The button **2** is used together with the lever motion:
  - Up / Down moves the stage up / down
  (regardless the Link Z to FWD status).
  - Left / Right tilts the stage left / right
  (available for stages with motorized tilt axis movements).
- The button **3** speeds up the stage motion:
  - 10× in X / Y axis
  - 5× in Z axis
  - 2× in R / T axis

Optional Detectors

HELIX DETECTOR

This detector is used as an optional detector for the Low Vacuum mode in the whole pressure range from 0.08 to 1.5 Torr (10 - 200 Pa). It limits the field of view to about 0.5 mm at the working distance of 5 mm. The minimum working distance is limited to about 3 mm.

FIGURE 7-3   HELIX DETECTOR
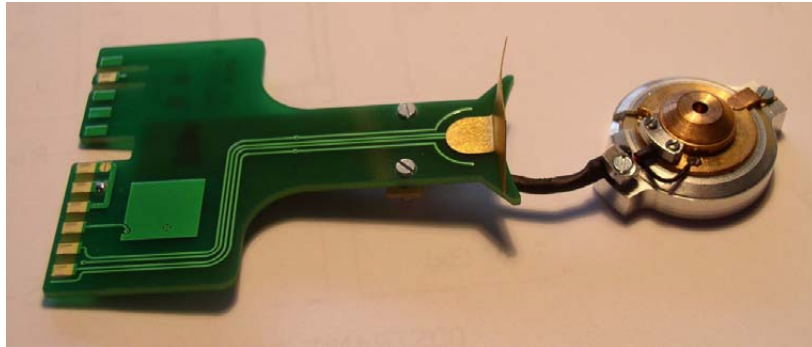
This detector is in fact the combination of the LVD and Helix detectors. Usage of the LVD part is the same as described (see Chapter 5). The Helix part can be used in all SEM imaging Modes, but is primarily designated and gives superior signal in Mode 2 (immersion). It is the best detector for high resolution imaging at Low Vacuum conditions.

Only one of the LVD / Helix detector signals can be acquired at a time. Therefore the LVD / Helix detector appears in the xT microscope Control software as two independent incompatible detectors. Selecting either the LVD or Helix detector in the software activates the corresponding part of the physical detector and de-activates the other one. If the other detector is chosen in another Quad, this Quad is automatically paused.

Installing / Removing Helix Detector

Follow the procedure described for the standard LVD (see Chapter 5).

Helix Settings

After the pump down and the purge process, switch on the accelerating voltage. The **Detectors** module / **Bias** is automatically set to the last used value. Adjust it to increase the signal or to stop possible discharges. Keep the pressure as low as possible.

The **Ion Trap Voltage** influences the gas cascade process, which enables detection in LoVac mode. By setting appropriate value of ion trap voltage (from -100 V to +100 V; default value 0 V is sufficient for most applications) stable conditions at sample surface can be achieved. This is important especially for highly charging samples.

Spot 4 will always give a sufficient signal. Set the lowest possible magnification and increase the Contrast until a small bright circle can be seen in the center of the screen. Increase the magnification and adjust the Contrast and Brightness. In SEM Mode 2 it is possible to use Spot 3 (or smaller).
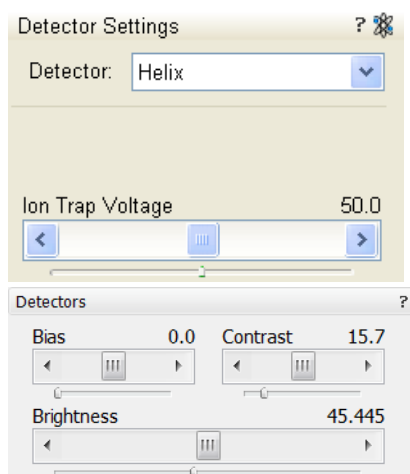
LENS MOUNTED ANNULAR GASEOUS ANALYTICAL DETECTOR (GAD)

This is the low voltage solid state backscattered detector with two concentric diodes segments. It has 500 µm PLA cone for **Low Vacuum** operation, especially the X-ray analysis, which extends from the objective pole piece down to working distance of about 2.2 mm. This reduces the gas path length of the primary beam about 2.8 mm for a specimen at the 5 mm analytical working distance. The diode has an active area of approximately 31 mm^2 per segment and it is positioned directly over the sample to achieve maximum detection efficiency. Therefore it causes some limitation in the tilt range.

FIGURE 7-4   GASEOUS ANALYTICAL DETECTOR
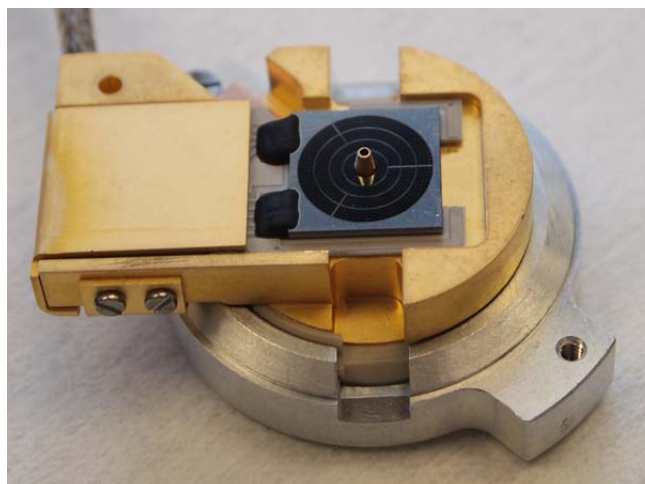
The detector is not compatible with the Beam Deceleration mode, it can be used down to Accelerating Voltage below 1 kV.

Installing GAD

Remove the detector from its parking holder. Hold the detector by its aluminium handle (diode pointing downwards) and put it gently on bayonet base of the objective lens. Turn to the left to fix it on the base.

Caution!

The diode is sensitive to mechanical damage so the active area (shiny diode) should never be touched. The GAD is mounted close to the (optional) X-ray detector collimator, which must not be touched when changing detectors. It is advisable to retract the EDX collimator when mounting / removing a detector on / from the objective pole piece.
With the GAD mounted on the objective pole piece, the minimum working distance is limited to about 3 mm.

Detector home position

The detector could be placed into a holder which is mounted inside the chamber. This keeps the diode safe from being hit by the the stage or a specimen when not used.
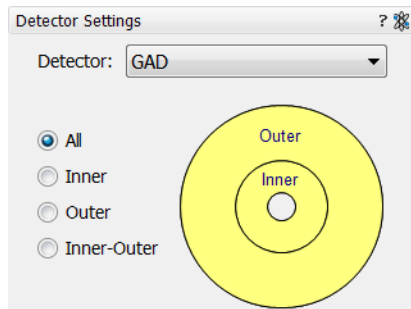
GAD Settings

1. Select the **Detector Settings** module / **Detector: GAD** or from the **Detectors** menu.
2. Select the radio button to choose a desired segment combination (yellow / blue color adds / subtracts the segment signal):
   - **All** – the strong topographical and material contrast
   - **Inner** – the normal BSE image:
     suppressed topographical and strong material contrast
   - **Outer** – the pseudo-topographical image:
     suppressed material and maximum topographical contrast
   - **Inner-Outer** – the highest material contrast

SPECIAL LOW VACUUM DETECTOR (LVD)

This detector is delivered together with the GAD (see above). It has no PLA to enable simultaneous operation with the GAD. For the control and setting follow the LVD description (see Chapter 5).

DIRECTIONAL BACKSCATTERED DETECTOR – CONCENTRIC BACKSCATTERED DETECTOR (CBS)

The CBS uses concentric segmentation of the detector diode to distinguish between BS electrons scattered close to the beam axis – inner segment (preferentially compositional contrast) and electrons scattered far from the beam axis – outer segment (more topography signal). Z-contrast mode provides signal collection from all detector segments.

FIGURE 7-5 DIRECTIONAL BACKSCATTERED DETECTOR / RETRACTABLE VERSION

Installing Lens Mounted CBS Detector

Follow the GAD installing procedure (see above).

Inserting and Retracting retractable CBS Detector

Before insertion the retractable version of the CBS detector, a user needs to set the following conditions:

- Chamber is pumped to HiVac.
- The Link Z to FWD procedure must be done, the WD must be more than 3.5 mm.
- The GIS's (if present) must not be inserted.
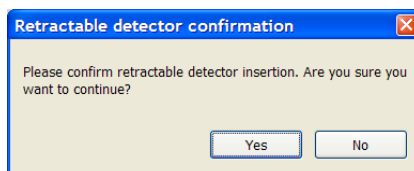
When clicking the **Insert** button the dialogue appears asking a confirmation of detector insertion or with an offer to move the stage to a safe position before insertion.

Specimen tilt is limited for insertion and operation of the retractable CBS. The tilt range depends on the WD and varies from +/- 2° at 4 mm WD up to -15° to +75° at 15 mm WD. To ensure additional safety, rotational axis is locked and maximum X / Y axis movement in the Get Mode is limited to 100 µm if the Tilt exceeds +/- 2°. The following figure shows preferred specimen position at the multistub specimen holder.

Retracting the detector is automatic with the Stopping / Starting the server or venting the chamber. Otherwise user can use the **Retract** button.

When the detector is retracted, the information text is displayed in each quad which uses it.

Detector Settings
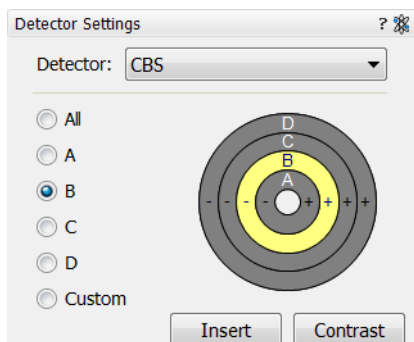
Select the CBS from the **Detector Settings** module / **Detector** list box. Choose the required mode (All / A / B / C / D / Custom) by clicking the radio button.

The **Custom** mode is used to define the segments to be used for detecting. Clicking the + / - sign over particular segment activates it to add (yellow color) / subtract (blue color) the segment signal. When the segment color is grey (clicking any sign twice), it is switched off.

The **Contrast** button is accessible only when the CBS detector is selected in several quads. Clicking it sets the brightness & contrast of each quad with CBS detector to the same level.

Distribution of electrons collected by detector segments changes with setting of working distance, lens mode and Beam Deceleration mode.

It is also possible to set different concentric segments in particular quads and thereafter to use the **Enhanced Image** module / **Mix 3** or **Mix 4** tab to mix color coded signals to create color images (see Chapter 5).

C a u t i o n !

When plasma cleaning (see below), place the CBS / GAD detector to the parking holder inside the chamber or out of chamber to protect it against damage.

RETRACTABLE DETECTORS CONTROL
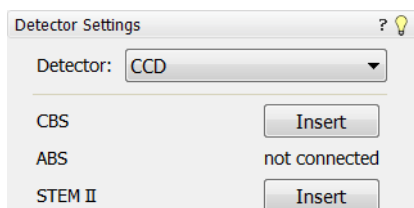
When any retractable optional detector is installed on the system, the appropriate **Insert** / **Retract** button is added to the **Detector Settings** module / **Detector: CCD** to enable the equipment control while observing the optical quad.

SCANNING TRANSMISSION ELECTRONS MICROSCOPY DETECTOR (STEM I)

The STEM I is a two segment solid-state diode mounted underneath the STEM I holder. It can be used at any available working distance (preferably close to the lens for high resolution) or at the eucentric position for simultaneous use of the EDX. It works best at a slow scan conditions.

The mounting pin below the detector locates into the standard conical single stub mount. The detector is connected to an SSD pre-amplifier input board.

Note:

When the STEM I detector is mounted to the chamber, stage rotation and tilt are locked automatically for the safety. It is possible to unlock these stage movements manually, but beware of possible detector cable damage while rotating or tilting the stage.

FIGURE 7-6 STEM I

Settings for STEM I Detector

The detector segments A (left) and B (right) can be switched independently, enabling the bright field (BF) or dark field (DF) contrast mode.

The STEM I holder has 8 positions for TEM sample grids. The following table refers to the positions numbering and their related capabilities.

TABLE 7-1   STEM I HOLDER POSITIONS

Grid Position	Observation Mode and Diode switching
1D and 5D	The object is left / right of the segment separator: **Segment A** gives BF / DF **Segment B** gives DF / BF
2,3,4	BF – use **Segment B** only
6,7,8	BF – use **Segment A** only

The **A+B** condition (default) can be used for the first time since the entire detector is working, which facilitates to get an imaging. To switch BF / DF choose **Segment A** / **B** in the Detector Settings module.

Choosing **A-B** gives a negative imaging that although will not be used frequently may highlight features by contrast not easily seen otherwise.
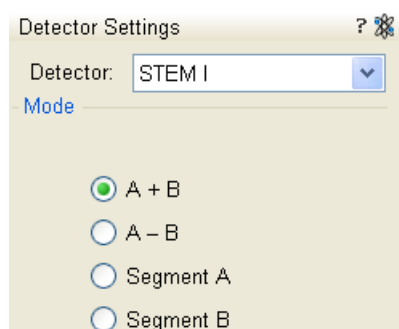
Loading samples

Materials or hard samples should be prepared as for the TEM by appropriate thinning technique. The STEM I holder (which is a part of the detector assembly) can either be loaded with samples while outside the microscope chamber (which is more convenient) or when it is mounted and fixed to the stage.

1. Remove the holder top (by loosening the central screw). This exposes the 8 grid positions (round holes with tweezers slots).
2. Load the TEM grids with samples face-up into the grid holes.
    The holder top has raised rings to press down in the grid holes to hold the TEM grids firmly in place. The holder top numbers should overlay the same ones on the base plate.
3. Replace the holder top carefully and tighten down the central screw.

To remove sample grids proceed in the reverse order.

Imaging

1. Switch on the accelerating voltage at 20 kV, set the spot size to 3.
2. Using a fast scan focus the top of the STEM I holder surface with SE detector.
3. Link Z to FWD and bring the focused surface to a 5 mm WD.
4. Move to the appropriate sample position and focus the TEM grid bars. The WD and Z position has now lengthened and re-setting of the Z-axis value to 5 mm is necessary.

This procedure is necessary to prevent inadvertently bringing the detector in contact with the final lens. The minimum safe distance to the sample surface is 1 mm. Be aware that the STEM I holder surface is now closer to the lens than the sample.

By moving off the grid bars and fine focusing most imaging corrections (image rotation, astigmatism) can be performed in the SE Mode.

5. Choose the **Detectors** menu / **STEM I** detector and select the segment mode, depending on the sample position in the holder. A transmission sample image should be visible at a low magnification.

•   The **BF image:** change the accelerating voltage to suit the contrast necessary through the sample. For example light element materials (such as silicon or silicon oxide) may work better with 5 - 10 kV to create contrast, whereas dense materials (such as metals) may require 10 - 20 kV or higher. Finally set the magnification, fine focus and correct the astigmatism.

    If the aperture adjustment is needed, it may be achieved more easily by momentarily switching to ETD, because a faster scan speed can be used.

•   The **DF image:** the samples that reside in the 1D and 5D positions can be observed in the dark field mode. The separator line of the two diodes crosses vertically the positions of 1D and 5D. An area of interest on the left / right side of the line can be observed with the right-hand / left -hand diode for DF / BF observation.

    DF observation may require higher HV to create a suitable image as the angle subtended to the detection diode can be wide. Choosing 2× the value used for BF is a good guide level.

Detector home position

While the detector is not used, it could be placed into a holder which is mounted inside the specimen chamber, saving it from a mechanical damage and pollutions.

RETRACTABLE ANNULAR SCANNING TRANSMISSION ELECTRONS MICROSCOPY DETECTOR (STEM II)

This is a 8 segments solid-state diode mounted on a retractable arm. It must be used only with a special sample holder, oriented in an exact position monitored by a software (see below). It works best at a slow scan conditions.

FIGURE 7-7   STEM II DETECTOR

Note:
When the STEM II detector is inserted to the chamber, the stage rotation and the tilt are locked automatically for the safety.

Holder Arm Installation

1. Run the Home Stage (Shift + F3) procedure.
2. Remove all sample holders from the stage plate.
3. Screw the holder arm to the stage plate.

FIGURE 7-8   HOLDER ARM
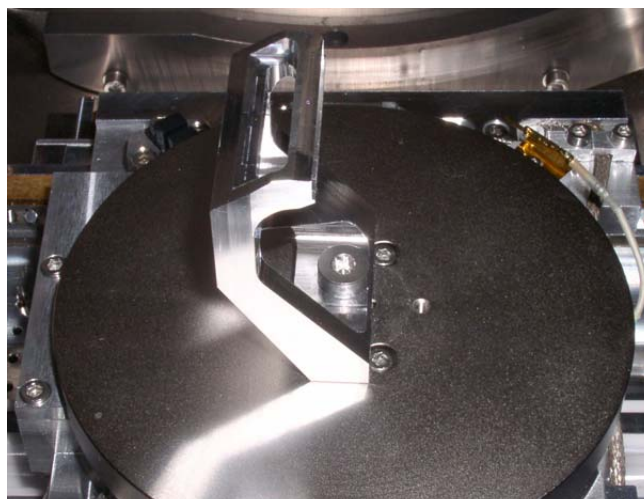
Load Sample in Row Holder

1. Place the row holder to the load base (the load base pin is beneath the position you want to load in / out). Tighten it by the screw knob, the pin lifts up the spring.

   If the pin does not lift up the spring enough to put the sample in,

adjust the lifting height by turning the screw.

2. Insert a sample under the row holder spring.

3. Release the screw knob and the entire row holder from the load base.

4. Repeat steps No. 1 - 4 to load in / out another samples.

5. Put the row holder to the arm.

FIGURE 7-9   ROW HOLDER ON THE LOAD BASE / ROW HOLDER ATTACHMENT INTO HOLDER ARM
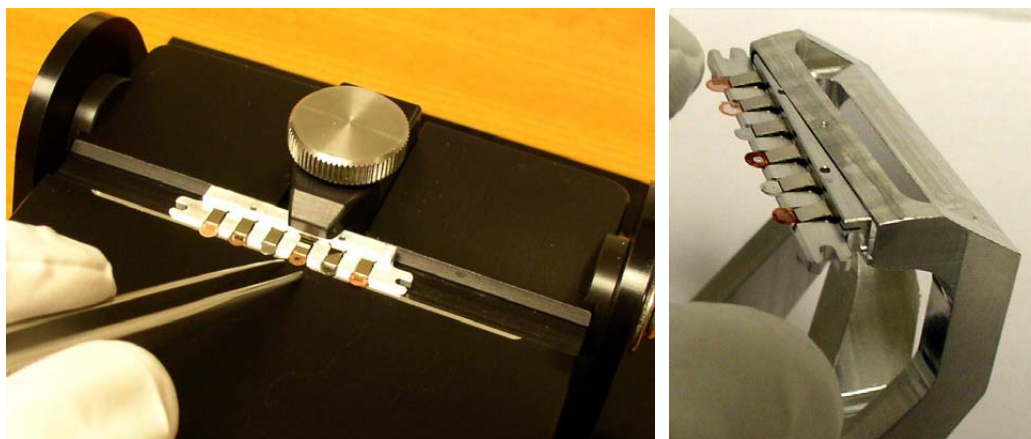
Inserting and Retracting STEM II Detector

C a u t i o n !

Always take care of any stage movement which could cause a collision with the STEM II detector. Any collision can cause damage of STEM II.

Before insertion the retractable STEM II detector, the chamber must be pumped, otherwise the **Insert** button is not active (a tooltip occurs under mouse cursor).

When clicking the **Insert** button the dialogue requires confirmation of the correct sample holder installation to enable detector insertion. When the stage is not in a correct position for insertion, another dialogue appears requiring a confirmation of moving it to the safe position.
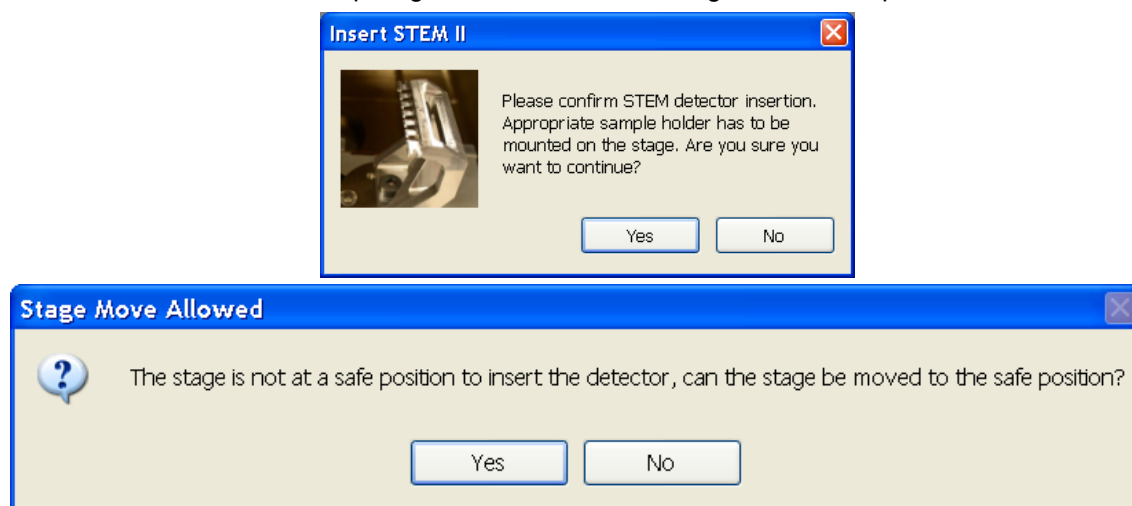
Retracting the STEM II is automatic with the Stopping / Starting the server or venting the chamber. Otherwise a user can use the **Retract** button. When the detector is retracted, the information text is displayed in each quad which uses it.
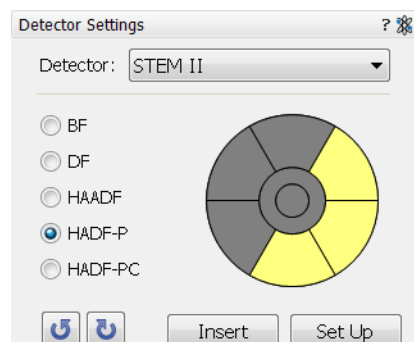
STEM II Settings

1. Position the desired sample in the field of view using the ETD. Focus and link Z coordinate to FWD.
2. Select the **Detector Settings** module / **Detector** list box / **STEM II** detector.
3. Insert the STEM II detector (see above).
- Clicking the **Set Up** button sets the **Bright Field** / **Dark Field** / **HAADF** imaging mode (see below) to the quad 1 / quad 2 / quad 3 automatically.

Bright Field imaging

1. Click the **BF** radio button.
2. Adjust the contrast and brightness. An image should be visible at low magnification.
3. Change the voltage to suit the contrast necessary through the sample.

   For example: light materials (poly-silicon or silicon oxide) may work better with 5 - 10 kV to create contrast, whereas dense materials (metals) may require 10 - 20 kV or higher.
4. Set the desired magnification, fine focus and correct the astigmatism.

Dark Field imaging

1. Obtain a Bright Field image first.
2. Click the **DF** radio button.
3. Adjust the contrast and brightness.

HAADF (High Angle Annular Dark Field) imaging

This mode may require higher voltage to create a suitable image as the angle subtended to the detection diode can be wide. Choosing 2× the value used for Bright field is a good guide level.

1. Obtain a Bright Field image first.
2. Click the **HAADF** radio button.

HAADF Partial imaging

1. Click the **HADF-P** radio button.

You can select any combination of HAADF segments by clicking it on detector diagram. Active segments are highlighted in yellow. HAADF segments cannot be combined with DF or BF.

Area of active segments can be "rotated" using the blue arrow buttons to view orientation contrast changes etc.

HADF Partial Complementary imaging

1. Click the **HADF-PC** radio button.

   It gives the signal from complementary segments to those selected in HADF Partial.

OBTAINING AN IMAGE IN BSE MODE

1. Select the corresponding Detector in a live Quad.

2. Close the chamber door and pump down the chamber.

3. Select appropriate PLA (GAD) when the Pole Piece Configuration dialogue appears. With the GAD the available chamber pressure ranges from 0.08 to 1.5 Torr (10 - 200 Pa).

4. When the Vacuum is ready, switch on HV and slowly increase contrast and brightness to obtain an image. The detector works best at a slow scan conditions.

Note:
Whenever the GAD / STEM I / STEM II / CBS is selected, the optical quad is paused (because the CCD camera infra-red LEDs are switched off not to emit the photons supersaturating the detector diode).
The special LVD (without PLA) is attached to the GAD option, which can be used in parallel with it. This allows simultaneous use of SE, BSE in a gaseous environment.

Energy Dispersive X-ray (EDX) Analysis

The EDX (sometimes referred to also as EDS analysis) is a technique used for identifying the elemental composition of the specimen, or an area of interest thereof. It works as an integrated feature of a scanning electron microscope (SEM), and cannot operate on its own without the latter.
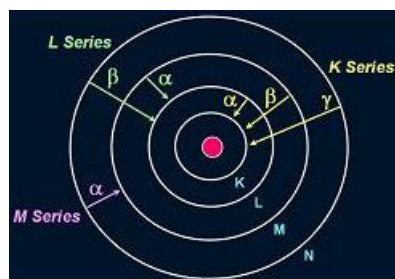
The specimen is bombarded with an electron beam inside the microscope column. These electrons collide with the specimen atoms' own electrons, knocking some of them off in the process. Positions vacated by ejected inner shell electrons are occupied by a higher-energy electron from an outer shell, while giving up some of its energy by emitting an X-ray. The amount of energy released depends on which shell it is transferring from / to. The atom of every element releases X-rays with unique amounts of energy, identifying it.

The output of an EDX analysis is an EDX spectrum, which is just a plot of how frequently an X-ray is received for each energy level. The higher a peak in a spectrum, the more concentrated the element is in the specimen.

For a X-ray analysis using either EDX or WDX spectrometer, the sample should be positioned to the eucentric position (WD = 5 mm).

HIGH VACUUM EDX ANALYSIS

HiVac operation gives the most accurate X-ray results, but the sample must be electrically conducting.

FIGURE 7-10 X-RAY IMAGING IN HIVAC MODE
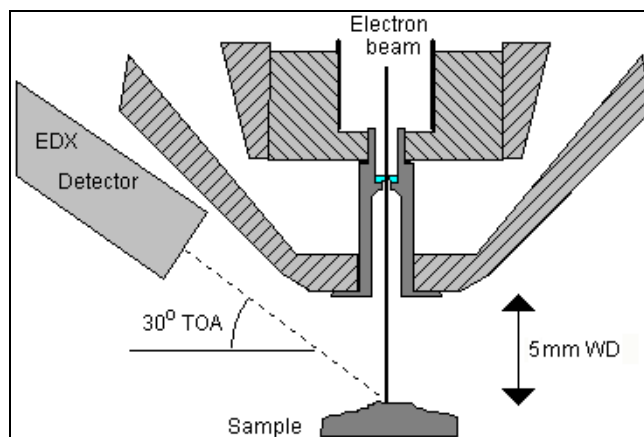
LOW VACUUM EDX ANALYSIS

X-ray analysis in LoVac mode is possible in combination either with the standard LVD detector, or with optional GAD or LVD/Helix detector. The GAD is recommended to achieve the best signal-to-noise ratio, especially when using lower HV values, because the long GAD cone minimizes the primary beam path and therefore its dispersion in the gaseous environment of the chamber. On the other hand, the LVD detector offers the largest field of view for the LoVac operation. The CBS is compatible with EDX.

The X-ray analysis should be performed at the lowest possible gas pressure to minimize the interaction of electrons with the chamber gas. Normally, it is performed with a relatively high beam current so that there is enough signal for a good LVD image even at very low gas pressures.

STEM EDX ANALYSIS

Select the area of interest in the STEM mode and perform X-ray analysis, mapping or line scans as appropriate.

Because the samples are not bulk in nature the beam spread normally associated with SEM samples is greatly reduced and therefore higher spatial resolution can be obtained with the STEM detector. This also provides less background in the spectrum and allows better separation of peaks as well as more accurate lower count rate mapping. The high voltage chosen for the analysis still depends mainly on the composition of the sample.

External Current Measurement (Keithley Picoammeter)

With this option the Status module is modified and shows the **Specimen Current** instead of the Gun Pressure.

When the **Stage** menu / **External Current Measurement** is ticked, it is expected to have Keithley picoammeter connected to the **External Connectors** panel / **Specimen Current** connector, which is located at the back side of the microscope console.

FIGURE 7-11 EXTERNAL CONNECTORS PANEL

In this case the **Status** module / **Specimen current** value is **N/A** and the meter readout shows actual specimen current.

Note:
When the **Stage** menu / **External Current Measurement** is not ticked, switch the picoammeter off or disconnect it! The **Status** module / **Specimen current** item shows the value.

Nav-Cam

Besides the Sample Navigation / Navigation Montage… feature this functionality represents a fast method to navigate across a large stage movement area. It gives fine Navigation image quickly and easily, which is convenient when investigating large area samples or several samples with the use of any multi sample holder.

CAPTURING NAVIGATION IMAGE PROCEDURE

1. Vent the chamber, open the chamber door and insert a sample.
2. Close the chamber door and set the WD to 5 mm (top sample surface) with the use of the **CCD 5 mm Marker** – at this position only the Nav-Cam functionality is correct! Do not pump the system!
3. Open the chamber door and rotate the navigation camera to point to the stage.

   At this moment the beam and the detector changes to Nav-Cam and a live imaging of navigation camera is obtained in the last time active quad (with the resolution of 768 × 512 pixels only).
4. Select the **Stage** menu / **Move Stage to Nav-Cam** function to move the stage to Nav-Cam position. Use this function also when one moves the stage to a different position to return it back under the camera.

   In case the **Preferences…** / **General** tab / **Automatic move to Nav-Cam position** item is set to Yes, the stage moves to the Nav-Cam position automatically.

C a u t i o n !

When the stage is moving to the Nav-Cam position, do not rotate the camera until the stage reaches the final position!
When the Stage movement stops wait about 5 seconds to let the camera to automatically adjust a brightness & contrast.

W A R N I N G !

Be aware of a stage movement, do not put fingers to the trajectory!

5. Capture a navigation image (with the high resolution of 3072 × 2048 pixels) by pressing the silver camera button on the top of its body or by Snapshot or Photo function (see Chapter 3). A green rectangle (or just a cross) represents a place, where electron beam will aim. The image could be saved or adjusted like any other image acquired from the microscope (image enhancement, process etc.).

   If sharpness of a navigation image is not sufficient, try to find a Z-coordinate (about ±1 mm from WD 5 mm) at which an image is sharp enough and repeat steps No. 3 and No. 4.
6. Rotate the navigation camera back to its home position (the stage moves to its last time position before venting the chamber), close the chamber door and pump the system.

Besides a navigation image one can use also the **Stage** module / **Navigation** tab and the **Digital Zoom** module to navigate the stage (see Chapter 3).

When the **Preferences…** / **General** tab / **Display Stage Map in Navigation quads** item is set to Yes, stage saved positions are displayed in the Nav-Cam photo (see Chapter 3).
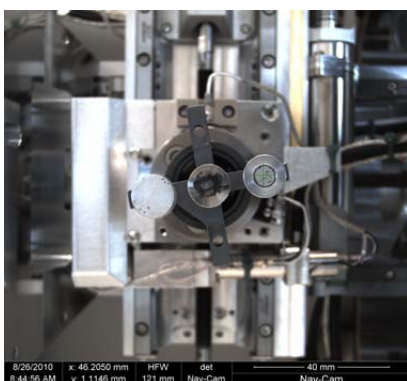
Nav-Cam

Besides the Sample Navigation / Navigation Montage… feature this functionality represents a fast method to navigate across a large stage movement area. It gives fine Navigation image quickly and easily, which is convenient when investigating large area samples or several samples with the use of any multi-sample holder.

CAPTURING NAVIGATION IMAGE PROCEDURE
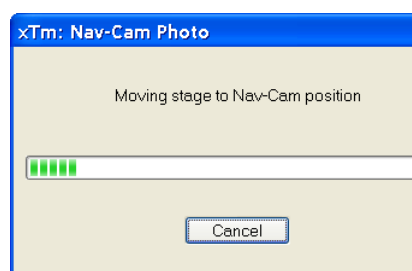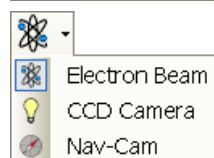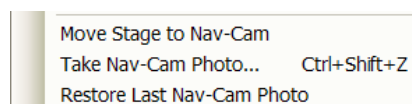
1. Vent the chamber, open the chamber door, insert a sample and pump the chamber.

2. Select the **Stage** menu / **Move Stage to Nav-Cam** function to move the stage to Nav-Cam position.

   At this moment the beam and the detector changes to Nav-Cam and a live imaging of navigation camera is obtained in the last time active quad (with the resolution of 768 × 512 pixels only). Set the **Detectors** module / **Brightness** slider in case the imaging is not satisfactory.

   DANGER!
   Retract all retractable detectors to prevent equipment damage!

   Note:
   It is possible to run the **Stage** menu / **Take Nav-Cam Photo…** **(Ctrl + Shift + Z)** item to run steps 2., 3. and 4. automatically at once. It is possible to cancel this procedure by the **Cancel** button at any time, the stage remains in the actual position.

3. Capture the Navigation image (with the high resolution of 3072 × 2048 pixels) by using the Snapshot / Photo function. The image could be saved or adjusted like any other image taken from the microscope (image enhancement, process etc.).

   It is possible to capture the Navigation image after the **Home Stage** procedure was run. For better image quality and navigation accuracy it is recommended to run the **Link Z to FWD** also.

   Note:
   Wait until image capturing is finished (about several seconds).

4. Click the **Stage** menu / **Move Stage to Nav-Cam** function again to move the stage to the last time stage position.

   A green rectangle (or just a cross) represents a place where electron beam will aim.

Note:
Nav-Cam operation is restricted for highly shiny and simultaneously planar specimens (Si wafers, mirrors etc.).

Besides a navigation image one can use also the **Stage** module / **Navigation** tab and the **Digital Zoom** module to navigate the stage (see Chapter 3).

When the **Preferences…** / **General** tab / **Display Stage Map in Navigation quads** item is set to **Yes**, saved stage positions are displayed in the Nav-Cam photo (see Chapter 3).

In case a user log off and the sample and its stage loading position did not change, use the **Stage** menu / **Restore Last Nav-Cam Photo**.

Remote Imaging

The Remote Imaging enables to connect to the Microscope PC via network using the VNC application and to control the microscope operation remotely.

For information how to install this functionality, see *Installation Instructions* available on the installation CD. For more details on the remote connection and its possibilities, see *VNC documentation* available on the installation CD.

CONNECTION TO THE MICROSCOPE PC

Follow the steps below to connect to the Microscope PC.

VNC Viewer 4

1. Double-click the VNC Viewer icon on the remote PC desktop to launch the VNC Viewer application.

2. In the **Connection Details** dialogue, type the computer name of the Microscope PC you want to connect to, followed by colon (:) and the port number 5905, into the **Server** field.
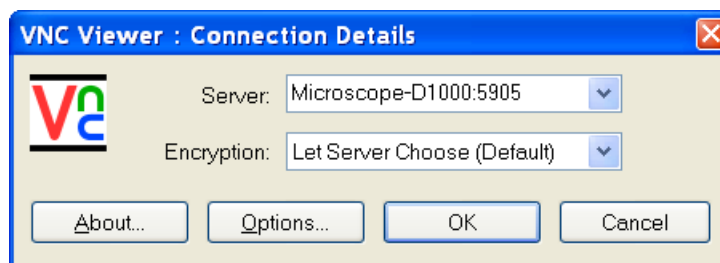
In case your configuration consists of both Microscope PC and Support PC, you need to connect to the Support PC. Type the Support PC name, followed by the colon (:) and the port number 5905, into the **Server** field. Click the **OK** button.

3. Some secure key and signature related dialogues may appear. Confirm all of them by clicking the **OK** or **Yes** button.
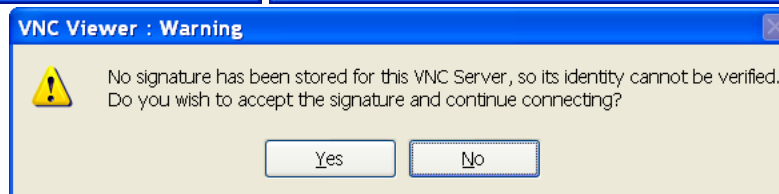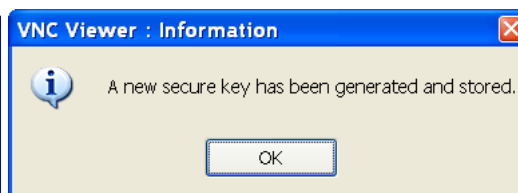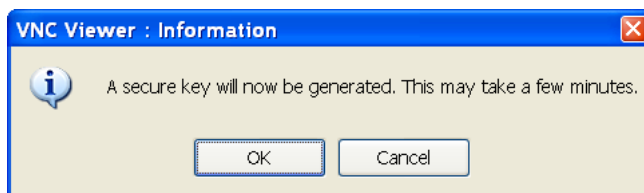
4. In the **Authentication** dialogue, fill in your microscope **Username** and the corresponding **Password**. Click the **OK** button.
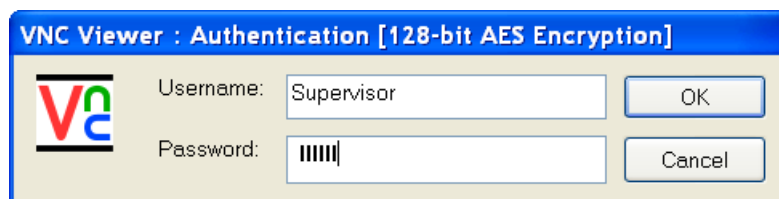
When this step successfully passes, you are connected to the Microscope PC and the VNC window with its desktop opens.

When connecting remotely, be aware of the fact that there might be some person operating the microscope locally, i.e. working directly with the Microscope PC.

To close the remote connection to the Microscope PC, just close the VNC Viewer window.

MICROSCOPE PC'S DESKTOP SHARING

Several users can connect to the Microscope PC at the same time and thus share its desktop on the remote PC's. This can be used e.g. for the educational purposes. The typical scenario is that a dedicated user/ supervisor controls the microscope (locally or remotely) and the other connected users can only view the Microscope PC's screen over the network.

1. In FEI User Management application, create a non-active user account for the view only purpose.
2. Open the VNC Viewer application on the remote PC of the person who is intended to control the microscope and connect remotely to the Microscope PC as user/supervisor.
3. Other users will then open the VNC Viewer application on their remote PC's and connect remotely as 'view-only' users.

Note:
The desktop sharing must be enabled in the VNC Server application on the Microscope PC. For instructions how to do so, see *VNC Server documentation* available on the installation CD.

CONTROLLING THE MICROSCOPE REMOTELY

After connecting remotely to the Microscope PC, you can do all the tasks as if you work directly with that computer. It is possible to control the microscope operation, run the supportive applications, backup or restore user data, view the log files etc.

In general, expect slower response on your commands and actions. This limitation comes from the amount of data that have to be transmitted and from the network bandwidth.

In case the xT microscope Control user interface stops responding or the *Server Busy* dialogue appears, the Microscope PC is probably overloaded and may have problems with the actual conditions being operated remotely. If such a problem occurs, wait till the Microscope PC recovers; or restart it yourself when necessary.

Here are some recommendations for the remote control operation:

• Be very careful when navigating the stage. Always keep in mind that what you see in the CCD camera image is not the exact position of the stage (because of delay in imaging data transmission).
• You can improve the performance / response time by setting the more convenient scanning conditions: quad instead of full screen, single quad running instead of more quads resumed; lower resolution; slower scan (i.e. higher dwell time).
• Benefit from the automatic functions that are not affected by the delayed response problem (Auto Contrast Brightness, Auto Focus, Auto Stigmator). In case you prefer to focus or use the Stigmator manually, it is better to do so in the reduced area.

Quick Loader

The Quick Loader was designed for:

- Easy Sample transfer
- Faster sample through-put
- Contamination free chamber environment
- Materials applications

Caution!

Minimize a Quick Loader usage with the CryoCleaner (see below) filled with LN2!

It is strongly recommended to vent the specimen chamber and replace the Nitrogen Vessel with a clean one after completing cca 20 subsequent Load cycles with the cool CryoCleaner! This is because each Load cycle adds small layer of gas and ice onto the Nitrogen Vessel surface, thus decreasing the CryoCleaner efficiency and increasing the amount of gas released into the specimen chamber in case the LN2 dries out.

GENERAL DESCRIPTION

The loader module can manually load and unload small samples into the SDB / SEM. The loader module is connected to the specimen chamber of the SDB / SEM and it has its own pumping system.
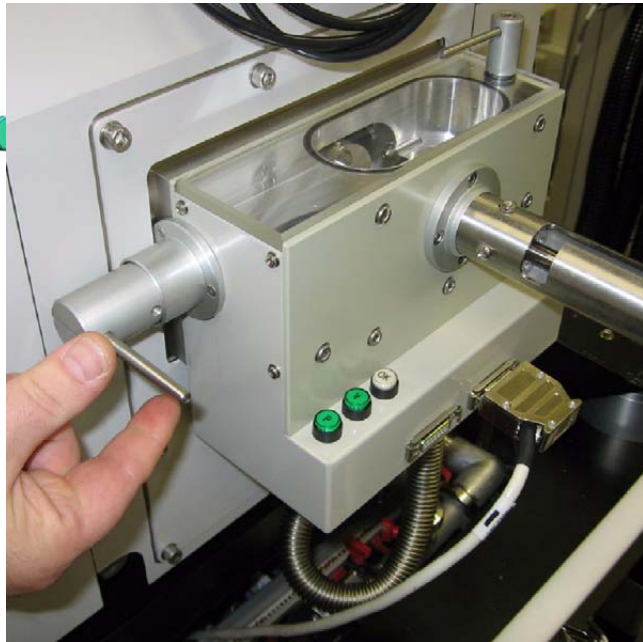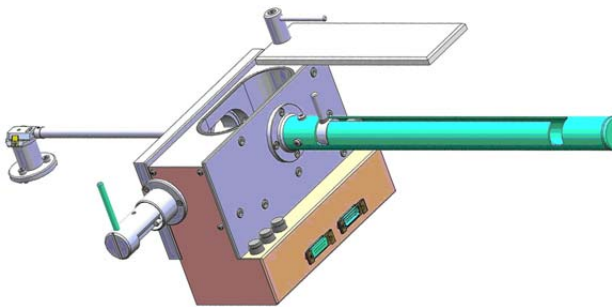
The loader consists of a loading rod with set slide and parking position, a loader chamber for loading and unloading the sample carrier (with sample) onto a bayonet fitting located at the end of the rod. A gate valve seals the vacuum of the SDB / SEM specimen chamber and can only be opened when the vacuum of the loader chamber is correct, this being indicated by the **OK** labeled LED prompted by an electrical and mechanical interlock.

The sample carrier can be entered into the main SDB / SEM specimen chamber by way of the rod and released by the rotating motion of the rod at a predetermined position on the stage adapter.
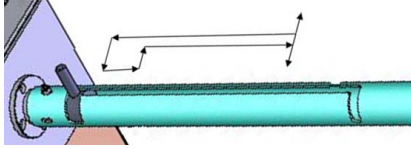
Loading rod

The loading rod has a pre-machined slot to move in to load or unload a sample. At each end there is a side slot. There are 2 side slots at the further end from the vacuum chamber. One is for loading and unloading the sample carrier in the loader chamber and the other is a parking position (prevents the rod to be sucked in by the vacuum).

C a u t i o n !

Do not unload the sample carrier with gate valve opened! The sample carrier could drop down from the rod.

At the end of the rod closest to the loader chamber is a large slot for coupling and de-coupling the bayonet into or out of the sample carrier when positioned on the carrier adapter.

The bayonet is designed to make a positive and secure connection to the sample carrier so that it remains horizontal and in a straight line to connect with the carrier adapter within the specimen chamber.

Gate valve

The Gate Valve has positions that are defined by the following status:

- rotated position of the Gate Valve Lever: LOCK / UNLOCK
  The position has to be turned from LOCK to UNLOCK to be able to move the loading rod IN and OUT
- colored strips on the side of the exposed barrel axis:
  one / two when IN / OUT
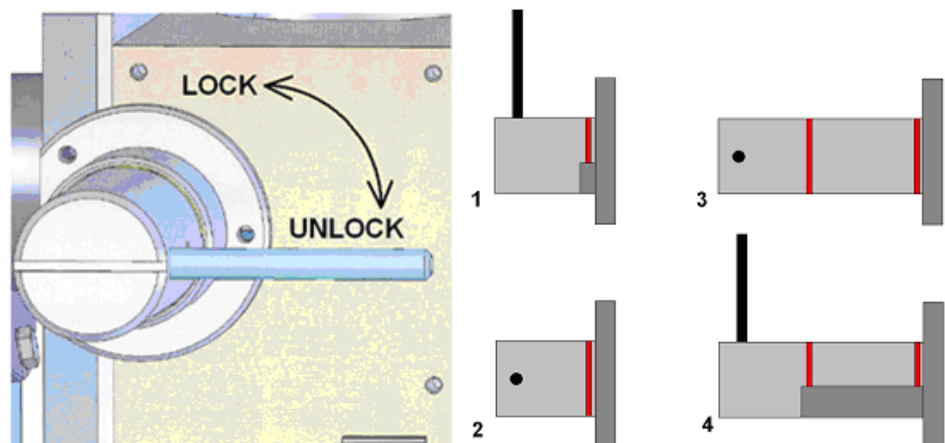
- Position 1 - IN and LOCK
- Position 2 - IN and UNLOCK
- Position 3 - OUT and UNLOCK
- Position 4 - OUT and LOCK (prevents vacuum closing valve).

The Gate Valve has a two safety movements.

- it can be placed over the entry hole on the slide
- it can be locked in place by a turn of the connecting knob (securing the closure of the valve)

A system interlock takes care of correct conditions (system vacuum, accelerating voltage) for loading and unloading cycles (movement of the gate valve).

Controls

There are 2 buttons (illuminated while in operation) and 1 indicator lamp:

- The **P** (pump) labeled button is pressed to pump the loader chamber to the required vacuum, the stage moves to a loading position at the same time. If the system reaches appropriate vacuum level, the lever interlock is released and the gate valve can be opened. The pump cycle is automatically terminated when the required vacuum is reached.

- The **V** (vent) labeled button is pressed once to vent the loader chamber. The vent cycle continues till the **P** button is pressed or it is terminated by time-out.

- The indicator lamp labeled **OK** lights up when vacuum is reached after pumping. When it goes out this means the wait time has been exceeded and the appropriate vacuum for a transfer has been lost. Pressing the **P** button again will bring the system to vacuum **OK** status.

Control buttons are not shining when the system is recovering from vacuum status transition (e.g. immediately after the load/unload sample, during venting the chamber...). After finishing the state transition the control buttons will be in operation again.

Sample Carrier, Sample Gate and Stage Adapter

A sample carriers (2 pcs.) are used to hold and transport the sample from the loader to the specimen stage of the SDB / SEM. The carrier sits in the stage adapter with a dovetail joint. It is fixed to the loading rod via a bayonet coupling. The loading rod is removed at the bayonet coupling when the sample carrier is located in the adapter and withdrawn leaving the sample carrier ready for sample observation.
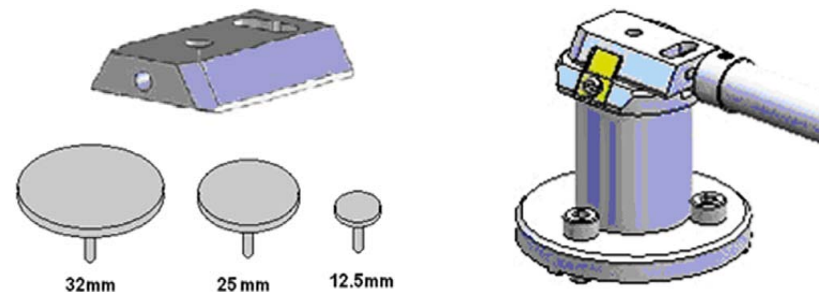
The Stage Adapter is connected to the rotation base of the FEI stage by 3 hexagonal headed screws. The base of the adapter has 3 high points for a firm 3-point contact to the rotation base to prevent vibration transmission.

The height of the stage adapter is distinct to the SDB /SEM system it is used with. The top of the adapter has a dovetail slot for the acceptance of the sample carrier from the rod loading mechanism.

Sample Height

Before mounting the Stage Adapter the stage must be homed with the chamber door opened.

Only samples that fit the Sample Gauge can be loaded. One sample stub of diameter up to 32 mm (1 1/4 ") can be used, although standard sizes of 25 mm and 12.5 mm can also be used. Height can be no greater than 9 mm.

The shuttle clamps with a spring in the dovetail shaped slot of the adapter. It is fixed to the loader arm via a bayonet coupling. The maximum pin length of the stubs that can be used is 11 mm (most common commercial FEI type stubs have a pin length no greater than 8 mm).
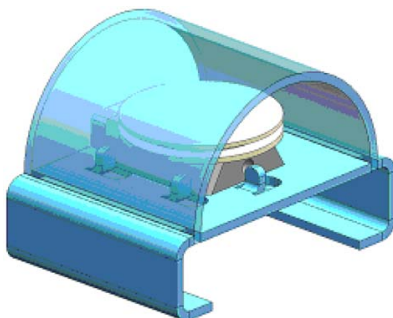
INSTALLATION

The Quick loader is pre-installed in FEI factory. No special adjustment is needed only the loading rod was removed for transport.

1. Unpack the lead glass lid.
2. Remove four screws holding the cover of the loading rod feed-through.
3. Use the same screws to attach the loading rod to the loader chamber.

Loading position

The load / unload position is preset from factory. If a calibration is needed, run the **Quick Loader Alignments** at first.

Alignments	?
Quick Loader Alignments ▼	
QuickLoaderAlignments	
QuickLoaderAlignment	
	Finish

Alignments	?
Quick Loader Alignments ▼	
Quick Loader Alignment	

This alignment procedure is used to define Quick Loader exchange position(x, y, z, r, t)

1. Set tilt to zero degrees.

2. Vent specimen chamber, open the door and home the stage.

3. Adjust rotation axis so that the dovetail joint of the adapter is parallel with Y axis of the stage, and the stop-pin is on the left. Write down adjusted rotation position.

4. Close the door, pump specimen chamber and pump the quick loader. Open the gate valve, set rotation to previously found position and insert transfer rod with the shuttle.

5. Adjust X, Y and Z to find the optimum exchange position

6. Retract the rod and close the gate valve

7. Press the Finish button to set the exchange position or press Cancel to restore previous exchange position.

X:	6.8765 mm
Y:	-4.6132 mm
Z:	28.8189 mm
R:	156.2 °
T:	0.0 °

Cancel	Finish

OPERATIONS

Loading a sample

1. Mount the sample with fast drying adhesive medium onto the stub. Allow to dry.
2. Check the sample satisfies the sample limits imposed by placing the top of the mounting tool over the base mount.

Caution!
If the sample proves to be too large this has to be addressed before the sample and carrier should be allowed into the loader chamber.

3. If the sample satisfies the limits, the sample loaded carrier can be loaded into the loader chamber. A user can either remove from or place a mounted carrier in the loader chamber by using tweezers for stubs which will fit around the stub rim.

   Note:
   Loading samples this way is an easier and safer than trying to mount the sample directly into the sample carrier while in the loader chamber.

Rod Loading Sequence
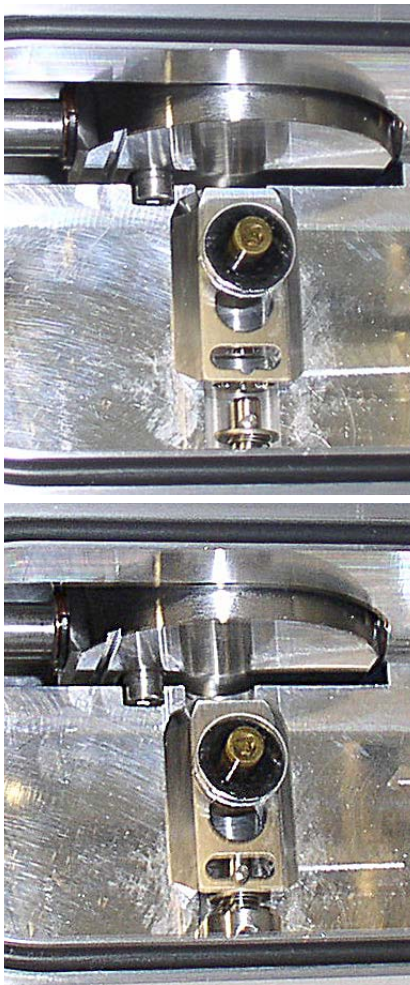
1. While holding the sample carrier on the loading table in the loader chamber move the rod out of the Parking position to the far left, to the back of the slot and forward to engage the bayonet into the sample carrier. Place the rod back into the Parking position after coupling to prevent the rod slowly creeping forwards.
2. Switch OFF the electron and ion beam accelerating voltage. Retract the GIS or STEM modules (if present) to a safe state (can not be used in combination with loader).
3. Close the loader chamber lid. After the lid is properly closed the **P** button starts to shine.
4. Press the **P** button, the button stops to shine and the pumping cycle starts, the stage moves to the loading position at the same time. When the vacuum in the loader chamber is correct the pump light starts to shine and the **OK** button lights up indicating operation can continue. The gate valve lever interlock is released.
5. Turn the Gate Valve knob lever from LOCK to UNLOCK position. Then carefully pull the knob bar fully out from the first mark on the knob drum to the second mark. Turn the knob bar to (counterclockwise) to the LOCK position.
6. Move the loading rod from the Parking position into the chamber while still holding the rod bar. The Sample Carrier will engage with the Stage Adapter at the end of the rod travel.
7. Turn the rod bar to the left (counterclockwise) to the base of the slot; pull back on the rod bar so it travels along the base of the slot, then turn to the right (clockwise) so that the rod bar is vertical and withdraw it back to the PARK slot at the far end of the rod guide.
8. Close the Gate Valve by turning the knob bar to the UNLOCK position and press the knob in to engage the valve over the opening, this can be seen through the lead glass lid, then turn the knob bar to the LOCK position to secure the valve. Good practice is to leave the loader chamber under vacuum.

Unloading a sample

1. If there is a sample carrier in the loader chamber attached to the bayonet, remove it (the chamber needs to be vented and the carrier removed).

2. Switch OFF the electron and ion beam accelerating voltage. Retract the GIS or STEM modules (if present) to a safe state (can not be used in combination with loader).

3. Close the loader chamber lid. After the lid is properly closed the **P** button starts to shine.

4. Press the **P** button, the button stop to shine and the pumping cycle starts, the stage moves to the loading position at the same time. When the vacuum in the loader chamber is correct the pump light starts to shine and the **OK** button lights up indicating operation can continue. The gate valve lever interlock is released.

5. Turn the Gate Valve knob lever from LOCK to UNLOCK position. Then carefully pull the knob bar fully out from the first mark on the knob drum to the second mark. Turn the knob bar to (counterclockwise) to the LOCK position.

6. Move the unloading rod from the Parking position into the chamber while still holding the rod bar. When resistance is found turn the rod bar to the left (counterclockwise) to enter the bayonet. Push forward and turn the rod to the right (clockwise) and the bayonet will engage with the Sample Carrier on the Stage Adapter close to the end of the rod travel.

7. Withdraw the rod back to the far end of the rod guide and place in the Parking position. The rod, bayonet and sample carrier are now out of the chamber and sit in the Loader chamber.

8. Close the Gate Valve by turning the knob bar to the UNLOCK position and press the knob in to engage the valve over the opening. This can be seen through the lead glass lid, then turn the knob bar to the LOCK position to secure the valve.

9. Press **V** button once. The chamber will be vented and the lid can be opened. The sample carrier can be released by turning the rod bar to the far left and pulled back then returned to the parking position. Remove the sample carrier.

10. Close the loader chamber lid.

11. Press **P** button to evacuate the loader chamber.

Note:
In case the sample carrier falls from the loading rod, vent the chamber with gate valve opened, put the carrier back to a correct position and close the gate valve. Proceed from the step No. 1.

CryoMAT Loader (Optional)

The CryoMAT Loader is in fact the Quick Loader (see above) with the addition of the Cryo option, which technically can be added after Quick Loader installation. It is therefore important to become familiar with the Quick Loader operation prior to using the CryoMAT option.

The CryoMAT Loader is designed for dehydrated sample transfer, cryogenic cooling, and temperature control within a SEM or DualBeam instrument. It has single stage transfer, a preset sample temperature control, and is integrated into the existing SEM or DB vacuum system. The result is a simpler system to use for less experienced and experienced Cryo users alike. It is also designed to be used for more demanding delicate IC sample TEM prep where ambient temperature or beam conditions cause problems.

FIGURE 7-12 CRYOMAT LOADER BLOCK DIAGRAM
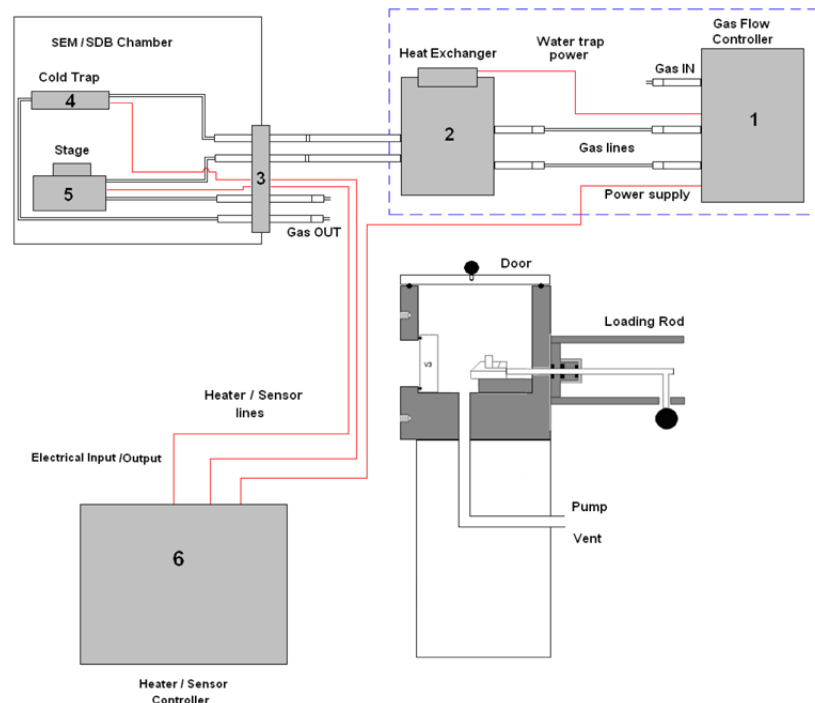
- 1. The **Gas flow controller** (on a trolley mount) controls the N2 pressure and flow through the cryo components.
- 2. The **Heat exchanger** cools down the flowing N2 to cryogenic temperatures. A **water trap** captures water from the N2.
- 3. The **Gas and electrical interface flange** introduces the gas pipes and electrical cables through the chamber wall.
- 4. The **Cold trap** creates the coldest position in the chamber to trap condensing water vapor molecules.
- 5. The **Cryo stage** Holds the sample at cryogenic temperature.
- 6. The **Cryo heater** & **sensor controller** allows temperature changes to the sample, gives temperature feedback to a visual display for the cold trap and cryo stage.

1. GAS FLOW CONTROLLER

The gas flow console panel is housed on the top part of the heat exchanger trolley to control the N2 flowing through the LN2 heat exchanger for cooling the cold trap and the cryo-stage.

Primary function of this unit is to regulate the gas flow independently to the cryo-stage and cold trap via the heat exchanger. The N2 pressure is regulated from the original supply to this unit at 1.5 bar (21.75 PSI) and 5 liters / minute flow rate.

FIGURE 7-13 GAS FLOW CONTROL PANEL

Trolley panel components

*   2× pressure valves for regulation of the incoming gas pressure
*   2× gas flow regulators 10 l/m scale
*   2× back pressure end valves with not closing action
*   7× gas connections with inter-connective piping
*   Water trap heater temperature read out display with preset controls
*   Power supply to drive the temperature control, display and N2 water heater
*   Output socket to N2 water heater + cable
*   Temperature controller connection + cable
*   Power input cable and connection (at rear).
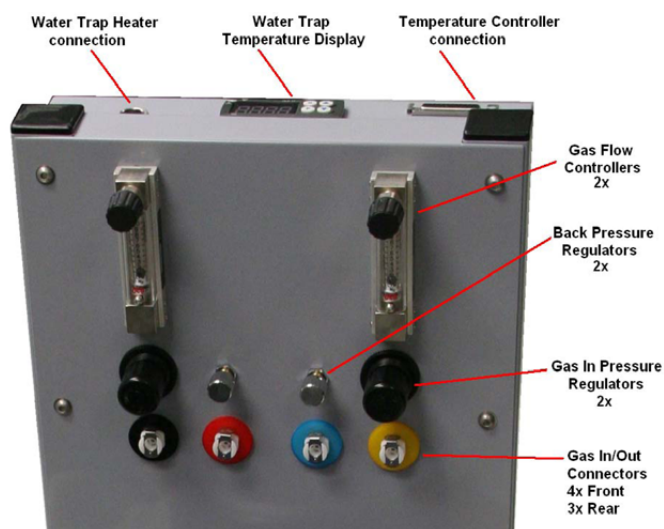
2. HEAT EXCHANGER AND LN2 DEWAR

The Dewar volume is 12 liters and will be filled with LN2. It accommodates a central pipe core of four pipes (two in and two out). Gas flows from the gas flow control to the two incoming pipes and further into the heat exchanger. At the end of the central core the pipes end as two coils which sit at the base of the Dewar to create cooling transferred by conduction from the LN2 to the N2 gas flowing in the pipes.

FIGURE 7-14 HEAT EXCHANGER AND DEWAR

Heat Exchanger components

*   Stainless steel or aluminium vacuum container (Dewar)
*   Water trap with heater and cable
*   Central pipe core with heat exchange coils at base
*   Insulated cold N2 pipes out of the central core
*   Not insulated warm N2 pipes in to the central core
*   Power supply (housed in trolley)

The insulated pipes coming out of the central core then proceed to the gas flow and electrical interface flange situated on a chamber port.

The cooled gas feeds the cold trap and cryo stage independently before returning to the interface flange. The return pipes with gas flowing back from the cryo stage and the cold trap also enter the insulation (neoprene) so that ice does not form at the port. These continue to the trolley entering gas connections through the two back pressure valves and then to atmosphere.

Water Trap

To prevent water entering the cooling system via the N2 gas, a water trap is designed into the top of the central core of the heat exchanger. The water trap chamber volume is heated to evaporate the unwanted water condensing into the trap. An independent power supply house in the trolley panel drives the heater.

WARNING!

Whenever handling LN2 (the 12 liter nitrogen Dewar and the Heat Exchanger), wear face and hand protection (face visor and a pair of thermal protective gloves). Do not touch cold surfaces as this could result in burns!

Lowering the Heat Exchanger into the Dewar

1. Allow the LN2 to stabilize from boiling after filling before transporting the Dewar and before lowering the heat exchanger into the Dewar.
2. Lower the heat exchanger into the Dewar slowly and with caution as the LN2 will boil due to the warm heat exchanger components.

Removing the Heat Exchanger from the Dewar

WARNING!

1. Remove the heat exchanger from the Dewar slowly and with caution as the core components remains at cold LN2 temperature for some time.
2. Place the cold heat exchanger core at the side of the Dewar to warm up. Do not touch the heat exchanger until the ice condensation on it has completely thawed.
3. Close the lid to the 12 liter Dewar.

4. COLD TRAP

The cold trap protects the sample from water vapor condensing on its surface while at low temperature. It is suspended by a bracket from the back of the chamber to one side of the lens cone.

The extension plate can be used (in addition) for even more effective anti-contamination of the sample. This encircles some of the lens diameter but is over the GIS needle input level.

Cold Trap components
- Cold trap plate
- Mounting rod and insulator
- Sensor element
- Ground connector
- Swivel bracket
- Extension Plate

FIGURE 7-15 COLD TRAP

5. CRYO STAGE

C a u t i o n !

The cryo stage can be rotated (because of the connections of pipes and wires) maximum ± 20°!

*With the cryo stage installed do not use the **Home Stage** procedure!*

The cryo stage is a complex construction allowing samples to be cooled down to cryogenic temperatures. The supporting components are insulated from the low temperature by a double ceramic minimized contact method. The cold part of the stage can be heated so temperature can be regulated with feedback via a thermal sensor. This allows the cold temperature of the sample to be carefully chosen.

The sample can be tilted with the cryo stage to 52° tilt for milling in a Small Dual Beam instrument.

The thermal insulation is constructed to prevent temperature exchange from the FEI main stage to the sample and so that constant temperature can be maintained.

The base plate is constructed in two parts so that the cryo stage can be removed quickly and conveniently without having to break connections or cut pipes.

The base has three point contact onto the FEI stage to eliminate vibration and a location pin that connects into the stage table. In this way, the load position alignment remains valid when remounting the cryo stage.

The X, Y and Z axes movements are not limited. Tilt is able to go to maximum but will only be restricted by the presence of the cold trap at approximately 56° tilt.

Note:
Moving the sample away from the protection of the cold trap (over the sample) can cause ice to condense on the sample by water molecules released from warmer surfaces.

The cryo stage can be removed easily and quickly.

FIGURE 7-16 CRYO STAGE CONSTRUCTION
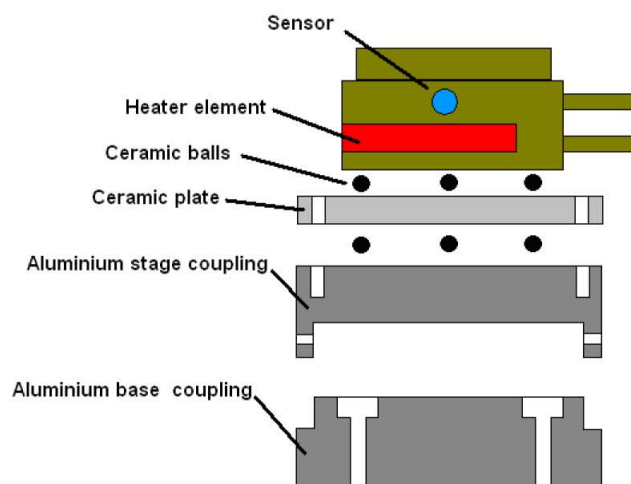
Cryo stage components
- Mounting base plate
- Thermally insulated stage mount
- Heater element to 100°C
- Sensor element
- Ground connector

Cryo Sample Carrier and Cryo Stubs

The cryo sample carrier connects to the loading rod bayonet with the same mechanism as the ambient sample carrier. Release and re-connection to the rod is also using the same mechanism as the Quick Loader.

The cryo sample carrier connects onto the cryo stage within the SEM/SDB with a "dovetail" device that is spring loaded on the cryo stage.

The sample stub hole is further along the carrier to a depth of 5.0 mm and of a diameter to accept with close fit a 10.0 mm diameter stub. The stub hole is terminated before penetration to the lower side of the sample carrier. A further 3.0 mm hole is drilled into the center of the base of the 10.0 mm stub hole for vacuum pumping purposes.

A small hex screw secures the stub through a threaded hole at the far end of the sample carrier.

Standard Cryo Stubs

A plain stub type (10.0 mm length × 10.0 mm diameter) is supplied with the cryo option as this can then be simply engineered with holes or slots when necessary. It is commercially available as a consumable product from many SEM accessory suppliers.

Samples are secured by conductive paint on/in:
- a plain stub for mounting regular or irregular samples,
- a slot in the stub can facilitate thin samples or sheet material,
- a drilled hole in the stub can accept viscous liquids, pastes or strips of material.

FIGURE 7-17 CRYO SAMPLE CARRIER WITH STANDARD STUB
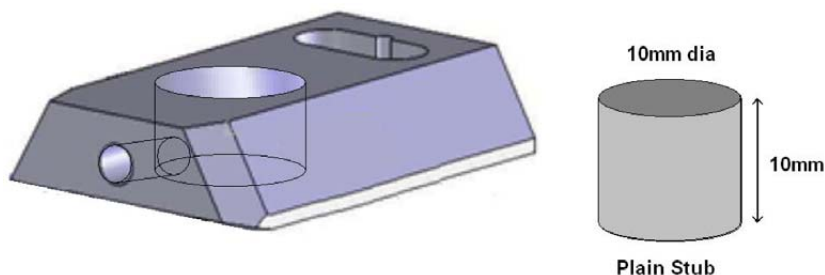
6. CRYO HEATER & SENSOR CONTROLLER

Temperature Controller

The controller displays actual (red numbers) **Cold Trap** / **Cryo Stage Temperature**. Required (green number) **Set Temperature** of the cryo stage could be set by buttons under the display.

The **3 way Temperature Switch** position determines a function:

- at **Up** position the high temperature is preset (**SET 2 Warm**) for sample exchange or removing (up to +50° C, default +20° C),
- at **Down** position the low temperature is preset (**SET 1 Cold**) for sample cooling,
- at **Center** position a temperature control is not in operation.

The cold trap temperature relies on the N2 flow and should be adjusted from the gas flow controller (–150° C to –190° C). It must always be at a lower temperature to the sample, approximately 10° C to 30° C difference.

FIGURE 7-18 TEMPERATURE CONTROLLER DISPLAY

Temperature controller components

- Free standing box.
- Temperature readout from Cold Trap.
- Temperature controller/readout from Cryo stage.
- 3 way temperature switch (High/Neutral/Low) for Cryo stage.
- Control interface cable
- Power cable

OPERATING THE CRYOMAT LOADER

Note:
Follow the sample loading / unloading instructions for the Quick Loader (see above) and become familiar with the process before operating the CryoMAT Loader.

Mounting the Sample

1. Mount a stub into the sample carrier and secure it by tightening the hex screw.

2. Mount the sample with strong adhesive medium such as Carbon or Silver paint onto the stub. Do not use carbon adhesive pads (Tabs) because their adhesive can become ineffective at low temperature and may cause the sample to fall off the stub.

Cooling Down the Sample
(First Time Operation in Session)

3. With the Heat exchanger removed from the Dewar, fill the 12 liter Dewar with LN2.

4. Switch on the water heater at the back of the Gas flow controller trolley. Open the pressure regulators and flow meters fully. The back pressure regulators should always be open and are only used to create temporary extreme low temperatures not normally in use. They have built-in safe none closing valves to prevent a closed circuit.

5. Turn on the dry N2 gas at its source and regulate the pressure to 1.5 Bar pressure to the Gas flow controller trolley.

6. Allow 10 minutes to flush the system of any condensed water. Adjust the pressure regulators to show 5 L/M on the flow meters. Make sure that the heat exchanger rod is completely dry and void of trapped water. Carefully immerse the heat exchanger rod into the 12 liter Dewar. Watch the temperature controller read-outs for the lowering of temperature.

Balancing the Flow Rate Versus Temperature

This is a procedure using the default temperature settings. Other temperatures can be used but the cold trap should always be at a lower temperature (at least 20°C but no greater than 40°C).

7. Wait for the boiling effect to subside before adjusting, this will be seen as bouncing balls in the flow meter tubes.

8. The Cold trap will reach a lower temperature first because it is a shorter circuit, the cryo stage will follow. Therefore first regulate the flow meter to slow down and stop the cold trap at approximately -160°C. This will probably be between 4 and 5L/M.

9. Immediately regulate the cryo stage gas flow so that it just over shoots -130°C. This will probably be between 3 and 4.5L/M.

10. Switch the 3 Way Temperature switch down to SET 1 Cold preset temperature and wait for the system to reach the required temperature (-130° C, usually after 10 minutes). The cold trap flow rate may need a small final adjustment and can now be set so that it stabilizes at a temperature of ~-160° C).

11. The read-outs on the controller box will indicate the temperature stability at the cryo stage and cold trap. Do not switch on the beams till the sample is at the necessary low temperature. Once this is stable viewing or milling can begin on the sample.

Sample Exchange / Removing

12. When the sample needs to be warmed up to ambient temperature before being exchanged or removed, bring the stage to a zero tilt condition and switch off the HV.

13. Switch the 3 Way Temperature switch up to SET 2 Warm preset temperature and wait for the system to reach the require temperature (usually after 20 minutes).

   During sample exchange keep the cryo stage at the SET 2 Warm temperature.

14. Follow from the step No. 10 on to proceed with observation.

FINISHING CRYOMAT LOADER OPERATION

Daytime Use

This operation should only take approximately 15 minutes.

1. Bring the stage to a zero tilt condition and switch off the HV.

2. Switch the 3 Way Temperature switch up to SET 2 Warm preset temperature and wait for the system to reach the require temperature (usually after 20 minutes).

3. Switch the 3 Way Temperature switch to center position (Off).

4. Remove the sample carrier from the SEM/SDB, vent the loader chamber and remove it from the loader with tweezers.

5. Turn off the N2 gas supply to the 12 liter Dewar unit and wait for the supply pipes to the chamber interface to become flexible (approximately 15 minutes).

6. Carefully remove the heat exchanger from the 12 liter Dewar and cap off the 12 liter Dewar to save LN2.

7. Turn on the N2 gas supply to the 12 liter Dewar unit and warm the coils at the end of the core with a hair dryer of at least 1000 Watt.

8. When the temperatures on the controller box show ambient temperatures, stop heating the coils and turn off the N2 gas supply. Switch off the water trap heater on the trolley panel.

Overnight

Follow the procedure for Daytime Use and skip steps No. 7. and 8.

9. Allow the system to warm up over night.

Patterning

With this option the Patterning menu, the Patterning page and some toolbar icons are available within the UI to enable entire process control. Patterning is the process of moving a beam over the specimen with the purpose of:

- **milling** – removing well-defined amounts of existing material
- **deposition** – depositing well-defined amounts of new material

at well-defined locations (the shapes such as rectangles or circles), leaving other areas untouched.

PATTERNING MENU (ALT + P)
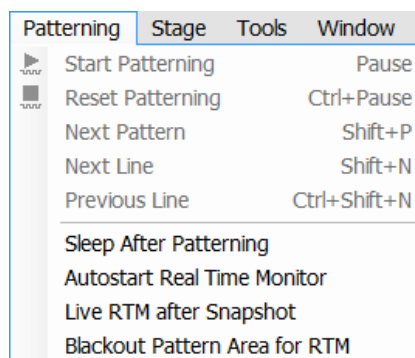
opens the Patterning menu functions:

Start / Pause / Resume Patterning

starts / pauses patterning of the enabled pattern(s) in the active quad. The menu item and a corresponding toolbar icon changes according to actual condition.

Reset Patterning (Ctrl + Pause)

cancels the patterning procedure.

Next Pattern (Shift + P)

In serial patterning the actual shape Patterning is stopped and the procedure continues with the next shape (if present).

Next Line (Ctrl + N)

When milling a Cleaning Cross Section shape, milling of an actual line is cancelled and continues with the next one.

Previous Line (Ctrl + Shift + N)

When milling a Cleaning Cross Section shape, milling of an actual line is cancelled and continues with the previous one.

Autostart Real Time Monitor (RTM)

When selected, this function releases the pause function for the quad with patterns enabling automatic start of the real time monitoring of the milling process.

Live RTM after Snapshot

After acquiring a snapshot RTM feature continues automatically.

Blackout Pattern Area for RTM

In case the Real Time Monitor is running, the area not milled is darkened to enhance the visibility of the RTM information. The visibility of the individual patterning pixels is greatly enhanced (this is especially important for patterns with extremely large pitch or very thin lines).

FIGURE 7-19 IMAGING with / without BLACKOUT PATTERN AREA
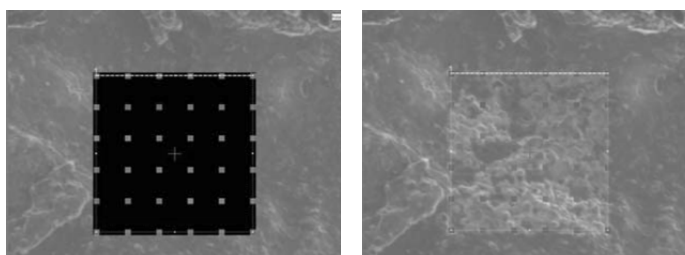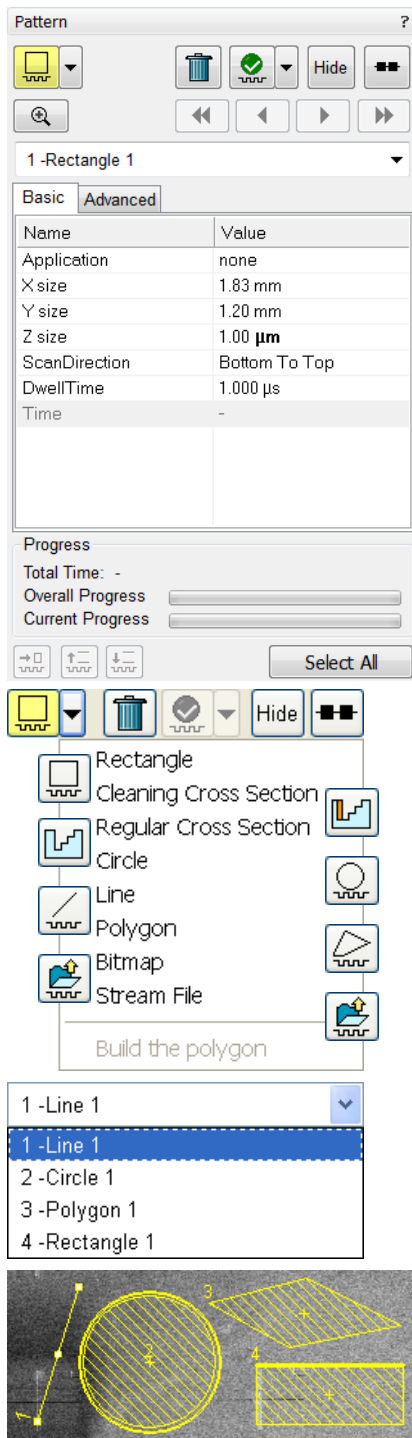
PATTERN MODULE

There are several tool icons, **Basic** / **Advanced** / **Progress** / **S. Mill** tabs and the **Progress** monitoring area within the module.

Tool Icons

Clicking the icon activates (highlighted with an yellow background) / deactivates (normal background) the tool. If no icon is selected, the pattern selection cursor (arrow) is active.

- The **Pattern selector:** Clicking the arrow next to the icon activates the drop down list to select an appropriate icon:
  Rectangle / Cleaning Cross Section / Regular Cross Section / Circle / Line / Polygon / Bitmap / Stream File (see below).
  When two rectangle patterns are overlapping, it is possible to join them into one pattern by the use of **Build the polygon** item.
- The **Trash Can (Delete)** button deletes the selected patterns.
- The **Pattern / Exclusion Zone** (area of the difference between two overlying patterns) **Enable / Disabled** button sets selected pattern / exclusion zone to be / not to be processed.

- The **Hide / Show** button hides the selected pattern.
- The **Patterning Serial / Parallel sequence** button switches between two possibilities (see below).
- The **Zoom** button enlarges selected pattern / patterns to fill entire quad.
- The **Patterning sequence** buttons set the pattern milling order.
  Patterns are milled in the order they are created (for parallel patterning this is valid for all beam passes). Numbers are displayed close to the pattern and in front of its name to indicate the actual milling order. This can be changed by click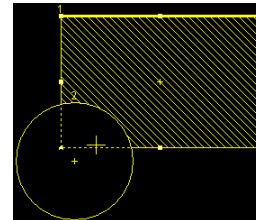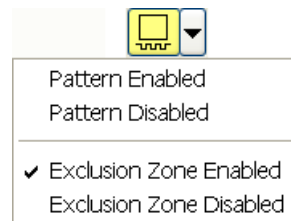ing the left / right single arrow to move the selected pattern one position up / down and by clicking the left / right double arrow to move it to the first / last position.

Bitmap Pattern

From the patterning page a pattern is available that allows you to import bitmaps as a pattern. In this 24 bits RGB bitmap each pixel consists of:

- The **Red** component – actually not used.
- The **Green** component – determines if the beam is blanked. Any other value then 0 activates the beam.
- The **Blue** component – determines the dwell time per pixel. If blue is set to 0 the dwell time of a pixel is 100 ns. If blue is set to 255 the maximum UI dwell time is used. The dwell time for the pixels in between these values is linearly interpolated and then rounded to the value from a (fixed) dwell time table with 124 entries.

Note:
When drawing a bitmap it is recommended to use black (0 / 0 / 0) for none milling points and white (255 / 255 / 255) for milling points.
Do not forget to optimize other properties such as application file, depth, leading edge etc.

Stream File Pattern

A stream file, created as an ASCII text or binary file that addresses the patterning DAC directly, produces custom pattern files. Because a 12-bit DAC is used, the patterning field of view is divided into 4096 steps. The range in X is 0-4095, but in Y is approximately 280-3816. Y values outside of this range will be off the image area and may not scan correctly.

s	96 2867 2867	96 1639 2048	96 2457 1639
40	96 1229 2457	96 2048 2048	96 2867 1639
25	96 1639 2457	96 2457 2048	96 1229 1229
96 1229 2867	96 2048 2457	96 2867 2048	96 1639 1229
96 1639 2867	96 2457 2457	96 1229 1639	96 2048 1229
96 2048 2867	96 2867 2457	96 1639 1639	96 2457 1229
96 2457 2867	96 1229 2048	96 2048 1639	96 2867 1229

The file must begin with an **s**, indicating a stream file. The second line defines the number of loop repeats (**40** times). The third line indicates the total number of X, Y coordinates (pixels) in one loop (5 × 5 = **25** in this case). The **96** figure represents dwell time in units of 0.1 µm (9.6 µs). The range of dwell time is 0.1 µs to 4.6 ms, with 124 values distributed approximately logarithmically within this range.

Note:
Stream files are for users who write their own programs for specific applications. They cannot be created directly from xT UI, use any suitable text processor.
Besides the described 12 bits file there are also 16 bits files, which are recognizable by the first header line (s16 / s16,25ns / s16,DAC / s16,25ns,DAC).

Serial Patterning

All patterns defined on the screen are processed *consecutively*; milling / deposition is completed on one pattern before moving to the next one. Serial patterning is always used with cleaning cross section milling. This is the default patterning mode.

Parallel Patterning

All patterns defined on the screen are processed *concurrently*, one pass of the beam is completed on all patterns before moving to the second pass. Parallel patterning is typically used with regular cross section milling and to avoid a reverse deposition of material on the adjacent areas.

With parallel patterning, the mill time is recalculated to include all the patterns that are displayed in the image window.

When a user changes to the Parallel mode, the following shape properties in the group must necessarily be the same: Number of Passes, Beam, and Gas properties. The first selected shape determines these values for all other ones.

Other properties (Material File, Overlap, Sputter Rate, Recovery Time and Depth) are also all set to those of the first selected shape to avoid confusion, even though they could theoretically remain unchanged. Restoring Serial mode does not undo these changes; the properties remain as in the Parallel mode.

Pattern Area Processing

Select one of the patterns from the **Pattern selector** drop down list. Once selected, the cursor is ready to draw a pattern onscreen. This is possible in the quad or in the single screen, whichever is selected. Draw a suitable pattern size with the draw cursor.

- ✔ Rectangle
- Cleaning Cross Section
- Regular Cross Section
- Circle
- Line
- Polygon
- Bitmap
- Stream File

Build the polygon
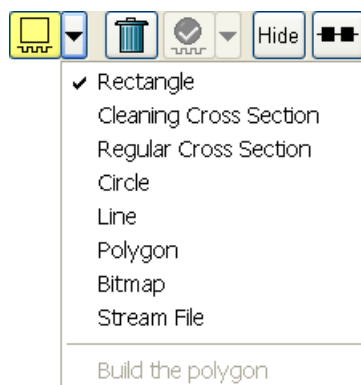
Importing / Exporting Patterns

Defined patterns may be imported via menu File / Import / Patterns and exported (saved) via menu File / Export / Patterns.

Pattern Area Editing

Once a pattern has been drawn, it can be modified.
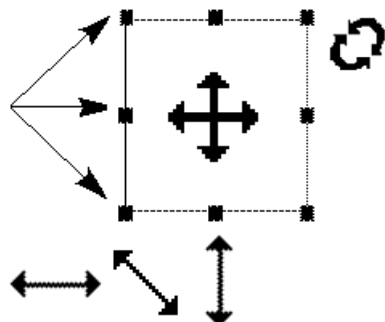
- **Selected Pattern** is denoted by the addition of resizing handles to the pattern outline (use pointer cursor).
- **Moving Pattern:** click & drag inside the boundary of the pattern (move cursor).
- **Resizing Patterns:** click & drag the resizing handle until the desired size is reached (use horizontal, vertical or diagonal resizing cursor). This can also be achieved by entering values in the Property list.
- **Selecting all Patterns** (in an selected quad)**:** hit **Ctrl + A** keys or click the **Select All** button.
- **Delete selected Pattern(s):** click the **Trash can** icon or hit the **Delete** key.

Basic and Advanced tabs

A certain pattern shape could be selected by the list box. It has many associated parameters displayed in a fixed sequence (the most often needed properties are at the top) which could be set via the patterning Property editor:

- The **Application**: Clicking the value slot produces a drop down arrow bringing a list of applications. Choosing the required one sets the subsequent properties (see below), which could be pre-defined (non-editable) and user-defined (editable).
- The **X / Y / Z size**: dimensions of the milled pattern when finished.
- The **Scan Direction**: Bottom To Top / Top To Bottom
- The **Dwell Time**: a time the beam spends on a single pixel per pass.
- The **Time** required to pattern this shape.

Advanced tab

- The **Position X / Y** of the pattern relative to the origin (the quad center).
- The **Rotation** of the patterns (the positive direction is clockwise).
- The **Gas Type**: The gas to be used to pattern this shape (or None if no gas is to be used). Note that this determines the color of the pattern on the screen.
- The **OverlapX / Y** sets the beam diameter overlap.
- The **PitchX / Y** sets the pitch between two spots.
- The **Area Calculation** defines how the patterning area will be calculated in order to get the most accurate value of the Dose. This value is related with the OverlapX/Y. The Pattern (default) / Array are set for positive / negative overlaps.
- The **Dose** defines charge dose per area. Be aware of different values depending on Area Calculation setting.
- The **Vol per Dose**: The volume of material that is removed per Coulomb.
- The **Sat Sput Rate**: The maximum linear sputter rate for a given gas. For Gas = None this is 0 (actually not used).
- The **Refresh Time**: The minimum loop time that must at least elapse before the next pass, so that the adsorbed gas can be refreshed.
- The **Loop Time**: The time required for a single pass (read only).
- The **Area**: The surface area of the pattern.
- The **ScanType**: The scanning strategy used while patterning.

Name	Value
Application	none
X size	1.83 mm
Y size	1.20 mm
Z size	1.00 **μm**
ScanDirection	Bottom To Top
DwellTime	1.000 μs
Time	-

Name	Value
Position X	167.90 μm
Position Y	835.30 μm
Rotation	0.0 °
GasType	none
OverlapX	50.0 %
OverlapY	50.0 %
PitchX	16.71 nm
PitchY	16.71 nm
Area Calculation	Pattern
Dose	4.99 mC/μm2
Vol per Dose	2.700e-1 μm3/nC
Sat Sput Rate	0.000000
Refresh Time	0 s
Loop Time	6.0 ms
Area	2.20 mm2
ScanType	Serpentine
Fill Style	Solid
Passes	1088880599
Defocus	0 μm
Blur	0 μm
Interaction D	0 μm
Total Diameter	33.4 nm
Max dose p A	0 nC/nm2
Sat cur dens	1.000e-6 A/nm2
Tot V sput r	3.456e-1 μm3/s

- The **Fill Style**: For box and circular patterns one can choose either to mill a solid or only the frame.
- The number of **Passes** that the beam scans over the pattern.
- The **Defocus** of the beam (WD change) - influences the Beam diameter and area.
- The **Blur**: Like Defocus, but specifying the (additional) diameter of the blurred spot.
- The **Interaction D** for an infinitely small beam - influences the Total diameter.
- The **Total Diameter**: The combination of the beam diameter and interaction diameter - influences the Overlap and Pitch values.
- The **Max dose p A**: Describes the adsorbed gas layer, allowing a certain dose to be deposited at a higher rate than the saturation current density, allowing a temporary higher rate (actually not used).
- The **Sat cur dens**: The current at which 63% of the saturation sputter rate is reached (actually not used).
- The **Tot V sput r**: The speed at which material is removed or deposited (actually not used).

THE PROGRESS AREA
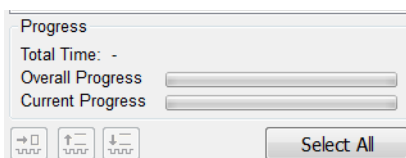
Here are information updated as the milling progresses:

- the **Total** / **Remaining Time:** estimated total / remaining patterning time
- the **Overall Progress:** related to the total patterning time of all patterns
- the **Current Progress** / **CCS Line Progress** – related to the actual pattern in progress
- Skip to a next pattern in order.
- Skip to a next line (available only with Cleaning Cross Section).
- Skip to a previous line (available only with Cleaning Cross Section).
- The **Select All** button selects all patterns in the active quad.

Note:
When patterning is paused in one quad it is possible to start patterning in another one. Similarly when patterning finishes there may still be a paused pattern in another quad.

It is possible to acquire an image from the signals generated during patterning. All imaging parameters are dictated by the patterning requirements and only the areas visited by the beam during patterning are recorded. Much better images can be recorded by a Snapshot during patterning. In this case patterning is paused, an image is recorded and patterning resumes.

Note:
If the magnification is too high, creating certain patterns can use too much memory needed for the control system to run. The pattern corners become round and the edges become jagged. A good rule of thumb is to pick a magnification where your pattern fills 35-50% of the screen.

INTEGRATED REAL TIME MONITOR

UI imaging shows the data acquired during the milling process. The acquired data are matched to the calculated positions of the corresponding milling points, the pixels shown on the screen may not therefore directly match to what is happening on the sample surface and some imaging artefacts (due to milling points and screen pixels mismatch) could occur. To prevent them try to change the field of view.

GAS INJECTION MODULE

Shapes have many associated parameters, such as the gas that can optionally be used during patterning to increase the speed of the process and which is delivered by a Gas Injection System (GIS).

As different applications require different gases, there could be more GIS's installed on your system. One can select an Application file for a given pattern in Patterning property editor. It automatically sets the appropriate GIS, the dwell and overlap, calculates the proper dose appropriate to the beam chemistry. A pattern must be defined before the material file is selected.

The GIS can be selected manually, but note that overlap, dwell and an appropriate gas type should be set carefully to avoid disappointing results.

C a u t i o n !

When any lens mounted detector is attached (GAD and CBS) the use of GIS's (option) is not allowed (see Chapter 7). The system does not block the functionality!

Setting up the GIS

The **Gas Injection** module enables to control installed GIS's. A Gas Type is allocated to each GIS (up to 5 injectors may be mounted on the system in total). A tool tip info is given about the selected GIS line:

- **Port**: Port # – GIS connection position
- **Lifetime**: a time of GIS employment

The GIS to be used must be held heated, inserted and opened.

Double-clicking or the right-clicking over the installed GIS module line opens a dialog list. By clicking the **Heater** selection the **Heat** / **Cold** status is replaced by a progress bar, which in turn is replaced by the **Heat** / **Warm** status when the GIS is fully heated.

Clicking the **In** box (its color depends on the **Gas Type**) enables to insert (tick mark) / retract (clear box) the GIS. A confirmation dialog appears.

Note:
Confirm the insertion if you know there is nothing obstructing its travel.

C a u t i o n !

Beware of stage moves while GIS is inserted! The GIS needle could be damaged by incautious stage movements!

Some conditions must be fulfilled before the insertion is enabled, which is notified by a tool tip.

To open / close the GIS valve double-click the **Closed** / **Opened** status in the **Flow** column. It will not be possible to open the valve if the GIS heater is not in Warm status.

Note:
If a gas type in patterning property list is chosen, the opening / closing of GIS valves is done automatically during patterning.

When not in use, the GIS should be closed (to save lifetime), cold and retracted. Leaving it closed, heated but retracted is also an option so that reheating is not necessary if it is to be used over several patterns.
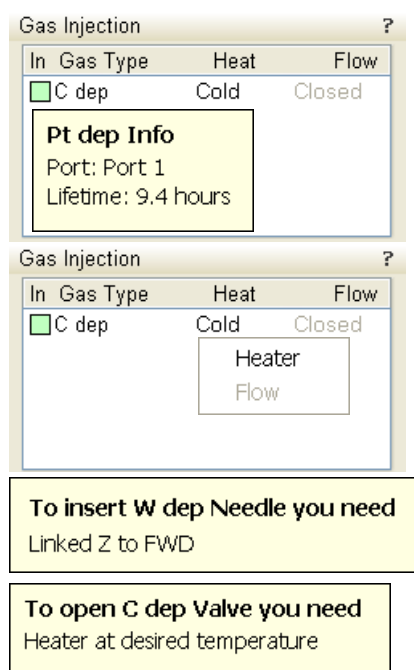
254 - GIS Alignment

The **Valve Open Time** and the **Heat Time** display operation periods for an actual GIS. Click the **Reset Lifetime** button to reset a GIS lifetime records.

Change target crucible temperature for a particular GIS by the **Working Temperature** slider. The **Heat / Open / Insert Needle** buttons are used for service operations.

Note:
The Working Temperature unit varies according to **Preferences…** / **Units** setting (see Chapter 4), but the **Actual Temp.** unit is always °C.

Alignments	?
254 - GIS Alignment ▼	
	Start

Instructions

This procedure allows the following actions:
- GIS mechanical alignment
- GIS temperature setting
- GIS lifetime reset

Note: Only the installed GIS units are controllable.

No step

Alignments	?
254 - GIS Alignment ▼	
Previous	Next

Instructions

GIS 1 adjustment page

For mechanical alignment, **Link Z to FWD** and move the stage to the eucentic position.

Step 1 of 7

Port 2	Pt dep
Valve Open Time:	0 h 00 min
Heat Time:	0 h 00 min

Reset Lifetime

Actual Temp:	20.0 °C	Heat
Heat Progress:	0%	Open

Working Temperature   318 K

◄ ||| ►

Insert Needle

Stage Z:

5.000 mm

Cancel

Alignments	?
254 - GIS Alignment ▼	
Previous	Finish

Instructions

Click the **Finish** button to quit.

Step 8 of 8

Cancel

CryoCleanerEC

These equipment allow to decrease the contamination level in the system. The CryoCleanerEC can be efficient to approximately 24 hours.

The kit consists of: Vacuum vessel, Vacuum vessel lid, Nitrogen vessel (Dewar) with cap (including proper warning labels), Nitrogen vessel stand and Nitrogen vessel safety Pliers.

W A R N I N G !
This option uses liquid Nitrogen (LN2), which may cause serious cold burns.

C a u t i o n !
It is strongly recommended to vent the specimen chamber and replace the Nitrogen Vessel with a clean one after completing cca 20 subsequent Quick Loader (see above) load cycles with the cool CryoCleaner!
If the chamber is vented with the CryoCleaner filled with LN2 (or empty but still significantly below the ambient temperature), the Nitrogen Vessel should be removed and baked before it is used again.

PARTS AND ACCESSORIES

The CryoCleanerEC consists of a Nitrogen vessel that is surrounded by an outer container - the Vacuum vessel, which is connected to one of the specimen chamber ports by a vacuum seal. The space between is then pumped by the microscope vacuum system.

FIGURE 7-20 NITROGEN VESSEL
VACUUM VESSEL WITH ACCESSORIES

When the specimen chamber (together with the CryoCleaner) is pumped, liquid Nitrogen is introduced to the Nitrogen vessel. Its outside cold surface absorbs contaminating products from the specimen chamber. The vacuum in the specimen chamber improves over a short period and contamination is now reduced.

When LN2 runs out, a pressure burst inside the chamber could cause the system to vent and to be at atmosphere for long periods of time if unattended. In this case the system switches the beam off, but it is protected from venting (about 30 min). After this period an automatic vacuum recovery procedure tries to pump the chamber, only if it is not successful the system is vented.

Flanges

The Vacuum vessel has special flange enabling to mount it to different chamber ports with the use of interlink with a desired shape (depending on the port to be used and the vicinity).

FIGURE 7-21 CRYOCLEANER FLANGES

The interlink flanges can be mounted on by means of the 3 screw-hole fittings on the perimeter of the vacuum flange. Care must be taken that the 'O' ring held in the end of the flange is secure, free of dirt and is not crimped when mounting.

CRYOCLEANER OPERATION

Once mounted the Nitrogen vessel can be placed in the Vacuum vessel. Secure the two components by fixing the clips to the top of the Nitrogen vessel and locking the clips down. Take care that the 'O' ring seal on the Vacuum vessel is secure when joining the two components together.

Dewar Vessel Refilling

WARNING!

The handling of LN2 should be performed wearing face and hand protection in the form of a face visor and a pair of thermal protective gloves.
Users must not touch the cold surfaces of the Dewar as this could result in burns. Use the Safety Pliers provided, when handling the Nitrogen Vessel.

1. Pump the specimen chamber, the Vacuum vessel is pumped along with it.
2. When the specimen chamber vacuum is ready (Pumped status), partially fill the Dewar with the use of funnel (the plastic cap upside down) and wait until boiling stops.
3. Then fill the Dewar and place the plastic cap on top of the CryoCleaner. The volume of liquid Nitrogen needed is approximately 500 ml.

Note:
The LN2 stops boiling very quickly so that no vibration is seen from this device. If the CryoCleaner needs to be used for longer periods it can be refilled with LN2.

Note:
Before re-filling it is recommended to perform Baking procedure (see below).

FIGURE 7-22 PLASTIC CAP FILLING POSITION
PLASTIC CAP OPERATION POSITION

## Removing Nitrogen Vessel

WARNING!
Use the Safety pliers provided when handling the Nitrogen vessel.

Removing the Nitrogen vessel depends on the level of contamination found in the specimen chamber. If the level is unusually high then the CryoCleaner could work continuously till improvement is seen, otherwise normally after approximately 2 to 3 hours the Nitrogen vessel can be removed.

Note:
It is not recommended to leave it inside the vacuum vessel after all nitrogen evaporates, because contamination evaporates back to the chamber.

1. Vent the specimen chamber (the excess LN2 starts to boil).
2. Release the Nitrogen vessel from the Vacuum vessel. Lift the Nitrogen vessel out of the Vacuum vessel by the Safety pliers placed under the ring on the neck of the Dewar cylinder.
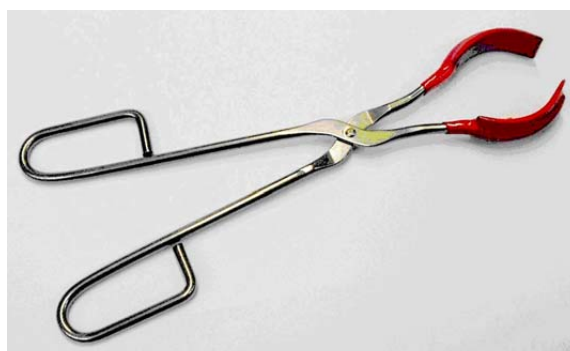
3. Place the Lid over the Vacuum vessel to seal it from the atmosphere (fix the clips). Pump the specimen chamber again, however the microscope vacuum remains cleaner than before and sample contamination is still reduced.
4. Remove the cap from the Nitrogen vessel and pour out the excess LN2 into a suitable container.

WARNING!
When the LN2 is removed from the nitrogen vessel, the bottle still remains at a very low temperature.

5. Place the Nitrogen vessel onto the Stand ready for baking.

Baking Nitrogen Vessel

1. Place the Nitrogen vessel Stand on a suitable heat resistant surface.

2. Place the Nitrogen vessel onto it and use an Infra-red lamp to bake the base of the bottle. Baking should take place for approximately 2 hours.

Alternatively the Nitrogen vessel can be baked in an oven at 90 °C for 2 hours.

Regenerating the Dewar by heat allows removal of condensed contamination and subsequent reuse of the vessel.

Note:
The oven that is used must have a venting system to extract any harmful fumes. Alternatively it should be baked in a fume cupboard using an infra-red lamp.

Replacing Nitrogen Vessel

1. Vent the specimen chamber. Allow the Nitrogen vessel to cool down before handling.

2. Unlock two clips holding the Vacuum vessel Lid. Remove the Lid from the Vacuum vessel.

3. The Nitrogen vessel can be placed in the Vacuum vessel, taking care that the 'O' ring seal on the Vacuum vessel is secure when joining the two components together. Secure the two components by fixing the clips to the top of the Nitrogen vessel and locking the clips down.

4. Pump the specimen chamber. The Vacuum vessel is pumped along with the specimen chamber.

MAINTENANCE

- Keep the 'O' rings clean of dust and fibre particles by inspecting the Vacuum vessel main 'O' ring on a regular basis. If the Vacuum vessel is removed frequently from the specimen chamber, inspect the specimen chamber 'O' ring seal each time.
- Keep the sealing surfaces of the Nitrogen vessel and the Vacuum vessel Lid clean and free of dust and fibre particles.
- Do not use any kind of vacuum grease on the 'O' rings.
- Wipe outsides of the stainless steel parts to remove finger stains with a lint free cloth dampened with pH neutral soap solution.

SPARE VESSEL

It is possible to obtain secondary nitrogen vessel kit, which contains:

- Nitrogen Vessel
- Vessel Stand
- Vessel Plug

Plasma Cleaner
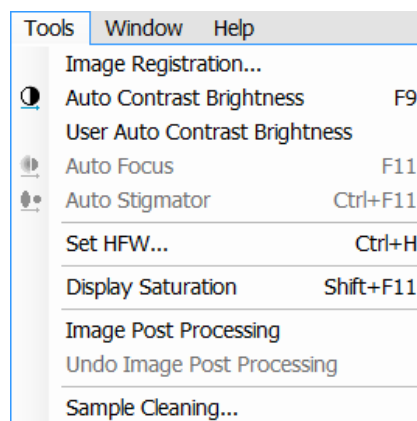
The **Tools** menu / **Sample Cleaning…** item starts the Sample Cleaning procedure, which is efficient process for removing very thin contamination layers, which are typically formed by hydrocarbons residues remaining on vacuum parts after conventional cleaning or could be transferred into the microscope chamber with a sample.

The plasma cleaner generates free oxygen radicals, which react with hydrocarbon molecules on the surfaces to form CO, CO_2, and H_2O molecules that can be pumped away. It is operated at vacuum conditions similar to the low vacuum operation (~50 Pa).

FIGURE 7-23 PLASMA CLEANER
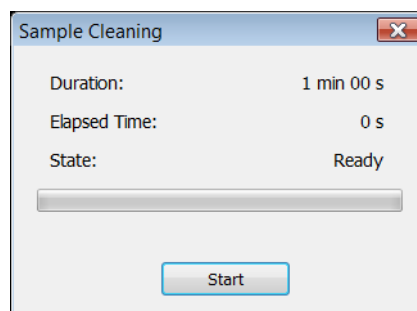
The Sample Cleaning procedure uses settings from the **104 - Plasma Cleaning** Alignment (see Chapter 4).

For avoiding of typical "weak" contamination artefacts during high resolution imaging (image darkening), 1-2 minutes plasma cleaning duration in combination with cryo cleaning (see above) should be sufficient. When bulky deposition is visible (mostly on image corners), 5 minutes duration is recommended.

Note:
Porous, biological or hydrocarbon based samples cannot typically be viewed without presence of contamination artefacts even after plasma cleaning, which is caused by presence of contamination source in the sample itself.
Sometimes, poor image quality could be caused by e-beam etching and re-deposition of etched material also.

SAMPLE CLEANING PROCEDURE

Caution!

When plasma cleaning (see below), place the CBS / GAD detector to the parking holder inside the chamber or out of chamber to protect it against damage.

1. Move the stage to the lowest Z-axis position.
2. Run the **Tools** menu / **Sample Cleaning…** procedure.

   It is possible to enter the procedure from the vented state with the use of **Vacuum** module also. When the procedure is finished or aborted by a user, the system remains pumped.

   During the procedure run, stage moves are disabled temporarily.
3. Place the sample back to the observation position and check the sample. If necessary, repeat the cleaning procedure.

When starting the procedure and some conditions are not allowed, the dialog or tooltip appears onscreen.

When Plasma Cleaning is started from LoVac mode, chamber is partly pumped to HiVac mode. User is asked to confirm this action before Plasma Cleaning is started.

Note:
When one is going to observe in LoVac immediately after plasma cleaning with a different gaseous environment, it is advisable to run the Purging procedure (see Chapter 3).
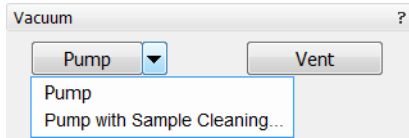
CHAMBER CLEANING

To periodically clean the whole system (due to build ups from samples, carriers, service events, etc.) use the Chamber Cleaning procedure set via the **104 - Plasma Cleaning** alignment (see Chapter 4). The clean chamber environment enables an operator to use the system at a level of cleanliness suitable for high resolution imaging and analysis.

Caution!

Never use Plasma Cleaner for Chamber Cleaning with CryoCleaner filled with LN2 (see above).

WARNING!

- If EDS / WDS / EBSD system is mounted, use 1 mm collimator on EDS detector and do not exceed 5 minutes overall procedure duration once a day at most.
- Always retract EDS detector before plasma cleaning!
Do not exceed 30 minutes of chamber cleaning once a week at most when the DBS detector is installed.
- Avoid leaving sensitive carbon containing samples (e.g. photo resist) inside the chamber during Plasma Cleaning procedure, as they may be etched by the cleaning process.
- Any material that can create or release oxide easily (e.g. silver) should not be plasma cleaned.
- The Au-C resolution tests samples could be left inside the chamber during the Sample Cleaning procedure but not very often!

Electrostatic Beam Blanker

On the Nova NanoSEM a High-speed electrostatic Beam blanker can be mounted next to the Final lens aperture (FLA).

INSTALLING THE BEAM BLANKER

1. Vent the specimen chamber.

   The BB holder mechanism can be found to the right of the FLA holder mechanism.

   Note:

   These units looks similar

2. Replace the Vacuum seal dummy in the BB holder mechanism with the Beam blanker rod.

3. Pump down the specimen chamber.

   Make sure that the blanking plates are either short connected or connected to a supply that controls the blanking.

4. Align the blanking plates in all 4 positions (see below) to the electron beam in the lowest magnification, not the other way around!

   Beam blanking will take place when a +5 V signal is applied to the blanking plates. The position of the blanking plates depends on the accelerating voltage of the electron beam.

TABLE 7-2 ALIGNMENT OF PLATES TO VOLTAGE

High Voltage [kV]	Position	Plate Gap Distance [mm]
> 20	1D	0.25
> 10	2D	0.5
> 5	3D	1.0
> 5	4D	2.0

FIGURE 7-24 BEAM BLANKER PLATES

In order to get maximum blanking effect of the beam the Aperture rod can be moved a little outwards of the column axis in the direction of the FLA holder mechanism. The best position is just before the beam current starts decreasing because of misalignment of the aperture.

Other options for increasing the On/Off ration of the blanker rate are:

- Use a smaller distance between the blanker plates (lower position number) than is prescribed in the table above. This may also increase chances of charging effects on the blanker plates.

- Use a higher voltage on the blanker plates. To allow voltages significantly above the standard value of +5V the 50 Ohm resistor between the plates has been disconnected to prevent overheating. This has resulted in a lower maximum operating frequency of the

electrostatic beam blanker. The 50 Ohm resistor should always remain connected to ground, otherwise there is a chance of charging problems.

When the beam blanker plates are positioned correctly with reference to the electron beam there should be no limitation in the field-of-view of the SEM image. Place the beam blanker in position 4 when it is not in used. Also disconnect the external cable and short-circuit the plates.

Re-align the FLA for high resolution performance.

C a u t i o n !

Do not fully retract the aperture rod when the Beam Blanker is mounted. You must (partially) retract the Beam Blanker first before the aperture rod can be fully retracted. Otherwise damage to the aperture strip and/or the blanker plates may occur.

CLEANING THE BEAM BLANKER

After intensive use the blanking plates of the Electrostatic Beam Blanker can get contaminated. This will lead to charging, beam drift effects and / or additional astigmatism that will make the SEM useless for lithography applications.

FIGURE 7-25 BEAM BLANKER PLATES
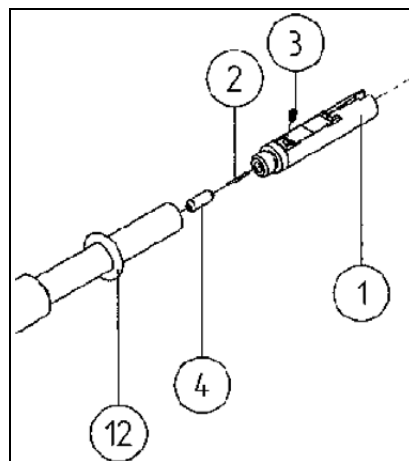
For initial cleaning a plasma cleaner is ideal as this can remove hydrocarbon based material very effectively. In case where the Beam Blanker cannot be cleaned with a Plasma system only because it has been excessively contaminated, follow the procedure described below:

Cleaning of the blanking plates normally involves Cyclo Hexane (or Isopropanol) with ultrasonic agitation.

1. Take t he BEAM BLANKER ROD with the blanking plates out of the column and replace it with the VACUUM SEAL DUMMY.
2. Release the blanking plates (item 1 in drawing) from the BEAM BLANKER ROD.
3. Clean the blanking plates for 15 minutes in an ultrasonic bath with Cyclohexane.
4. Clean the blanking plates for 15 minutes in a Cyclohexane vapour bath.
5. Make sure that all the Cyclohexane has left the openings of the blanking plates.
6. Dry the blanking plates with dry nitrogen gas.
7. Do a visual inspection (magnifying glasses, light microscope) for dust

particles etc. between the blanking plates. Repeat the cleaning steps 3-6 if necessary.

8. Mount the blanking plates again on the BEAM BLANKER ROD, using clean gloves.

9. Do not touch the blanking plates and repeat inspection of step 7.

10. Measure the resistance between the blanking plates (50 Ohm or infinite in case of a large [>10 V] blanking signal) and the resistance between connector and plates (< 1 Ohm).

11. Short circuit the plates by making contact between the connector kernel and shield.

12. Place the beam blanker in a clean holder and insert in the plasma cleaner.

13. Plasma cleaning: Ar/O 75/25% with 4 V pressure reading for 5 minutes

14. Take the beam blanker out of the plasma cleaner, remove short circuit and repeat step 10.

15. Remove VACUUM SEAL DUMMY from column and put the BEAM BLANKER ROD in without hitting anything inside.

16. Align the blanker plates to the beam for all four positions (gap widths). Also make sure that the plate surface is parallel to the beam.

Universal Mounting Base Sample Holders

FIGURE 7-26 UNIVERSAL MOUNTING BASE

The kit contains the following items:

• Universal mounting base (UMB)
• Storage box
• 2 stub modules each holding 3× 1/2" stubs or 2× 1" stubs
• 2 clamp bars
• User guide
• System calibration sample

The whole stub holder is mounted on the stage interface plate.

Stage Mapping

This is a stand-alone software enabling to obtain X / Y correction map in the whole of the stage action radius. The kit obtains:

• The Mapping software application
• The 6" calibration wafer attached to the special wafer holder
• The User manual

FIGURE 7-27 CALIBRATION MARKS
ON THE CALIBRATION WAFER