Helios NanoLab
450 / 450 S / 450 ML / 650 / 600i

User Operation Manual

Edition 2
23 Feb, 2012

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 both as the PDF file and 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, Equipments).
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. **Operations**
   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 FEI$^{®}$ Helios™ NanoLab™ 450 / 450S / 450 ML / 650 / 600i DualBeam™ systems integrate ion and electron beams for FIB and SEM functionality in one machine. Users can switch between the two beams for quick and accurate navigation and milling. Convergence of the SEM and FIB at short working distance allows precision "slice-and-view" cross-sectioning and analysis at high resolution.

FIB/SEM DualBeam systems provide an expanded range of capabilities not possible with separate FIB and SEM tools:

- Electron beam high-resolution imaging of FIB cross sections without eroding the feature of interest.
- Real-time cross-section electron beam imaging during FIB milling.
- Focused electron beam charge neutralization during FIB milling.
- Focused ion beam charge neutralization during SEM imaging.
- High resolution elemental microanalysis of defect cross sections.
- Sample surface imaging with the electron beam during navigation without erosion or gallium implantation from the ion beam.
- TEM sample preparation with in situ conductive coating.

The Tomahawk™ ion column provides fast, precise milling and high-resolution imaging of the sample surface.

The Elstar electron column takes advantage of FEI's most advanced Hexalens™ design for ultimate image resolution at low beam energies. It offers nondestructive imaging capability at a working distance optimized for ultrahigh resolution and can display samples magnified over 500 000× in mode 1 and > 2 500 000× in mode 2.

The Helios NanoLab was designed for imaging nanostructures of any material (man-made, biological, natural), particularly in the area of:

- Nanoelectronics,
- Process yield engineering,
- Biology.

The system was designed for:

- Data storage
- Process yield engineering
- Etching
- Lithography
- Metal and other materials deposition
- Fabrication of micro- and nanostructures

The instrument provides optimum throughput, resolution and automation.

 ❖ FEI™ C O N F I D E N T I A L

SYSTEM PERFORMANCE

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

- **Electron / Ion source**
  The beam of electrons or ions (particles) 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. This signal, modulated by the detection system signal produces the onscreen imaging of the specimen surface.

- **Detection unit**
  Particles striking the specimen react with atoms of the sample surface in various manners:

  – The electron beam produces electrons and photons (X-rays).
  – The ion beam produces ions, electrons and photons (X-rays).

  The detector system picks up the particles or photons, converts them into an amplified electrical signal which is then sent to the control PC and displayed on the monitor.

FIGURE 1-1 COLUMN SCHEMATIC OVERVIEW
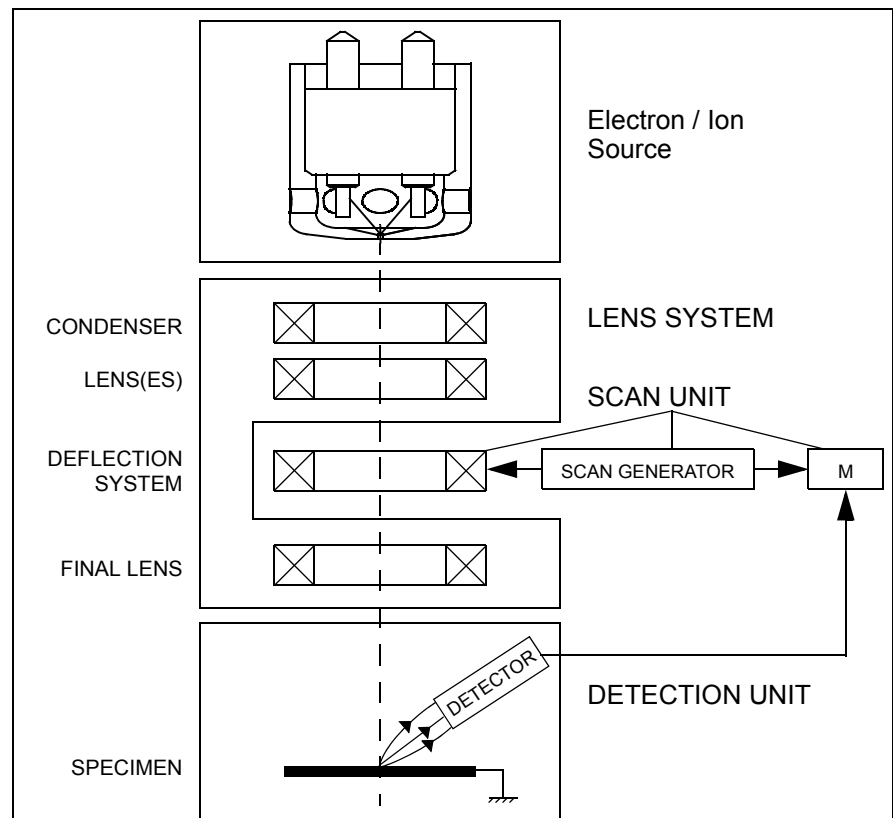
Computer Control

The xT microscope Server and xT microscope Control (User Interface) software integrate SEM and FIB functionality within a Windows XP™ 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 particle 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.

Stage

The Helios NanoLab 450 / 450S / 450 ML / 650 / 600i has a computer-controlled high-accuracy five-axis stage for small samples. It offers precision specimen computer controled 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 or through the LoadLock. The exchange takes a few minutes, with the Loadlock an exchange could be much more faster. Software and interlocks protect the system against a damage and users against an injury.

The Multiloader is a specimen exchange unit for the modified Flip stage. The Flip stage contains one cartrige for attaching TEM samples.

The Helios Nano Lab 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.

Beams Control

DualBeam systems ideally position the point of interest for simultaneous ion beam cross-sectioning and electron beam viewing. Separate scan generators for the two beams permit coupled or independent scan patterns and magnifications.

Imaging while milling aids in defining milled features. Immediate electron beam images of cross sections are possible without stage motion or sample transfer. Immediate highresolution SEM imaging after FIB milling also prevents exposure of milled cross sections to atmospheric contaminants.

Gas Injection System (GIS)

Multiple FEI GIS (option) can be installed for material deposition in conjunction with either electron or ion beam pattern definition. Electron beam-induced deposition offers the advantage of not sputtering the deposited material or implanting gallium FIB source ions simultaneously.

The GIS can also contain etching precursor for fast material removal with minimal redeposition, preferential etching of cross-section surfaces prior to SEM imaging, and rapid milling of TEM sections.

Several GIS chemistries can be installed on the instrument, depending on a system configuration. 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, FIB, and X-ray detection system (e.g. EDX – Energy Dispersive X-ray) (option) at short working distance allows precision "slice-and-view" cross-sectioning and chemical analysis at high resolution of surface and subsurface features.

Various vendor options are compatible with the instrument.

2 | SYSTEM CONTROL

Interface Elements
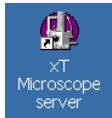
SOFTWARE v5.1.X

The software control contains graphic applications within Windows XP™ 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 XP 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 user interface 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** can hold some other software utilities. The **switch box** switches the keyboard and the mouse 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 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** or the **Manual User Interface**.

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 2-1   SYSTEM CONTROL PANEL POWER BUTTON

ON

Standby
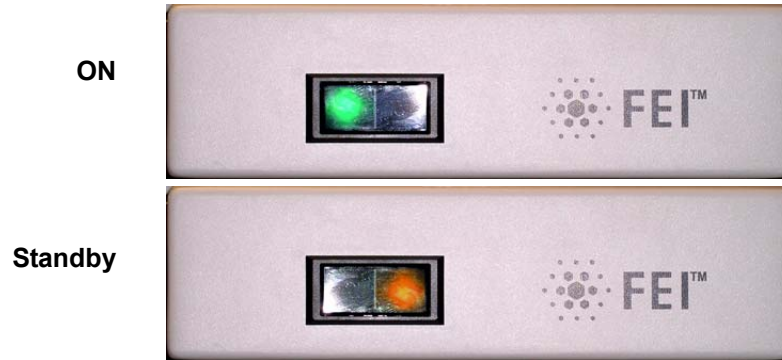
Vacuum System

Within the system are the following vacuum sections:

• Electron source
• Electron column
• Ion source
• Ion Column
• Specimen chamber – Loadlock

In operation the electron column is always pumped to high vacuum. The specimen chamber is at the pressure required for the given state.

All valve and pump operations are fully automatic.

FIGURE 2-2   HELIOS NANOLAB VACUUM SYSTEM

Legend:

BPV . . . . Bypass Valve
CCG . . . . Cold Cathode Gauge
CIV . . . . . Column Isolation Valve
CLV . . . . . Chamber LoadLock Valve
CVV . . . . Column Venting Valve
GIV . . . . . Gun Isolation Valve
IGP . . . . . Ion Getter Pump
Ion DP . . . Ion Column Differential Pumping
LVV . . . . . LoadLock Venting Valve
LRV . . . . LoadLock Roughing Valve
NAV . . . . Nitrogen Admitance Valve
PIGB . . . . Pirani Gauge Buffer
PIGL . . . . Pirani Gauge LoadLock
PVP . . . . Pre Vacuum Pump
RV . . . . . . Roughing Valve
TMP . . . . Turbo Molecular Pump
TVV . . . . . Turbo Venting Valve
VV . . . . . . Venting 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 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 (see Chapter 3):

• **Green: PUMPED** to the desired vacuum mode (see below)
• **Orange: TRANSITION** between two vacuum modes (pumping / venting)
• **Grey: VENTED** for sample exchange

In the Pumped status the chamber is in high vacuum and the pressure should be in the range 10^{-2} - 10^{-5} Pa (10^{-4} - 10^{-7} mbarr).

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

Pump button

When the **Pump** button is clicked and the status is **Vented** the system pumps to high vacuum mode and the Pump button gets highlighted in and not accessible.

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 actually 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 detectors voltage, high voltage supplies, vacuum pumps and uses the appropriate valves to vent the system.

The Vent button is highlighted and not accessible. After a specified venting time the venting valve closes and the vacuum status should indicate **Vented**. 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.

xTm: Vacuum message

Please confirm specimen chamber vent.

Venting will take a few minutes.

Are you sure you want to continue ?

Yes   No
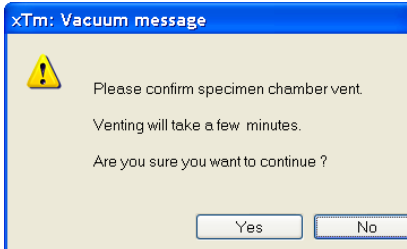
System States

There are several system states:

1. **Complete Shutdown** – service and emergency reasons

   Complete shutdown should be performed only if absolutely necessary and for the shortest possible time, so as to recover the column vacuum without the necessity of a system pump.

   The shutdown procedure brings the system to a non-powered state, where the vacuum in the specimen chamber is no longer supported by running pumps (PVP and TMP are switched off). All valves are closed, so the system remains in the last vacuum state. The TMP will slow down gradually and the chamber and column vent finally. The specimen and/or LoadLock chamber could not be accessible unless they are vented before the complete shutdown.

   The vacuum in the electron gun and column is still supported by an independent Battery Supply Unit for a limited amount of time (~ 9 hours). After that the system vents completely and the service procedures are needed to restore the system.

   Caution!
   The emission characteristics of the source are dependent on the shape of the tip. When the source is turned off, it cools. Reheating the source during startup changes the shape and emission characteristics, requiring the column to be re-aligned.

2. **Standby** – not using the system for a few days or during service

   This mode is only available for supervisor users. The electronics racks are powerless except for the E-column source, vacuum pumps and optionally Microscope Controller. The latest vacuum state is preserved. Returning to full operation takes a few minutes.

3. **Overnight** – not using the system for a few hours, e.g. overnight

   When not using the SEM, switch off the electron beam (accelerating voltage). To decrease energy consumption, switch off PC's also. Returning to full operation takes from a few seconds to a few minutes, depending on whether the microscope controller is switched off.

4. **Full Operation** – working

TABLE 2-1   SYSTEM ON / OFF OVERVIEW

Instrument Unit	Complete Shutdown	Standby	Overnight	Full Operation
Microscope console	Off	Partly Off	On	On
PC's (Microscope Controller & Support Computer)	Off	On / Off	On / Off	On
Software (xT microscope Server & xT microscope Control)	Off	Off	On / Off	On
Vacuum	Off	On	On	On
Electron Beam (HV)	Off	Off	Off	On

TABLE 2-2 STARTUP PROCEDURE GENERALLY
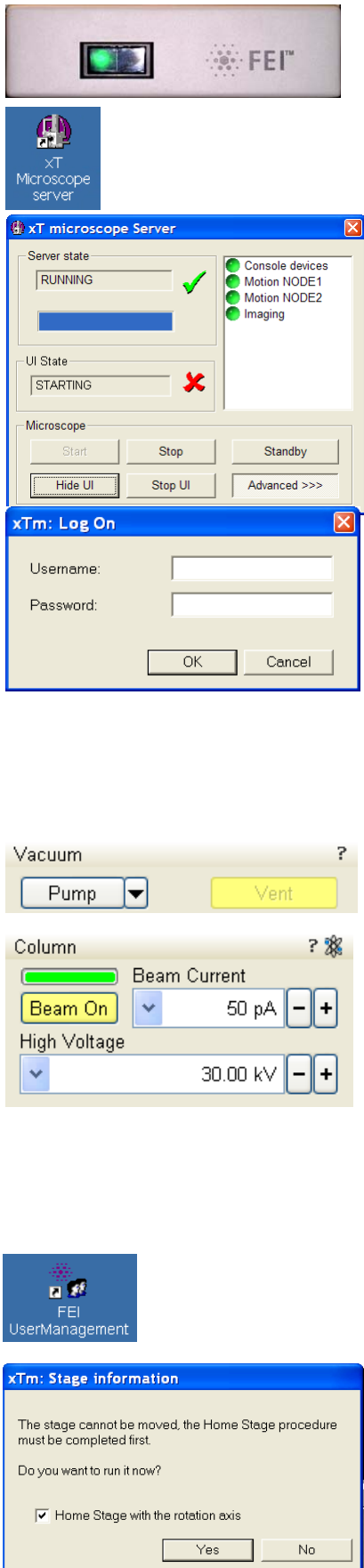
Transition	Action to reach Full operation state
from Disconnected	**1)** Connect compressed air and nitrogen (if present), cooling water and the power cord to the microscope console.
from Complete Shutdown	**2)** Push the power button on the microscope console front panel. **3)** Switch on the PC's. The operating system Windows XP loads[a] and displays the appropriate icons on the monitor desktop. **4)** Double-click the **xT microscope Server** icon to start the software (all device bullets should be green). **5)** Click the **Start** button to start the server. **6)** Click the **Start UI** button (if not started automatically) to start the **xT microscope Control** software. **7)** Enter your **Username** and the **Password** [a] into the **XTUI Log On** dialogue to activate the Microscope Control software [b]. **8)** Switch on the IGP's and the Emitter by the **Alignment 5 - Emitter Startup** (see Chapter 4). **Note:** When IGP's start fails (long time of interruption) call FEI Service Engineer. **9)** Pump the chamber to reach the **Pumped** status. **10)** Click the **Column** module / **Beam On** button (turns to yellow) to start the beam.
from Standby	Run the steps from No. 2) to 7) and follow with steps No. 9) and 10). **Note:** Skip steps which are allready done. **CAUTION!** Wait at least 10 sec after the system has got to the standby mode before you start the system again by pressing the microscope console power button.
from Overnight	Run the steps from No. 3) to 7) and follow with the step No. 10).
	See Chapter 5 to set desired imaging conditions.

Note:

[a] Once you have your **FEI Microscope User** / **FEI Supervisor User** account set up via **FEI User Management** software by **FEI Account Administrator** (see Chapter 3), you can use your name and password (case sensitive) to access both Windows XP system and the **xT microscope Control** software.

[b] The stage needs the home stage procedure (see Chapter 3) to be completed before full operation of the UI is possible. For this purpose a dialog is displayed onscreen after the Log-on procedure. If the procedure is not completed now, one can perform it by selecting the **Stage** menu / **Home Stage** (Shift + F3) later (when the imaging is on).

TABLE 2-3   SHUT DOWN PROCEDURE GENERALLY
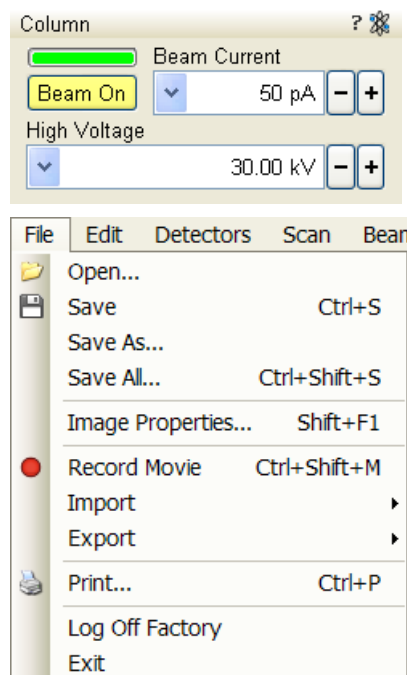
End state	Action from Full Operation on
to Overnight	**1)** Click the **Column** module / **Beam On** button to switch off the beam. [c] **2)** Select [d] the **File** menu / **Log Off…** to log off the present user and to provide the **Log On** dialogue for entering another one. **Note:** Optionally stop the xT microscope Server and shutdown the PC's to reduce the power consumption.
to Standby	Run steps No. 1) and 2). **3)** Click the **xT microscope Server** window / **Stop** button**.** **4)** Click the **xT microscope Server** window / **Standby** button. **5)** Switch Off the PC's and the monitors.
to Complete Shutdown	**6)** Switch off the Emitter (see Chapter 5). **7)** Vent the specimen chamber Run the steps from No. 2) to No. 5) on.
To Disconnected [e]	**8)** Disconnect the power cord, compressed air, nitrogen (if present) and cooling water. **Note:** Electron source and column vacuum is supported for another about 8 hours by an separate IGP's battery supply unit.

Note:

[c] It is strongly recommended to always leave the chamber in the pumped state when the instrument is not used.

[d] Waiting for a new user leaves the status of the **xT microscope Control** software non-operational and only the **xT microscope Server** software is active. Therefore changing an user does not require Logging off / Logging on at Windows XP level, but just restarting the UI level.

[e] Disconnecting the power cord brings the system to a non-powered state. All valves are closed, so the electron column and specimen chamber areas are not automatically vented, but the vacuum in the instrument is no longer supported by running pumps. This should only be carried out by an FEI service engineer. Normally it is used for a system transportation or for service actions, like repair of essential systems (e.g. power supplies).

POWER OFF

A power failure is never good for the system. Take sufficient measures to avoid power failures. If a power failure occurs while the instrument is fully operational, the microscope comes down to a safe state and the following happens:

- The accelerating voltage is switched off abruptly.
- Electron emission is switched off.
- 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.

  Caution!
  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.

Note:
If the power failures occur occasionally it is recommended to use the microscope Uniterruptible Power Supply (UPS - option).

Emergency Off

This 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:

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 2-3   MAINS SWITCH BOARD
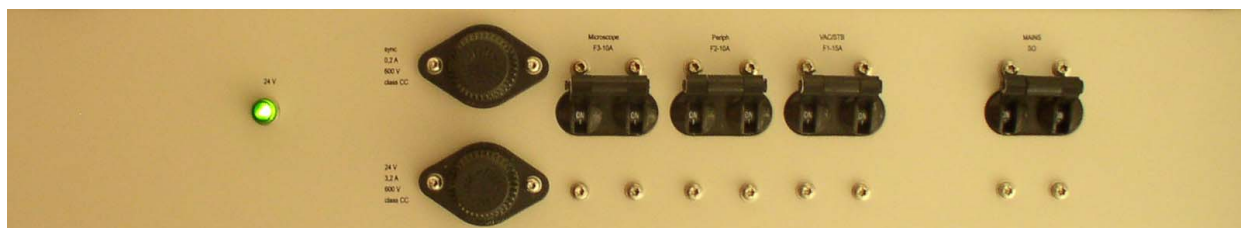
If this is not easily accessible:

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

Equipments
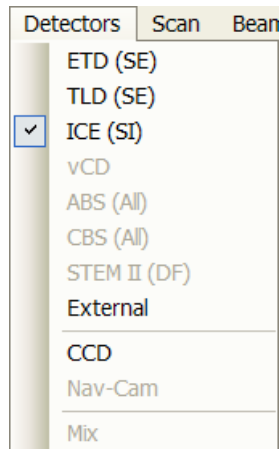
DETECTOR TYPES AND USAGE

The **Detectors** menu shows all installed detectors, the selected one has a tick mark next to its label. The system remembers the last detector used for a particular vacuum mode and its Contrast & Brightness settings.

Note:

If any detector not compatible with the actual mode which is selected, the imaging quad cannot be activated.

TABLE 2-4 ALL DETECTORS TYPES

Detector Name	UI Tag	Detected Signal	Note
Everhart-Thornley	ETD	SE / BSE	S
CCD camera	CCD	light, infra-red light	S
Through Lens	TLD	SE (tunable energy) BSE	S
External	EXT	detector-dependent	O
Secondary Ions Detector	ICE	Electron beam: SE / BSE Ion beam: SE / SI	S, O (650 / 600i)
Concentric Backscattered	CBS	BSE	O
Nav-Cam			S, O (600i)
Annular STEM	STEM II	TE	O

SE = secondary electrons, BSE = back scattered electrons,
TE = transmitted electron, SI = secondary ions
S = standard, O = optional

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

PLASMACLEANER

Helios NanoLab 450 / Helios NanoLab 450 S / Helios NanoLab 450 ML / Helios NanoLab 650 / Helios NanoLab 600i - option

The plasma cleaner decrease the hydrocarbon molecules contamination level (see Chapter 5).

STAGES

For settings and handling the stage and its accessories see Chapter 5.

The stage has the **X, Y, Z, Rotation** and **Tilt** movements motorised and is fully eucentric. All movements are read out on the screen, under the software control. The software control is an integrated part of the **xT microscope Control** software.

FIGURE 2-4 HELIOS NANOLAB 450S

X-section Sample Holder

This tool enables to observe sample cross sections (wafers etc).

FIGURE 2-5 X-SECTION SAMPLE HOLDER

Loadlock
Helios NanoLab 450 / Helios NanoLab 450 S / Helios NanoLab 450 ML

The Loadlock enables a specimen exchange through the pre-pumped Loadlock chamber, eliminating the need to vent and evacuate the entire specimen chamber.

FIGURE 2-6   LOADLOCK

Multiloader
Helios NanoLab 450 ML

FIGURE 2-7   MULTILOADER /
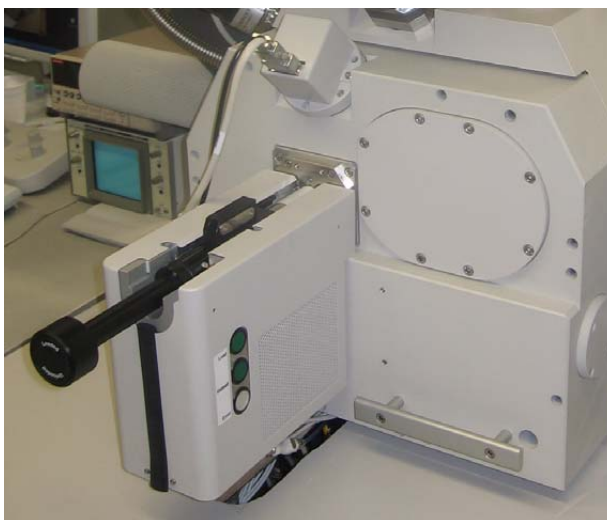
Nav-Cam (in-chamber)
Helios NanoLab 450 / Helios NanoLab 450 S / Helios NanoLab 450 ML

Stage movement limits

The motorised movements of the stage can be operated under the software control for more advanced location mapping. This includes **Shift**, **Get**, **Track** and the **Stage** module functionality. A live image can be repositioned either by the stage movement or by the **Beam Shift** (see Chapter 5).

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

FIGURE 2-8   STAGE MOVEMENT SCHEMA
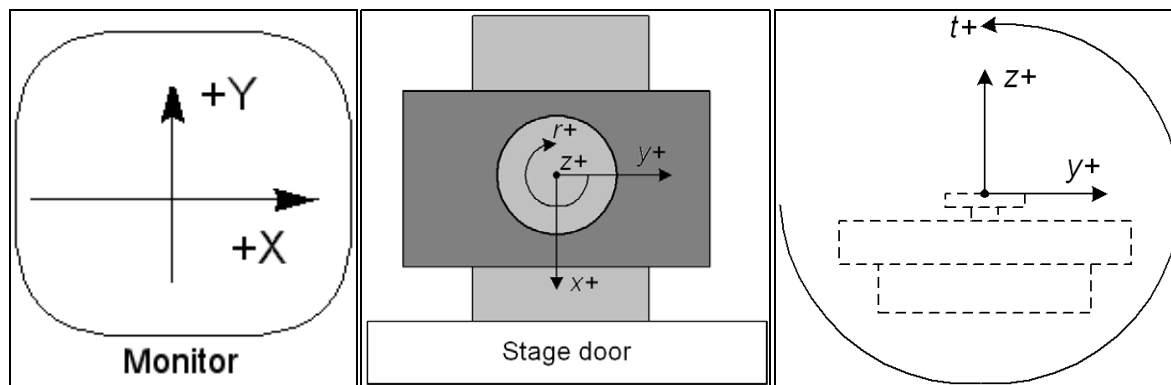
TABLE 2-5   STAGE FEATURES AND LIMITS

Item	100 × 100 mm Stage	150 × 150 mm Stage	Note
X	from -50 to +80 mm	-75 +75 mm	
Y	-50 +50 mm	-75 +75 mm	
Z	0 + 20 mm	10 + 20 mm	internal + external
R	360°	360°	continuous
T	-10° to +60°	-10° to +60°	Check the sample size
Eucentric Position	Electron: WD = 4 mm Ion: WD = 16.5 mm	Electron: WD = 4 mm Ion: WD = 16.5 mm	
Clamp	No	No	
Maximum sample weight	200 g	500 g	Loadlock, for all tilt angles
	500 g	1 500 g	without Loadlock, at Tilt = 0°

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 !
Stage tilt is limited by the specimen size. Beware of hitting the objective pole piece!

3 | SOFTWARE CONTROL

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

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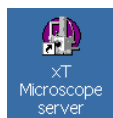
The software control contains graphic applications within Windows XP™ operating environment. **xT microscope Server** starts and stops the basic microscope functions.

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 XP 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 XP, refer to the *Microsoft® Windows™ User's Guide* shipped with your system.

Software Interface Elements
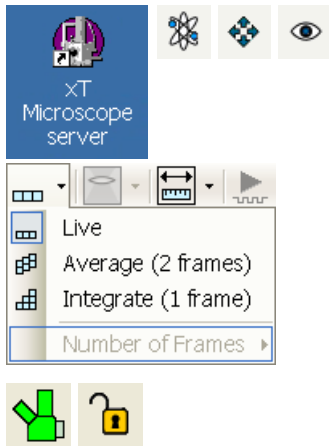
ICONS

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 press in and activate, clicking it again or clicking another one (depending on a particular case) causes it to spring out and deactivate.

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 an item on the user interface 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 grey 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.
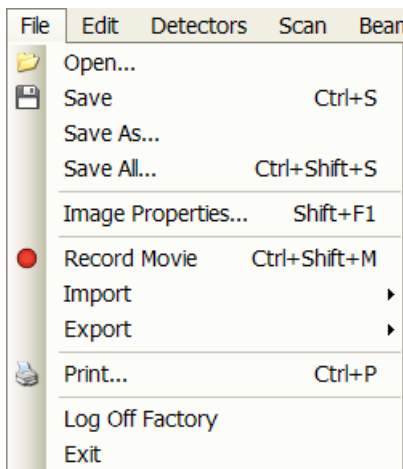
Using the Mouse

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

Press the menu bar item, drag the cursor down to a desired selection 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 quickly be 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
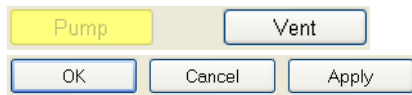
carry out or cancel functions. They press in when clicked and some change color to show the corresponding function activity.

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 an user to the following dialogue after necessary settings have been done.
- The **Previous** button moves an user to the previous page when settings need to be changed.

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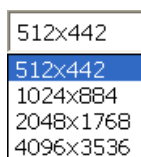
contain available choices, such as screen resolution, magnification settings, etc. Click the **List** box to roll down a list of available values, then click the desired one. The drop down list automatically closes and displays the new value as the actual one. The change of the setting is immediate.
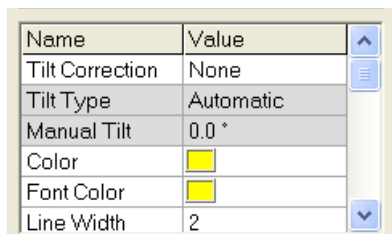
PROPERTY EDITORS

group list of related parameters and their values. The editable parameters have a white background, the fixed parameters are shaded. An 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
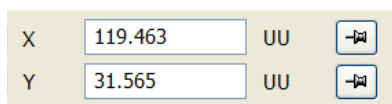
let you input text information (such as passwords, labels or precise numbers) using the keyboard. Some edit boxes, which are not part of a dialogue, require to confirm the input by pressing **Enter**. If you press **Esc** before leaving the edit box, its previous value is restored.

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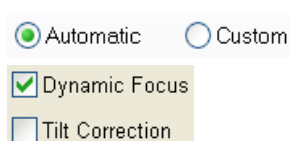
Within a group of related round **Radio buttons**, only one selection can be made active at any time by clicking the individual round box.

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

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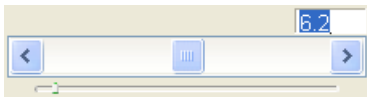
allow to change parameters, such as contrast, brightness, gamma etc. in a continuous way by pressing and dragging the middle adjuster or clicking in the grey bar. They always have a label in the upper left and right corners for readout information. Double-click the value in the upper right corner enables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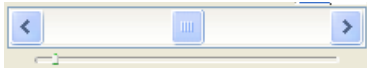
Exponential Adjuster

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 has. Its button position always corresponds to the actual parameter value within an available range.
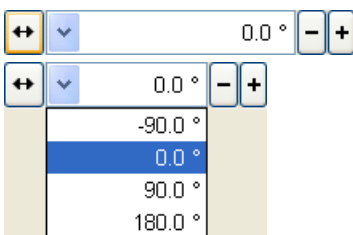
Preset Adjuster

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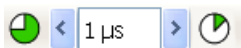
2D CONTROLS
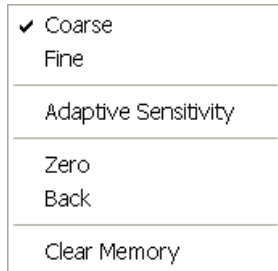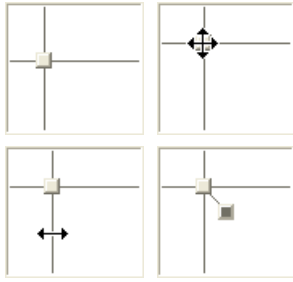
are represented by an X-Y box. The position of the crosshair corresponds to the actual parameter value with respect to its full range being represented by the perimeter of the box.

Pressing 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 moved in four directions. Pressing directly on the X / Y axis changes the active quad cursor to the two-ended arrow, which can be moved 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.
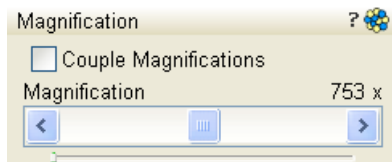
MODULES

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.
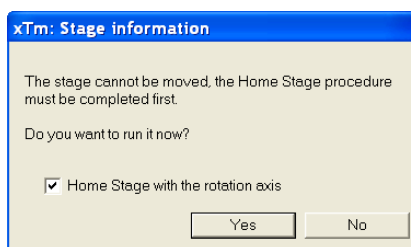
DIALOGUES

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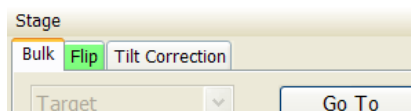
In modules or dialogues containing more interface elements than would fit into the limited area the **Tabs** are used. These related elements are split into the groups (sections) and each one is supplemented with the labeled Tab. Clicking the Tab brings it to the foreground displaying the corresponding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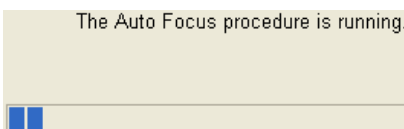
PROGRESS BARS

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

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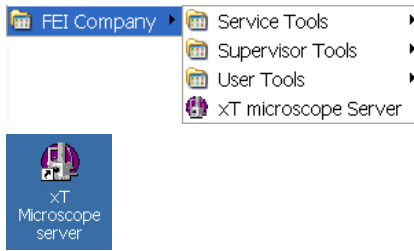
The **xT microscope Server** application starts and stops the software service controlling basic microscope functions and also the user interface (UI) software **xT microscope Control**.

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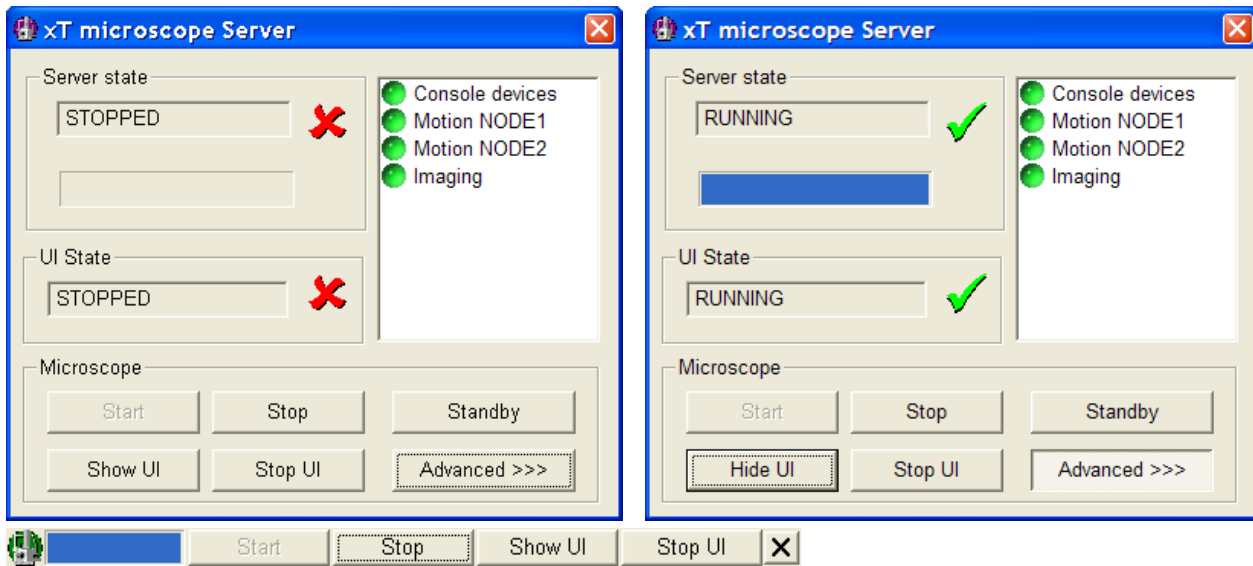
- The **Server State** / **UI State** modules display the **RUNNING** or **STOPPED** state of the xT microscope Server / xT microscope Control software services. During a transition between these states **STARTING** or **STOPPING** is displayed.

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

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

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

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

   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** checkbox: when ticked (default), the Start button automatically starts xT microscope Control after starting the Server.
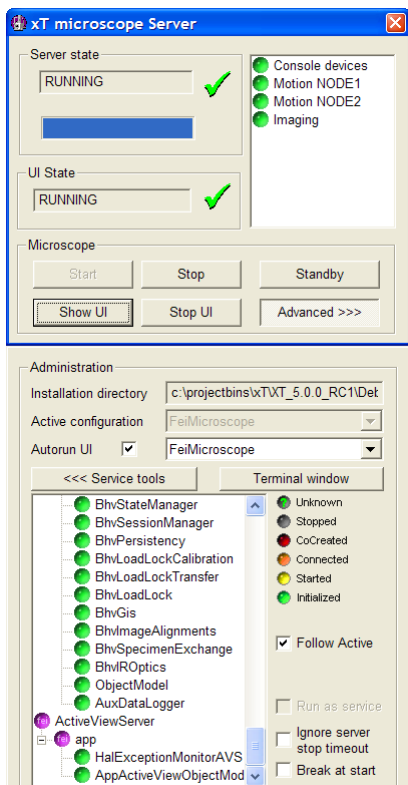
xT microscope Control Software

xT microscope Control – also called User Interface (xTUI or UI) – is made up of several elements which compose the main window, displaying status and control features.

Note:
Today the UI suports 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
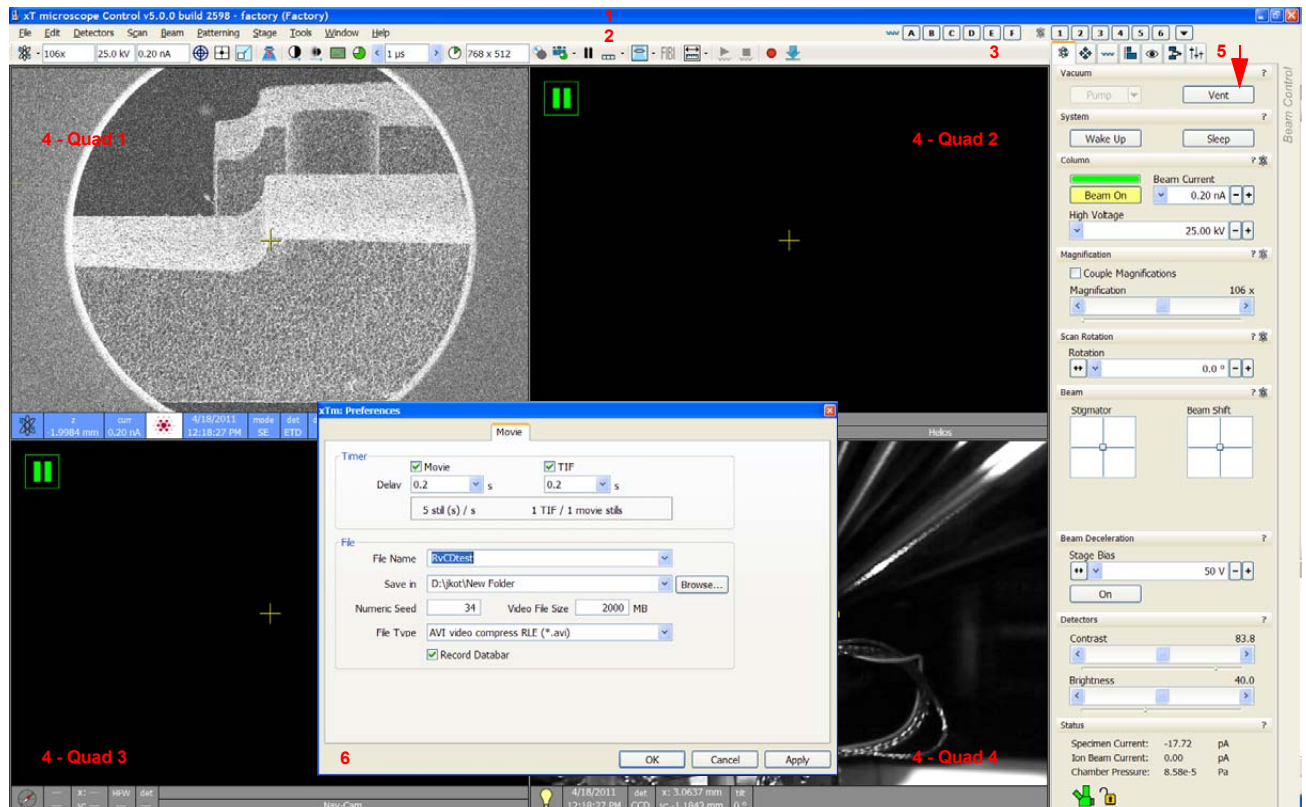
1. The **Title bar** – labels the application
2. The **Menu bar** – contains all operation menus and submenus
3. The **Toolbar** – contains functional icons for the most frequently used microscope controls and for the fast access to the Pages
4. The **Imaging area** – quads with adjustable Databar
5. **Pages and Modules** – microscope and imaging control elements organized into modules making up the pages
6. The **Preferences dialogue** – presetting of operating conditions (displayed image is illustrative only)

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
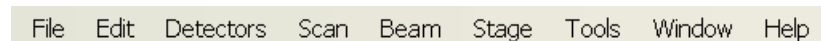
Select pull-down menus from the menu bar by:

- clicking the Menu title
- Alt + hitting underscored keyboard letters + using keyboard arrows

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 xTUI.

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 active quad. You can choose different 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.
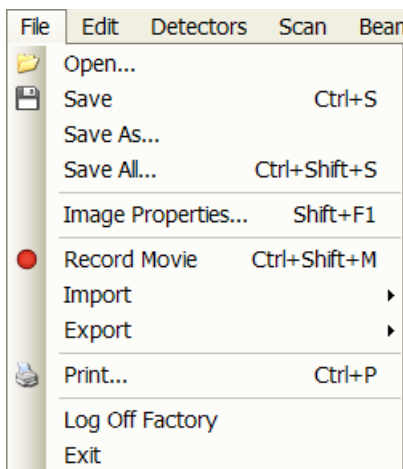
FIGURE 3-5 SAVE AS… DIALOGUE
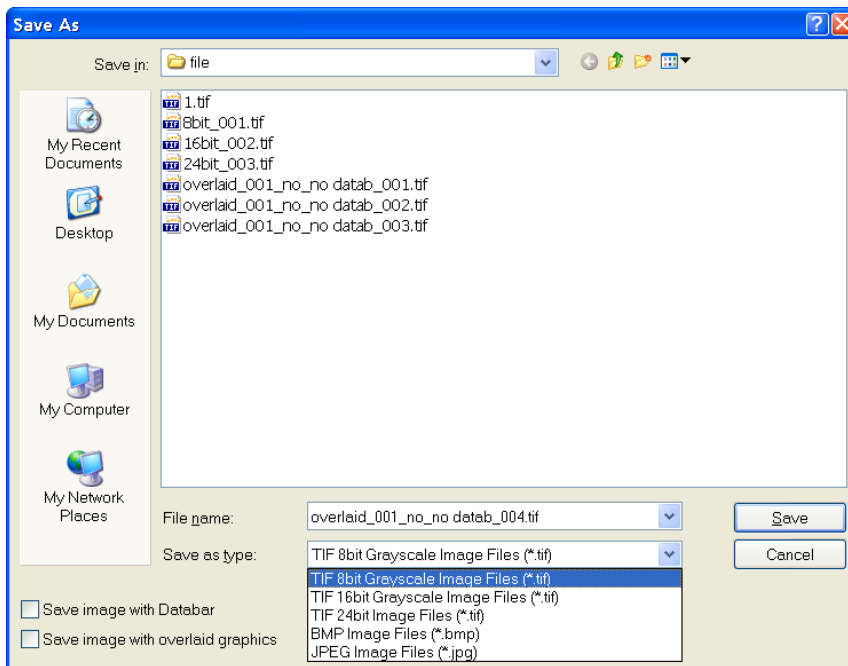
Save All… (Ctrl + Shift + S)

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
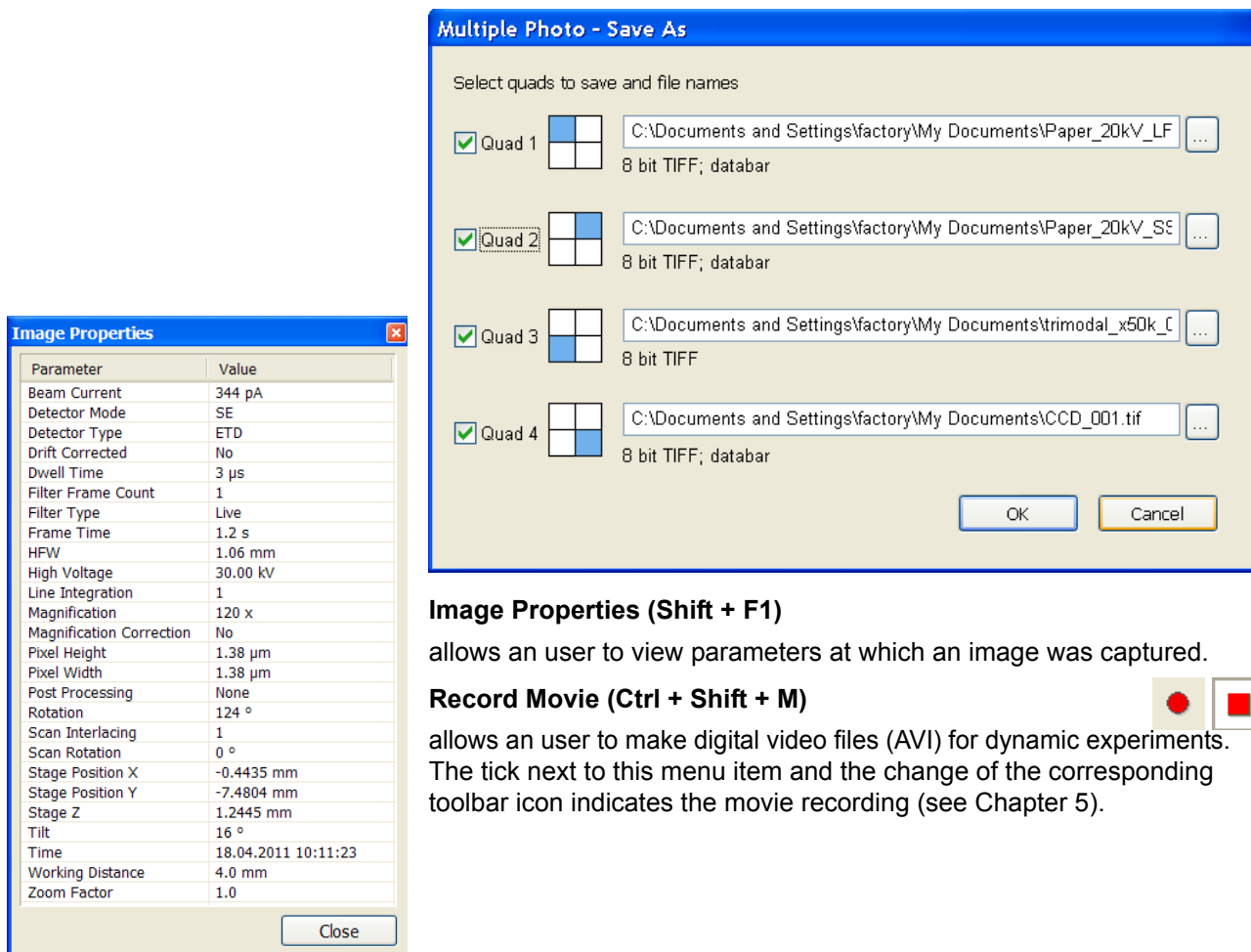
Image Properties (Shift + F1)

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

Record Movie (Ctrl + Shift + M)

allows an 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).

Parameter	Value
Beam Current	344 pA
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	1.06 mm
High Voltage	30.00 kV
Line Integration	1
Magnification	120 x
Magnification Correction	No
Pixel Height	1.38 µm
Pixel Width	1.38 µm
Post Processing	None
Rotation	124 °
Scan Interlacing	1
Scan Rotation	0 °
Stage Position X	-0.4435 mm
Stage Position Y	-7.4804 mm
Stage Z	1.2445 mm
Tilt	16 °
Time	18.04.2011 10:11:23
Working Distance	4.0 mm
Zoom Factor	1.0

Import / Export

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

- The **Stage Positions…** stored with the use of the Stage module (.**stg** files)
- The **Patterns…** used in the patterning module (.**ptf** files) (see Chapter 5)
- The **End-Point Monitor Graphs…** used for milling (.**epm** files)
- The **Scanning Presets…** parameters (.**scp** files) (see Preferences…)
- The **Quad Presets…** parameters (.**qps** file: Beam type / Detector type / Detector Mode / Detector contrast & brightness / Digital Contrast / Digital Brightness)
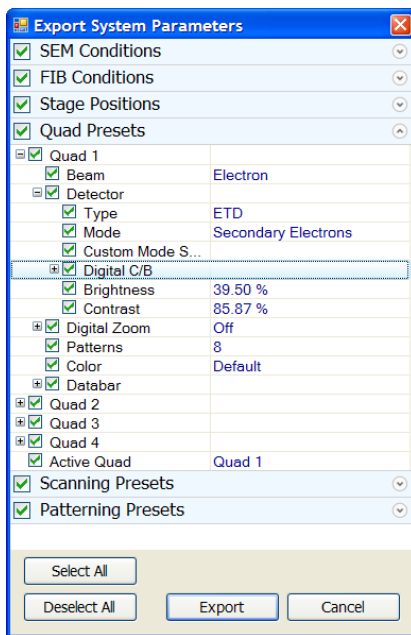
The **System Parameters…** option enables to save a selection of actual microscope settings (.**par** files) also including above mentioned ones. When importing them back likewise only selected ones are loaded.

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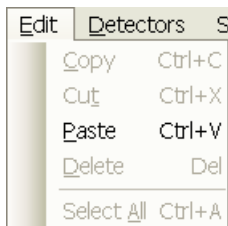
Edit Menu (Alt + E)

opens some helpful functions applicable for patterns, measurements and annotations:

Copy (Ctrl + C) / 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.
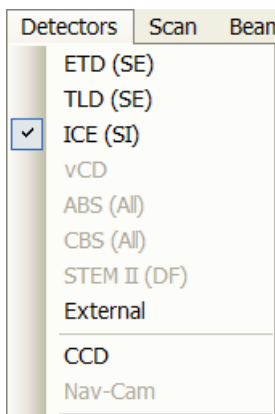
Detectors Menu (Alt + D)

opens the selection and setting of all installed Detectors (see Chapter 5 and Cahpter 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.

Scan Menu (Alt + C)
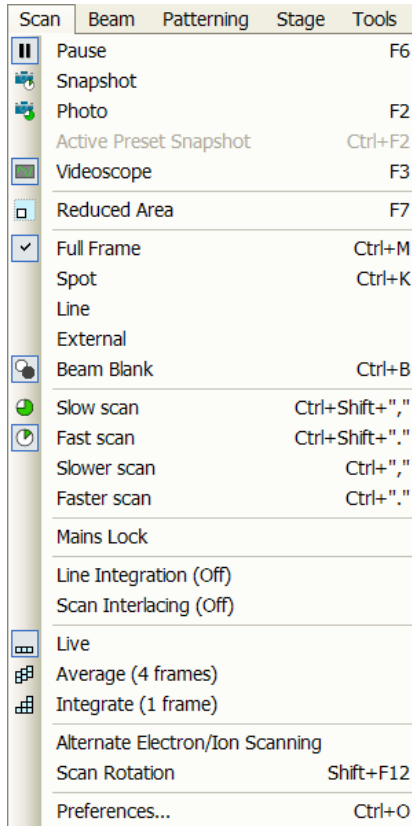
opens the scanning control functions:

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 Pause icon is pressed-in and has an orange background. When the quad is paused the icon remains pressed-in but its background reverts to normal and a green box surrounding two vertical green bars appears in the corresponding quad.

Select Scan menu \ Pause item or press F6 button or click the toolbar Pause icon to release the pause function (the icon button pops out) and to return the scanning to the previous state. Shift + clicking the Pause icon pauses / activates all quads with an electron imaging at once.

Snapshot ((Ctrl +) 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.

Note:
There are two hotkeys for the Snapshot: F4 for an electron and Ctrl + F4 for an ion imaging (not mentioned in the Scan menu). The Photo hotkey F2 works with an active imaging beam.

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 electron beam Snapshot / active Preset Snapshot from all quads at once.

Videoscope (F3)

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

Reduced area (F7)

This mode is useful when focusing and stigmating 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 pressing and draging. 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. Press and drag the selected area to the desired position and release the mouse.
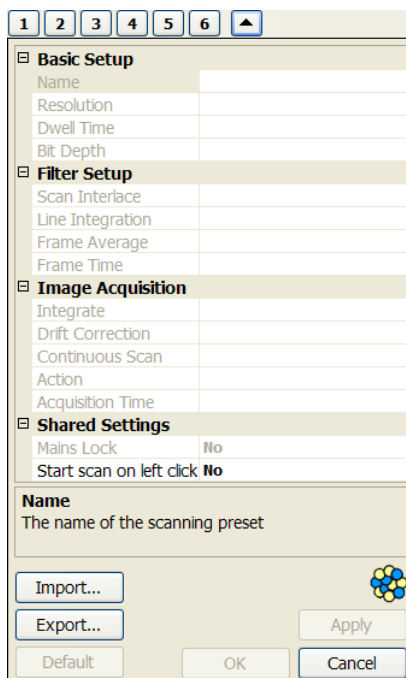
- **Changing the size:** Place the mouse cursor over the edge of the selected area. The cursor changes to a 2-ended arrow, either horizontal or vertical. A corner can also be used to move two sides. Press and drag the side out or in to obtain the desired size and release the mouse.

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 move the cross or click anywhere around the screen to change its position.

Line

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

External

switches to activate external control of the scanning system, such as beam control from an EDX system. 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 oscillations. 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 100) 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.
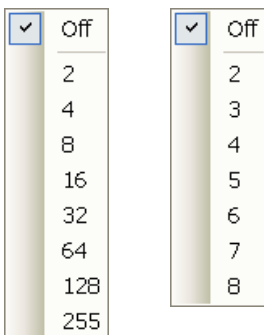
Scan Interlacing

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.

Note:
When two above mentioned functions are active, it is represented in the toolbar scan speed spiner with the letters LI / SI.
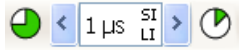
Live

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 icon displays menu items **Live** / **Average** / **Integrate**, **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 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).

Alternate Electron/Ion scanning

When ticked, tha scanning alternates between the electron and ion imaging in two separate quads after completion of each frame.
A message is displayed in affected quads. All scanning parameters are changed during switchng the quads so it takes significantly long time under some settings.
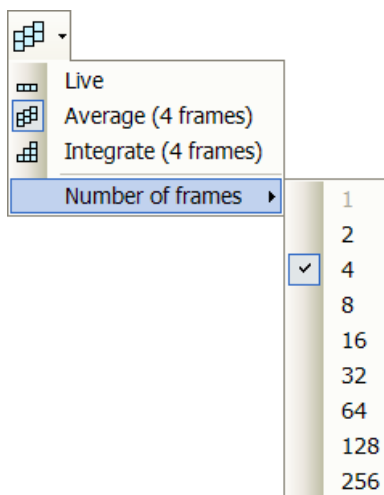
Scan Rotation (Shift + F12)

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 non-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).
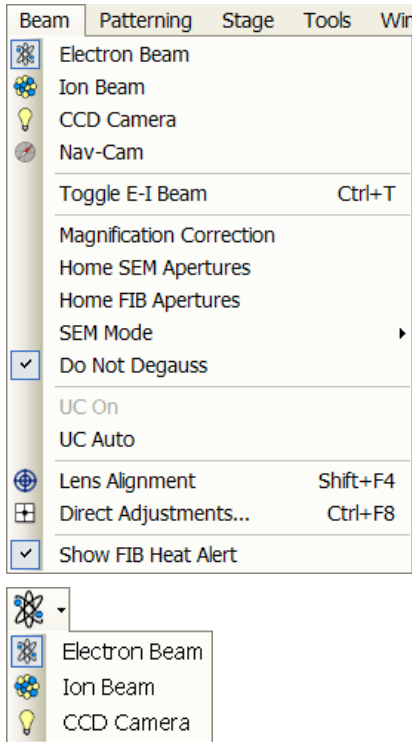
Beam Menu (Alt + B)

opens the Beam menu functions:

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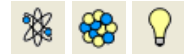
makes the quad or single screen active to the **Electron Beam / Ion Beam / CCD Camera** (the displayed icon sequence) with respect to the source, column, scanning, and detector settings. Only one is active at any time, but can be operated independently for each quad.

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

Toggle E-I Beam (Ctrl + T)

This function quickly toggles electron and ion beams to be used in the selected quad for an imaging.

Magnification Correction

When ticked, the **E-column: Magnification Correction** alignment (see Chapter 4) influences the imaging, otherwise it is not appllied.
The "c" letter is added to appropriate databar fields (Mag, HFW) and the "Magnification Correction" text is added to the imaging quad.

Home SEM / FIB Apertures

This function sends the SEM / FIB aperture mechanism to its home position in case of troubles.

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).
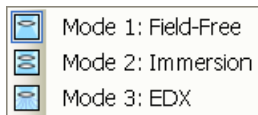
Do Not Degauss

When ticked, an automatic UHR lens degauss procedure is dissabled because of accelerating operation (for instance during switching from electron UHR mode to ion beam imaging).

UC On / UC Auto

Model difference: Helios NanoLab 600i does not have the UC item.

When ticked the UC-mode (UniColor mode) for the electron beam is set on. Ticking the UC Auto switches UC-mode on automatically, when particular conditions are accomplished (see Chapter 5).

Lens Alignment (Shift + F4)

This feature activates / deactivates the final lens alignment mode for the fine alignment (for the electron beam only). The scanning changes to the fastest scan value, lens modulator turns on and the alignment cross appears in the center of all imaging quads.

Pressing activates a 5-arrow ended cursor. The mouse motion starts the final lens alignment (see Chapter 5).

Direct Adjustments (Ctrl + F8)

opens the Direct Adjustment window (or places it over 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).
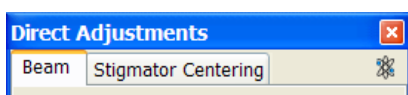
Show FIB Heat Alert

When ticked, the system informs an user 1 minute prior to the automatic FIB Heat procedure (started when ion emission beam is lower then approx. 2 µA) and enables to stop it (see Chapter 4: **253 - Supervisor: Ion Beam** alignment).

Patterning Menu (Alt + P)

opens the Patterning menu functions (see Chapter 5):
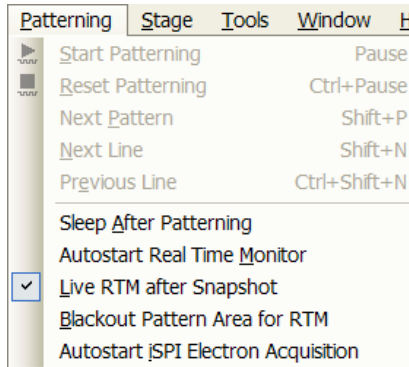
Start / Pause / Resume Patterning (Pause button)

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 button)

cancels the patterning procedure.

Next Pattern (Shift + P)

In serial patterning the actual Patterning is stopped and the procedure continues with the next pattern (if present).

Next Line (Ctrl + N)

When milling a Cleaning Cross Section pattern type, milling of an actual line is cancelled and continues with the next one.

Previous Line (Ctrl + Shift + N)

When milling a Cleaning Cross Section pattern type, milling of an actual line is cancelled and continues with the previous one.

Sleep After Patterning

When selected, this function applies the **System** module / **Sleep** command when patterning process finishes.

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 3-7 IMAGING with / without BLACKOUT PATTERN AREA
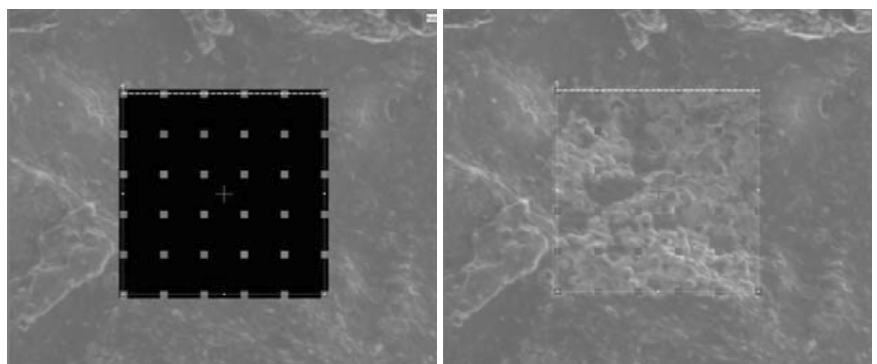
Autostart iSPI Electron Acquisition

When ticked and iSPI is on (intermittent Switching between Patterning and Imaging) starts automaticlally when starting patterning. Electron beam is released, when paused. When not ticked, nothing happens.

Stage Menu (Alt + S)

opens the stage and sample navigation functions:
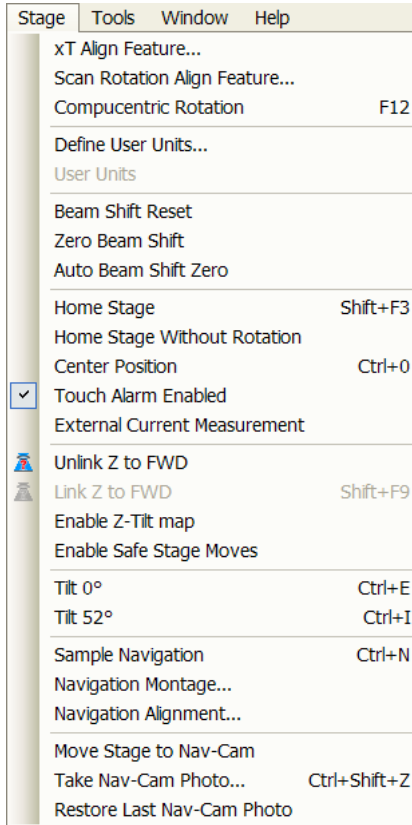
xT Align Feature

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 5).

Define User Units…

activates a procedure guiding an 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 non-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 image 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:
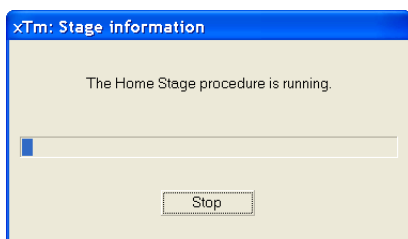
X / Y position is set to the factory pre-set stage rotation centre, **R** = 0°, **T** = 0°, **Z** = preset long working distance (depends on the stage type).

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 ticked, the **Status** module / **Speciment current** value is N/A, because it is expected to have an external measuring device (option) connected (see Chapter 7).
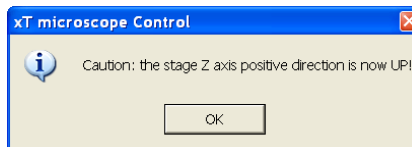
Unlink Z to FWD

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.
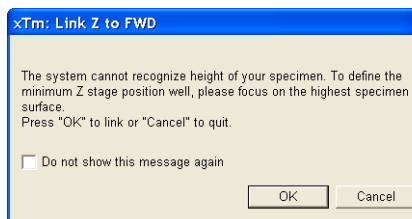
Link Z to FWD (Shift + F9)

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 10 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.

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) / Tilt 52° (Ctrl + I)

tilts the stage to 0° / 52°.

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 selected 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 read (e.g. when the stage rotation or tilt changes).
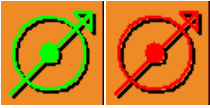
Navigation Montage...

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

Navigation Alignment...

This procedure alignes the sample image according to specific demands (see Chapter 5).

Move Stage to Nav-Cam / Take Nav-Cam Photo (Ctrl + Shift + Z) / Restore Last Nav-Cam Photo
Helios NanoLab 450 S / Helios NanoLab 450 S / Helios NanoLab 450 ML

This items control the Nav-Cam navigation feature (see Chapter 5).

Tools Menu (Alt + T)

opens the Tools menu functions:
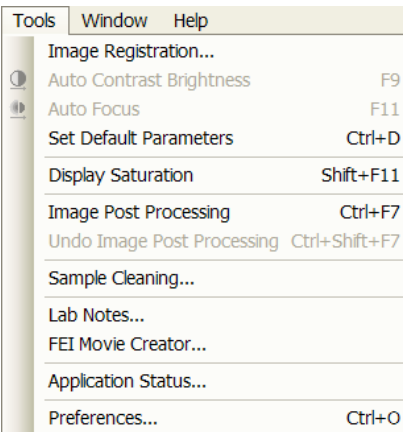
Image Registration

With user-specified alignment points one can transform one image spatially to correspond to another one, then use that new one as if it were an image of the sample. The transformed image could include one taken with the optical microscope that corresponds to the real sample, or several taken at various depths of focus. This is also called image-to-image registration and image alignment.

Click the **Image Registration…** and follow the prompts. The user first selects the quad with the reference image and then the quad with the target image (this is the one that will be transformed). After this a single or multipoint alignment can be applied by selecting similar points in both the reference and target image. **Register** will apply the transformation after 1, 2 or 3 pairs of points have been selected .

Register button will re-apply the registration on any new or restored image in the same or a different quad. When **Show** is selected from the **Overlay** panel a copy of the registered target image will be shown (in red, green or blue) on the reference image which shows the quality of the registration and to allow information from both images to be used in placing patterns. The **Threshold** value (0 to 255) determines which gray levels of the target image are shown in the overlay.

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.
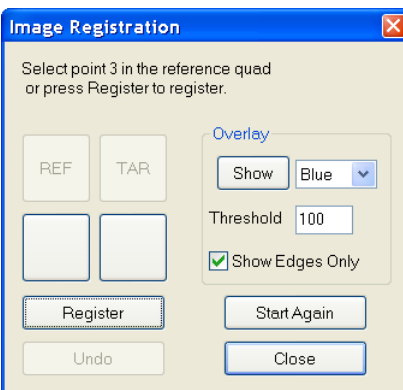
Auto Contrast Brightness (F9)

ACB activates the automatic contrast and brightness routine. The system attempts to set the Contrast and Brightness of the selected detector in the active quad to suit the actual sample and conditions so that the majority of grey levels is displayed.
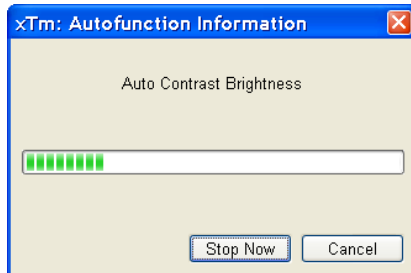
Auto Focus (F11)

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

Note:

When ACB / Auto Focus is activated the dialogue appears to show the progress. The function can be interrupted by clicking the **Stop Now** button, which leaves the setting at the current stage of progress. Clicking the **Cancel** button before the function ends returns the setting to its original value.

Set Default Parameters (Ctrl + D)

This functionality loads default settings. It switches UI to quad Image mode and selects the default detector for quad 1 and the CCD camera for quad 4. The microscope and image parameters are selected so that there is a big chance to get usable and prompt imaging.

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…
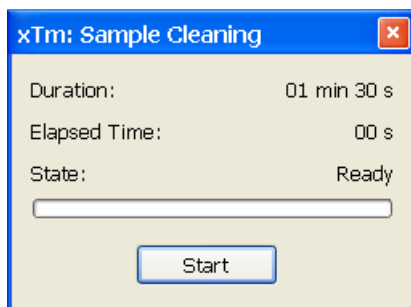
This feature starts the sample cleaning procedure set in the **101 - Plasma Cleaning** alignment (see Chapter 4). This cleaning method is effective process for removing very thin contamination layers, which are typically formed by hydrocarbons residues remaining on vacuum parts after conventional cleaning or could be transferred into the microscope chamber with sample (see Chapter 5).

Lab Notes…

opens the Windows Notepad application over the UI for an 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 above 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.
- Three icons in the lower left corner enable to switch on / off displaying of errors, warnings and informational messages.

FIGURE 3-8 APPLICATION STATUS
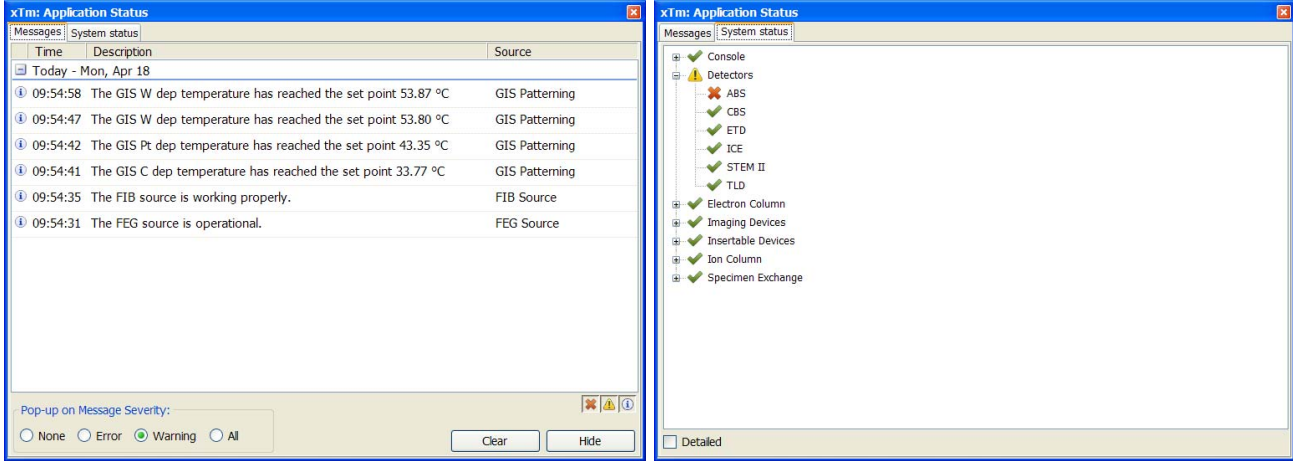
Window Menu (Alt + W)

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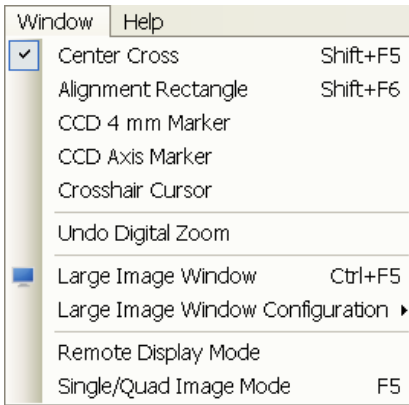
Center Cross (Shift + F5)

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

CCD 4 mm Marker

places a short horizontal line with 4 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.
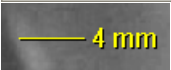
CCD Axis Marker

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.
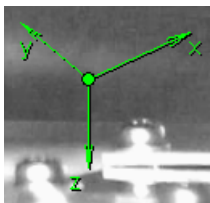
Large Image Window (Ctrl + F5)

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

FIGURE 3-9 LARGE IMAGE WINDOW
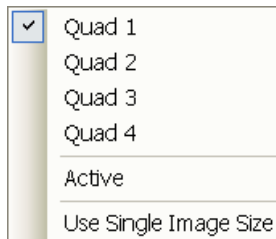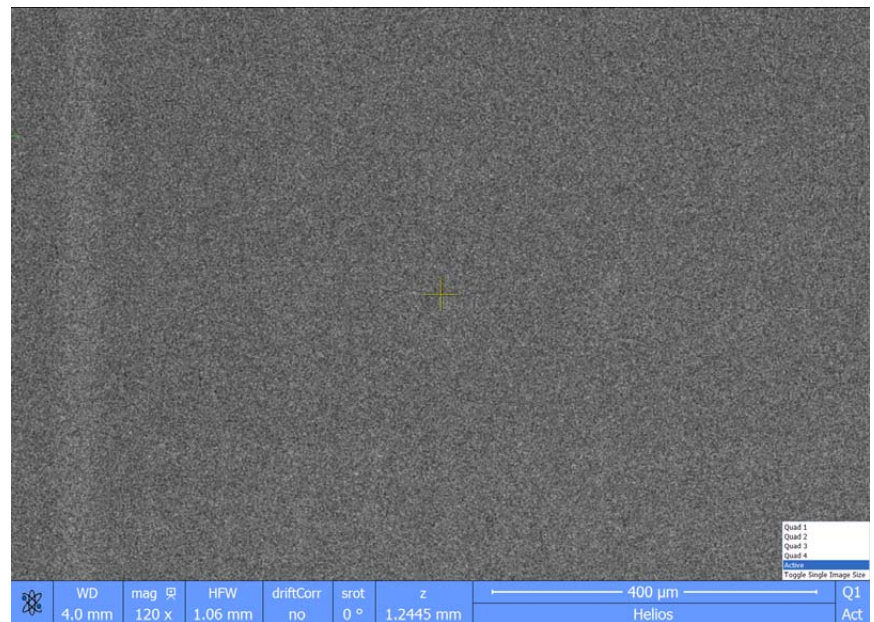
Large Image Window Configuration

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 performace and it is displayed in the bottom left quad corner.

Single / Quad-Image Mode (F5)

toggles the imaging 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 beams, detectors or scan conditions.

Quad 1 / Quad 2 / Quad 3 / Quad 4

The selected quad is indicated by a tick 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.

Help Menu (Alt + H)

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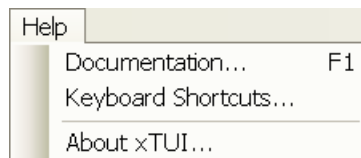
Documentation… (F1)

The Help window shows complete User Manual in PDF format using an embedded Acrobat Reader with its useful navigation, search and selection tools.

Clicking the **Question mark** at the right side of the module header (see below) opens the respective part of the user manual.

FIGURE 3-10 DOCUMENTATION
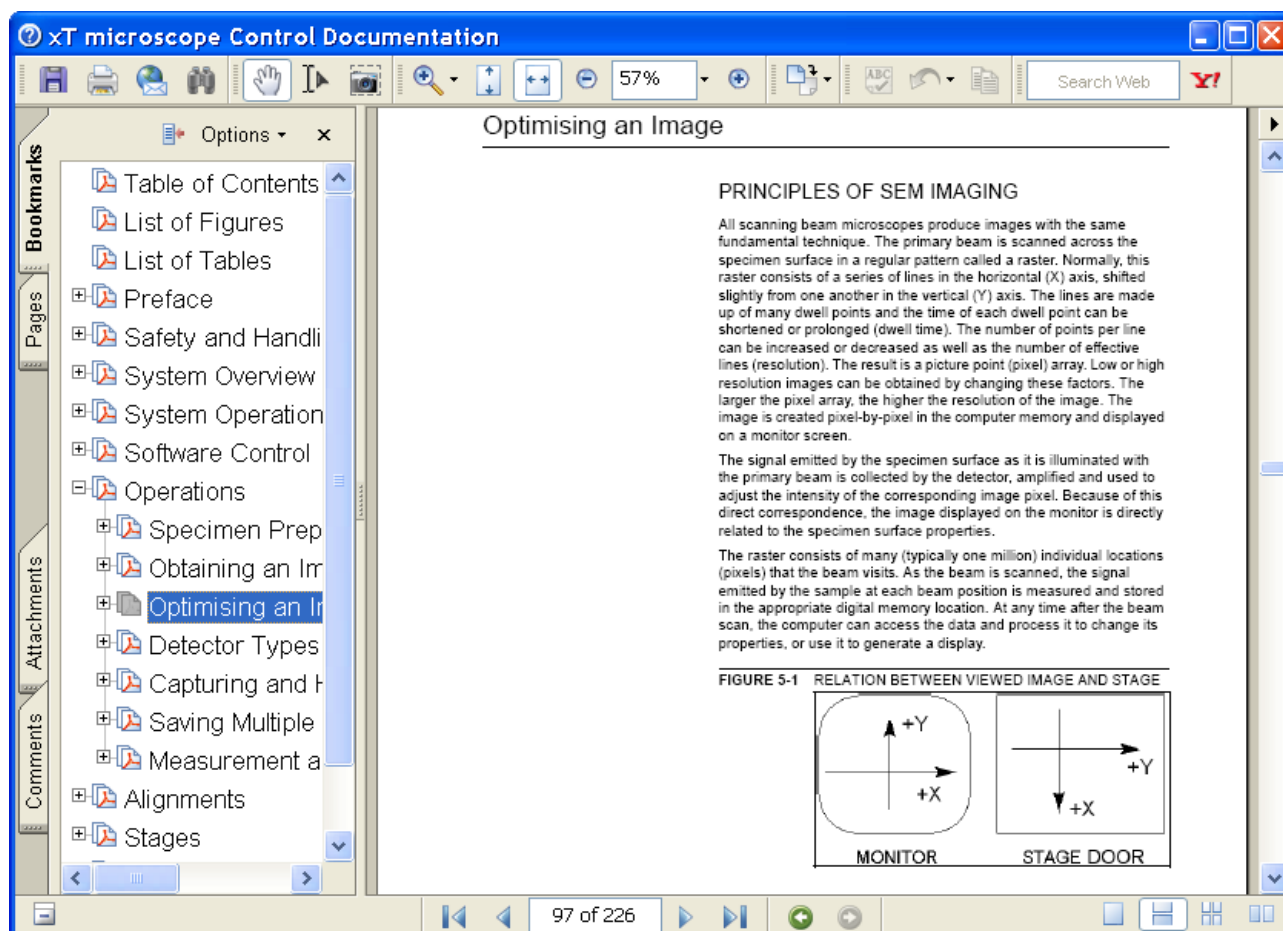
Keyboard Shortcuts…

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

About xTUI…

displays a window with a microscope picture containing information about the product version. The window automatically disappears after any mouse 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).

FIGURE 3-11 THE TOOLBAR
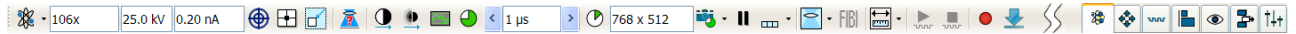
Rest the cursor over the icon for two seconds without clicking it to see its explanatory tool-tip.

Whenever you select a function the corresponding icon is highlighted to indicate that the function is active (except of auto-functions, which display a progress dialogue).

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

Magnification / High Voltage / Beam current 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).

Imaging Pixel Resolution List Box

This list contains available imaging pixel resolutions (also used for captured images). Selecting a new resolution results in the 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 activates (yellow color) / deactivates (grey color) the functionality (see Chapter 5).
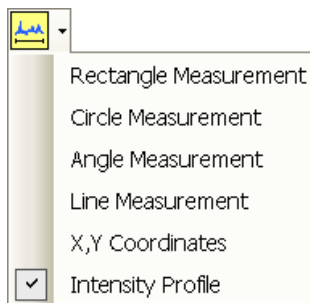
FIBI (FIB Immersion)

This utility enables to quickly switch from an ion imaging to an electron UHR imaging. The icon is not accessible if following conditions are not accomplished:

•   electron HV =< 3 kV

•   ion HV = 30 kV

IMAGING AREA

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.

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), lens alignment, Scan / Compucentric Rotation, XY-move (get or tracking mode)
- **Ion imaging** (incl. External and Mix): focus, astigmatism correction, Beam Shift, magnification change (coarse, fine), zoom (in / out), Scan / Compucentric Rotation, XY-move (get or tracking mode)
- **Optical imaging**: 4 mm Marker placement, Compucentric Rotation, Z-move (tracking), 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.
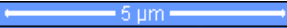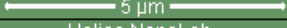
Image Databar

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. Additionally clicking the label field induces the label editing menu and double-clicking the micron bar induces the image properties window (see above).

FIGURE 3-12 THE DATA BAR EXAMPLES

Selected electron imaging		HV 5.00 kV	curr 1.6 nA	HFW 14.9 µm	det ICE	mode SE	5 µm Helios NanoLab
Unselected ion imaging		HV 30.00 kV	curr 7.7 pA	dwell 50 ns	det ETD	mode SE	10 µm Helios NanoLab
Unselected optical imaging		3/15/2010 11:56:26 AM	det CCD	z 9.9960 mm			
Selected Patterning Imaging		HV 5.00 kV	curr 1.6 nA	HFW 14.9 µm	det ETD	mode SE	5 µm Helios NanoLab
Unselected Patterning imaging		HV 5.00 kV	curr 1.6 nA	HFW 14.9 µm	det ETD	mode SE	5 µm Helios NanoLab

Note:

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

PAGES (ALT + P) 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 pressing 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. System, 3. Column, 4. Magnification, 5. Scan Rotation, 6. Beam, 7. Beam Deceleration, 8. Detectors, 9. Status
Navigation	10. Stage (Map / Coordinates / Tilt Correction) or (Bulk / Flip / Tilt Correction), 11. Stage Z, 12. Loadlock, 8. Detectors, 9. Status (reduced)
Patterning	13. Pattern (Basic / Advanced / Progress / S Mill), 14. Omniprobe, 15. End Point Monitor (iSPI / Monitor / Settings), 9. Status (reduced)
Processing	16. Measurement / Annotation, 17. Digital Zoom, 18. Enhanced Image (LUT / Mix 3 / Mix 4 / Color / Process), 8. Detectors, 9. Status (reduced)
Detectors	19. Detector Settings, 20. Quad Presets, 7. Beam Deceleration, 8. Detectors, 9. Status
Sample Preparation	13. Pattern (Basic / Advanced / Progress / S Mill), 14. Omniprobe, 5. Scan Rotation, 10. Stage (reduced)
Alignments	21. Alignments (Instructions / Individual steps), 9. 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.
Some of the module controls are beam dependent. In this case, an active beam type is indicated by the corresponding icon at the right-hand side of the module.

1. Vacuum Module
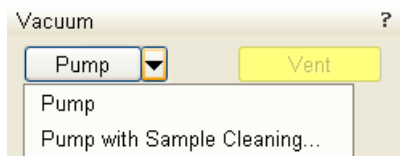
is used to control the pressure in the specimen chamber. The **Pump** button starts the pumpdown procedure for the specimen chamber and the column. The **Pump with Sample Cleaning…** choice pumps the system, makes Sample Cleaning procedure (see Chapter 5) and remains columns evacuated. The system allows the accelerating voltage to be switched on only when the columns are sufficiently evacuated. The **Vent** button starts venting for a sample exchange after the user confirmation (see Chapter 2).

2. System Module

contains the possibility to carry out several operation in one click:

The Wake Up Button

- starts the Ion source
- starts the Electron source (if it is switched off)
- switches the electron and ion beam accelerating voltage on

The Sleep Button

- switches the electron and ion beam accelerating voltage off
- stops the ion source
- switches the GIS's heating off
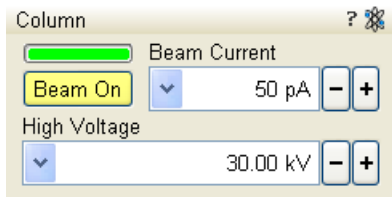
3. Column Module

contains controls for setting the electron beam conditions:

Beam On Button

switches the accelerating voltage on / off.

Beam Current Preset Adjuster

enables to adjust the electron **Beam current** in the selectable accuracy steps (see the **Preferences… / General** tab). The actual value 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.

High Voltage Preset Adjuster

enables to adjust the overall electron 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).
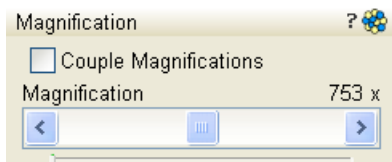
4. Magnification Module

The continuous adjuster offers a variety of ways to control the actual 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).

Magnification Control

The **Couple Magnification** check box ensures the same magnification for electron and ion beams.

- Clicking the **end arrow** increases magnification by about **5%**.
- Clicking **between** the **end arrow** and the **button** increases magnification by about **20%**.
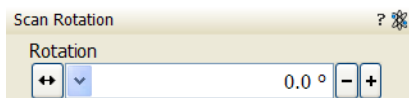
5. Scan Rotation Module

controls and displays the Scan Rotatio value (see Chapter 5).

6. Beam Module

Stigmator 2D Control
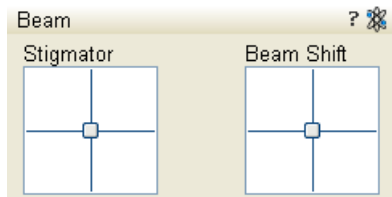
enables to correct an image astigmatism. The crosshair cursor indicates the actual setting.

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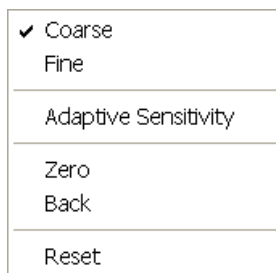
7. Beam Deceleration Module
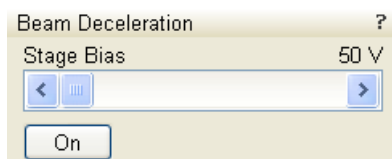
In the Beam Deceleration mode a negative potential (Stage Bias) is applied on the stage, which influences both primary and signal electrons. It allows to decelerate the primary beam up to 50 V landing energy (see Chapter 5).

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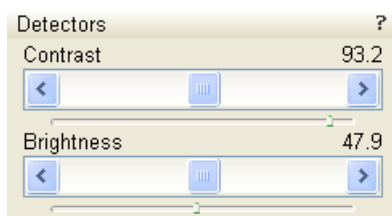
contains continuous adjusters to control the active detector **Contrast** (detector voltage) and **Brightness** (voltage offset). The values are remembered for each detector and a quad. The adjusters are disabled if the detector is not available or cannot be controlled (e.g. CCD camera or an External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

Contrast & Brightness 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.

9. Status Module

can be found at the base of most
pages, displaying the following information in a full or any constricted
form, some of them as a tooltip (said values are approximate only):
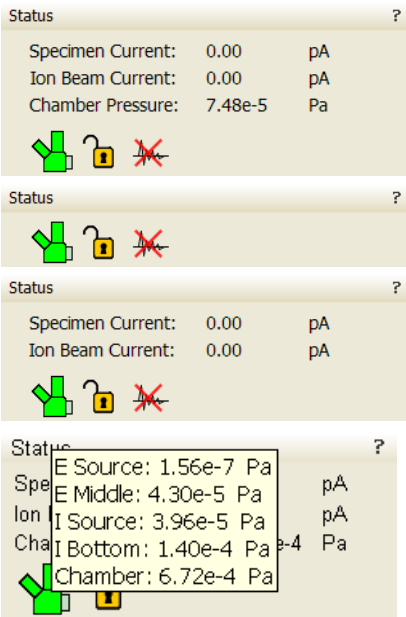
- The **Specimen Current:** shows the electron current reaching the
  specimen.
- The **Ion Beam Current:** shows the ion beam current.
- The **Chamber Pressure (Chamber):** shows the specimen chamber
  pressure.
- The **E Source** / **E Middle** / **I Source** / **I Bottom** / **Chamber:**
  shows pressure in the corresponding vacuum system section.

The system conditions are displayed by means of the icons:

TABLE 3-2   STATUS ICON MEANING

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

10. Stage Module

consists of the tabbed sections varying according
to the microscope model (see Chapter 5).

Helios NanoLab 450 / Helios NanoLab 650 / Helios NanoLab 600i

- 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 Correction** tab contains correction features for the tilted
  imaging.

Helios NanoLab 450S / Helios NanoLab 450ML

- The **Bulk** / **Flip** tab combines features of Map and Coordinates tabs.

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 3-13 THE STAGE MODULE
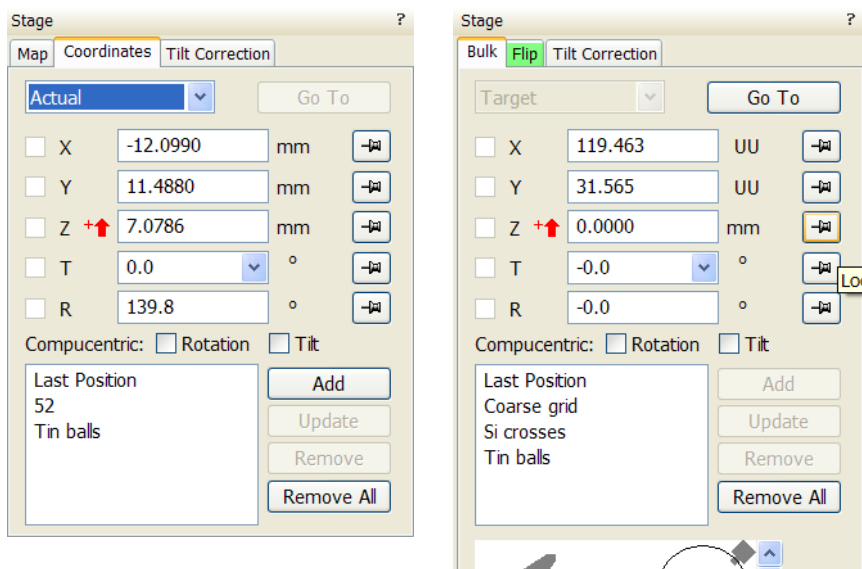
11. Stage Z Module
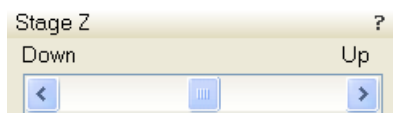
This module enables to softly move the stage in the Z-axis direction. The more the slider is pushed to the each side, the faster is the stage motion. Clicking the slider bar or the arows at its ends moves the stage about an infinitesimal distance.

12. LoadLock Module

Helios NanoLab 450 S / Helios NanoLab 450 ML
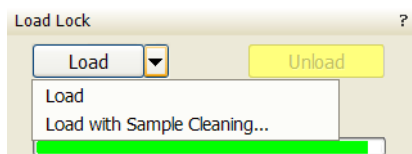
The loadlock enables sample exchange to the specimen chamber, eliminating the need to vent and evacuate the entire specimen chamber during exchanges (see Chapter 5).

- Pressing the **Clamp** push button (on the LoadLock body) attaches the carrier onto the loadlock arm.
- Clicking the **Load** button moves the sample on the carrier into the chamber.
- Clicking the **Unload** button moves the sample out of the chamber into the loadlock.
- Pressing the **Release** push button (on the LoadLock body) loosens the carrier from the loadlock arm.

The **Load with Sample Cleaning…** choice pumps the system, makes Sample Cleaning procedure (see Chapter 5) and remains columns evacuated.

13. Pattern Module

A pattern type can be selected and handled by using the icon buttons on top of the module. It can be drawn in the selected quad and then it is displayed in the pattern list with a relative number. The pattern properties could be changed via the **Basic** and **Advanced** property editor. The **Progress** indicator displays the **Overall** / **Current Progress** (over time) of the active patterning. The **S. Mill** tab enables to process only specified grey levels of the selected pattern (see Chapter 5).

FIGURE 3-14 THE PATTERN MODULE
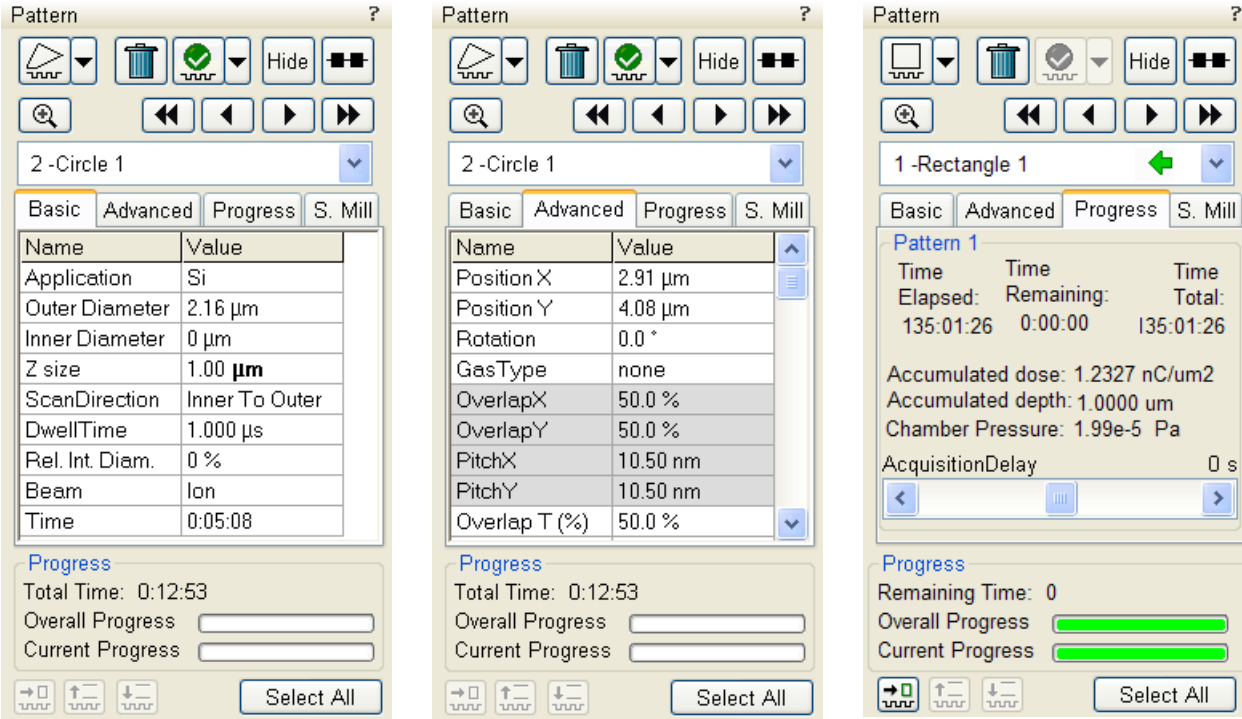
14. Omniprobe Module

Model difference:
Option for
Helios NanoLab 450 / Helios NanoLab 650 / Helios NanoLab 600i.
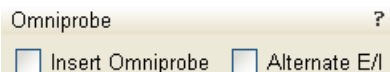
This module operates the micro manipulator, which allows you to extract a TEM sample in situ. By selecting / deselecting the **Insert Omniprobe** checkbox the Omniprobe needle can be inserted / retracted. Movements of the stage are possible with Get and Relative moves while the needle is inserted. Instructions for use of the Omniprobe are supplied by the Omniprobe Company independantly with each Omniprobe device.

The **Alternate E/I** check box functionality is the same as the **Scan** menu \ **Alternate Electron/Ion scanning** item (see above).

15. End Point Monitor Module

This set of features enables to monitor a milling process in detail, enabling to grab inspectional images during the progress (see Chapter 5).

FIGURE 3-15 THE END POINT MONITOR MODULE
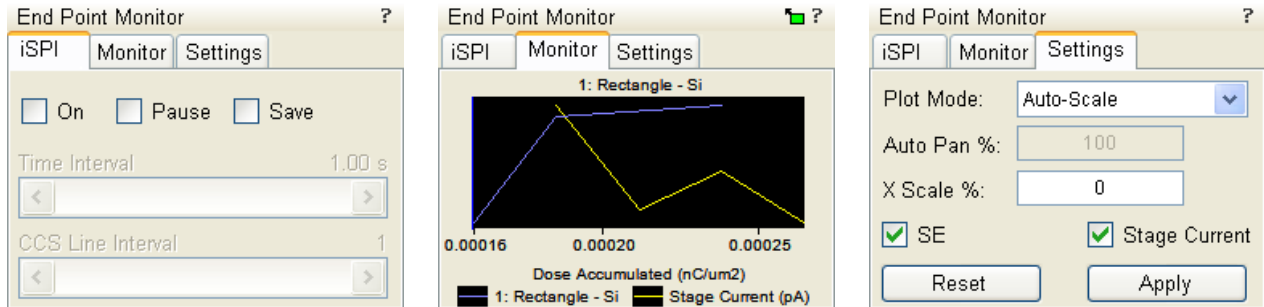
16. Measurement / Annotation Module

combines tools for measuring and making annotations in imaging. A measurement tool, an annotation shape or a text label can be selected from the first three icons on 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 are possible to change in the property editor (see Chapter 5).
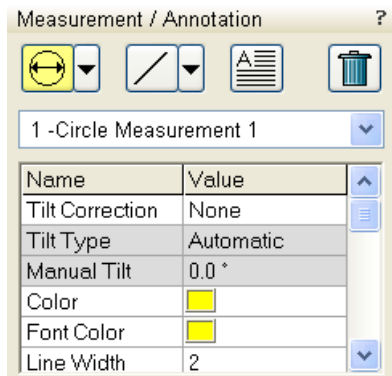
17. Digital Zoom Module

The procedure takes place in the computer memory only and helps to navigate across the enlarged view. Click the **+** / **- magnifying glass** button to enlarge the view in the selected quad. Click the switching button to turn over a digital magnification last used and a normal view. Press and 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.

When the digital zoom ratio is applied, the icon appears in the appropriate quad.
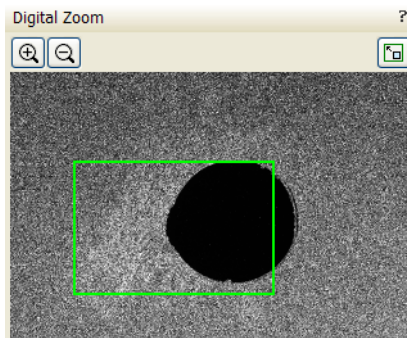
18. Enhanced Image Module

consists of four 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 the 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 3-16 THE ENHANCED IMAGE MODULE
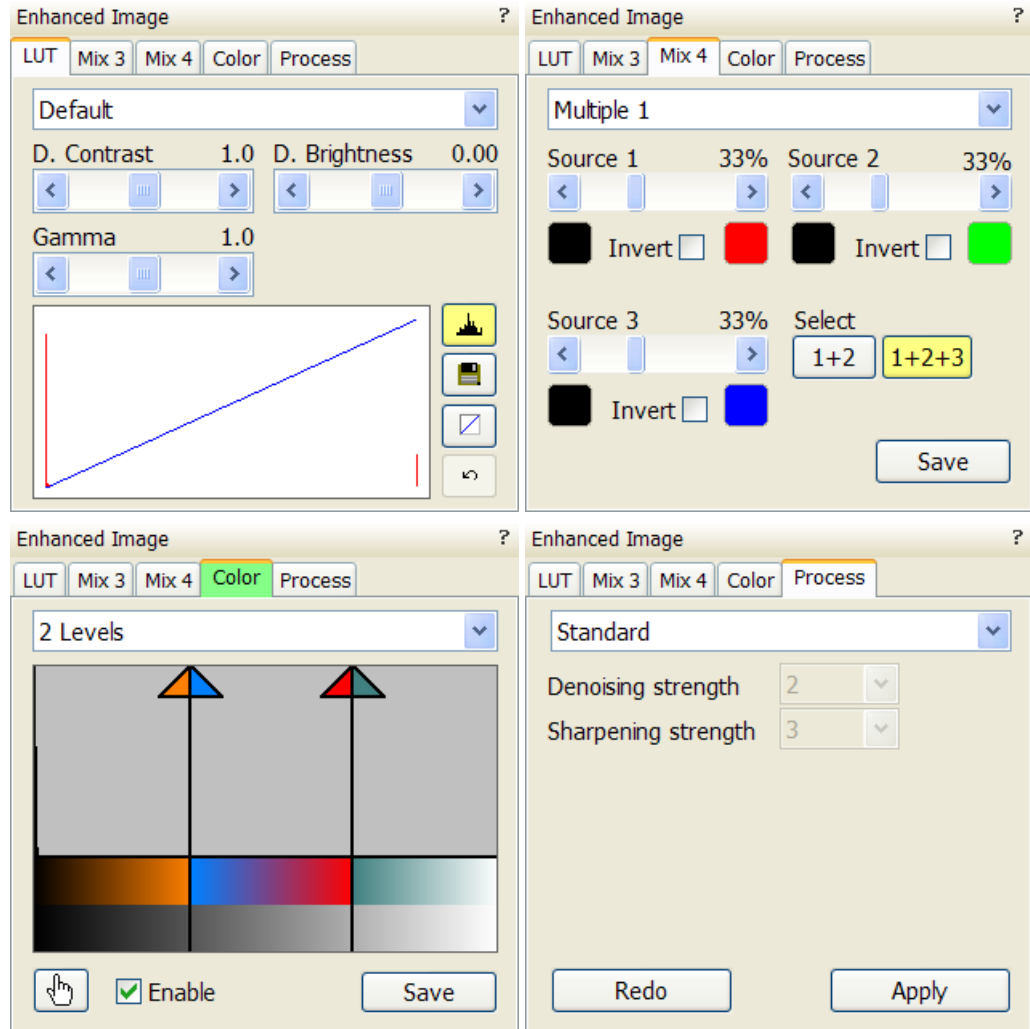
19. Detector settings Module

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

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 Chapter 5 and 7).

20. Quad Presets Module
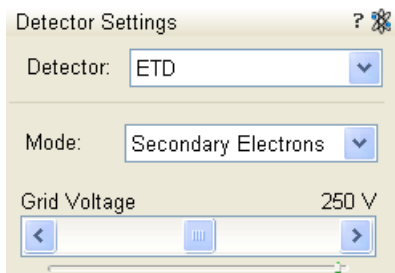
Quad Presets   ?

| Import | Export |

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

21. Alignments Module

Alignments

5 - Emitter Startup
17 - Quick Stage Rotation Center Alignment
18 - Accurate Stage Rotation Centre Alignment
65 - UHR-FIB wait time configuration
100 - Vacuum. Start IGP's.
102 - Vacuum: User Tools
104 - Plasma Cleaning
105 - Pre-vacuum pump operation mode
114 - Gas Flush mode
210 - ION: Beam Alignment
211 - FIB-I Ion Column Alignment
253 - Supervisor: Ion Beam
401 - Nav-Cam AutoBrightness
E-column: UC User Alignments
E-column: Aperture Map Selection
E-column: Magnification Correction

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.

Caution!
An 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 almost the same, if it is not mentioned.

FEI User Management Software
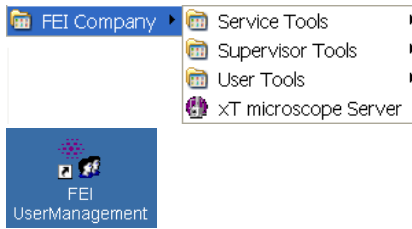
The FEI User management software allows to FEI Account Admistrators, FEI Supervisors and FEI Microscope Users to organise user accounts that can possibly be used to run the xT microscope Control software. It allows the creation and removal of user accounts, the setting of user passwords and group membership, 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 drag and drop 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 3-17 FEI ACCOUNT ADMINISTRATORS CONTROL OVERVIEW
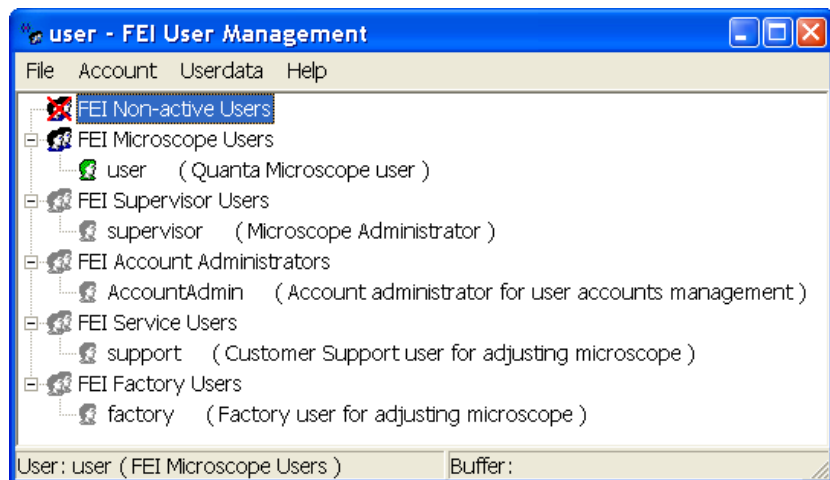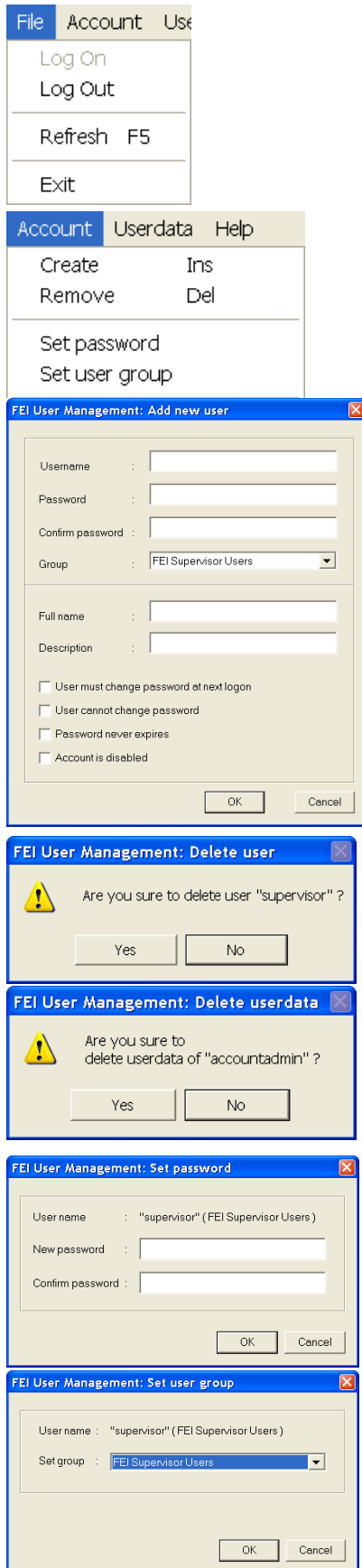
File Menu

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. An 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 an user. An user 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 an user. An user must first be highlighted in the tree. When confirmed, an user is moved to selected group. When moving an 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.
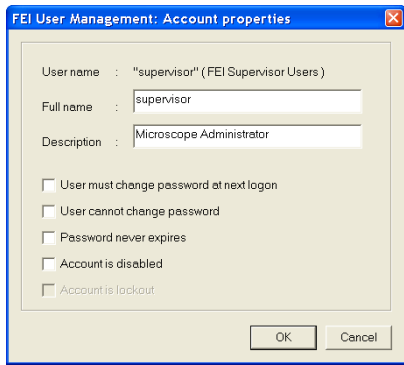
- **Properties (Alt + Enter):** click to see and change the properties for that user. An user must first be highlighted in the tree.
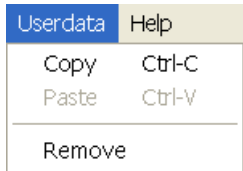
Userdata menu

contains the following items.

- **Copy (Ctrl + C):** click to copy user data from an 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.
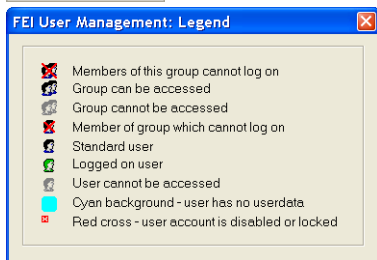
- **About:** displays the FEI User Management software version and copyright.

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 the directory 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

Preferences… Dialogue

This dialogue can be opened by selecting **Preferences…
(Ctrl + O -** *letter***)** from the pull-down menus: **Scan, Beam, Patterning, Stage** and **Tools**. The opened 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.

Units Tab

allows an 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 3-18 UNITS PREFERENCES
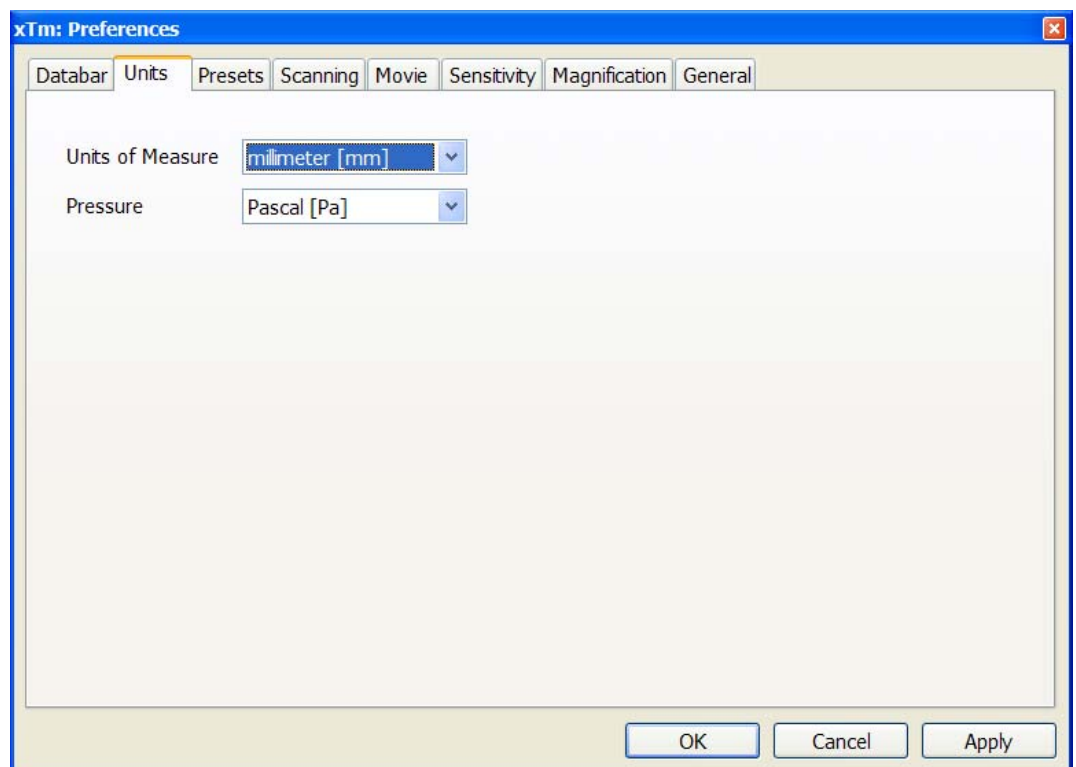
Selection possibilities are:

- **Units of Measure:** millimeter [mm] / micrometer [µm]
- **Pressure:** Pascal [Pa] / torr [Torr] / millibar [mbar]

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).

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 / Ion / Optical) for the selected quad. The Label can be set independently for each quad.

FIGURE 3-19 DATABAR PREFERENCES
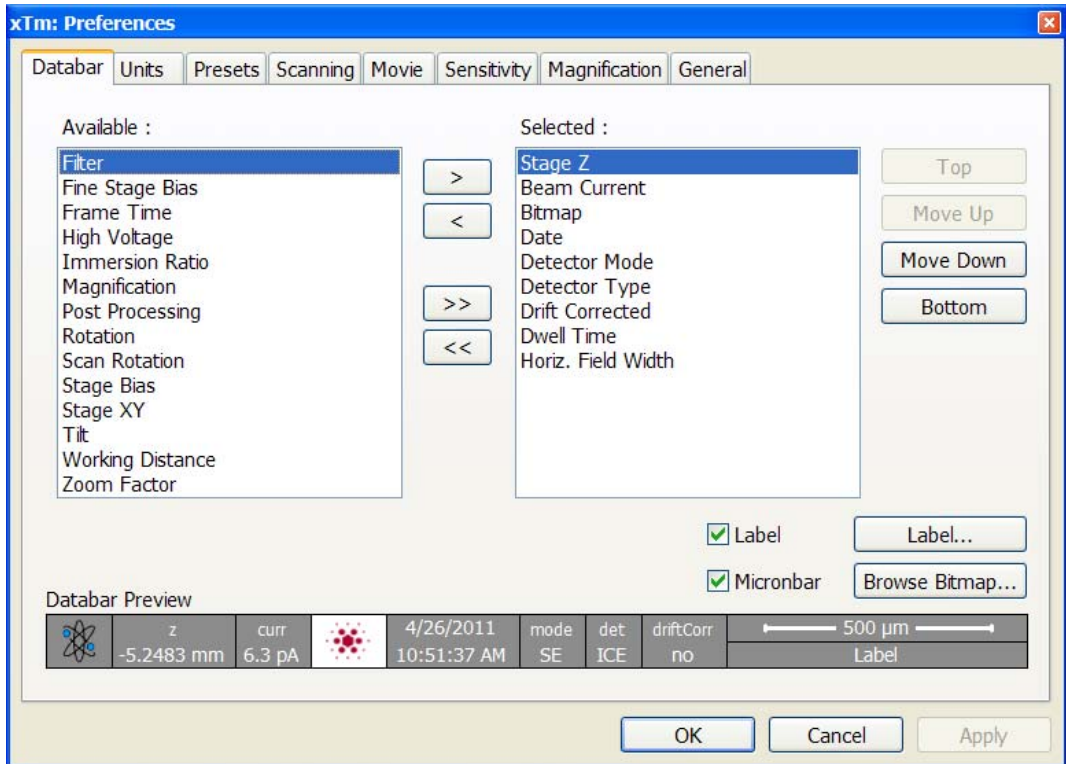
There are two lists in the dialogue, one labeled **Available** and the other **Selected**. Items in the Available list can be added / removed individually (**>** / **<**) or as a whole (**>>** / **<<**) to / from the Selected list. The Selected list contains items that are displayed in the Databar. The 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 the 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.
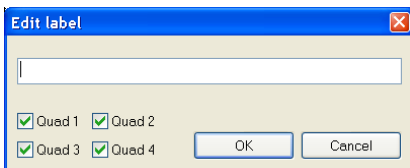
Presets Tab

allows an user to change the pre-set values in the **High Voltage** and **Magnification** drop-down lists. The configuration and available items differ for the beam selected (Electron / Ion / 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 3-20 PRESETS PREFERENCES
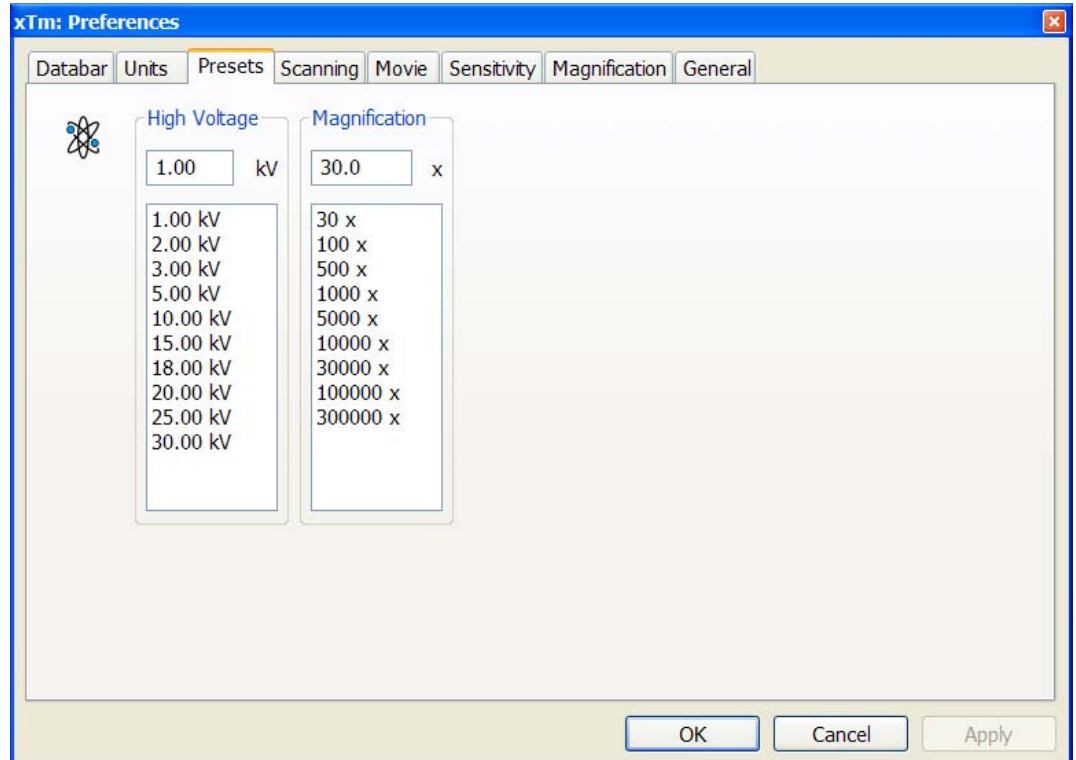
The **High Voltage** list can be changed to span any values from 200 V / 500 V to 30 kV for the electron / ion beam. The values must be entered in kilovolts (0.2 means 200 V).

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 000x.

Scanning Tab

allows an 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 / Ion / Optical) for the selected quad.

FIGURE 3-21 SCANNING PREFERENCES
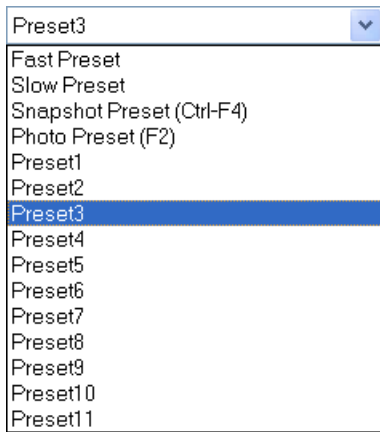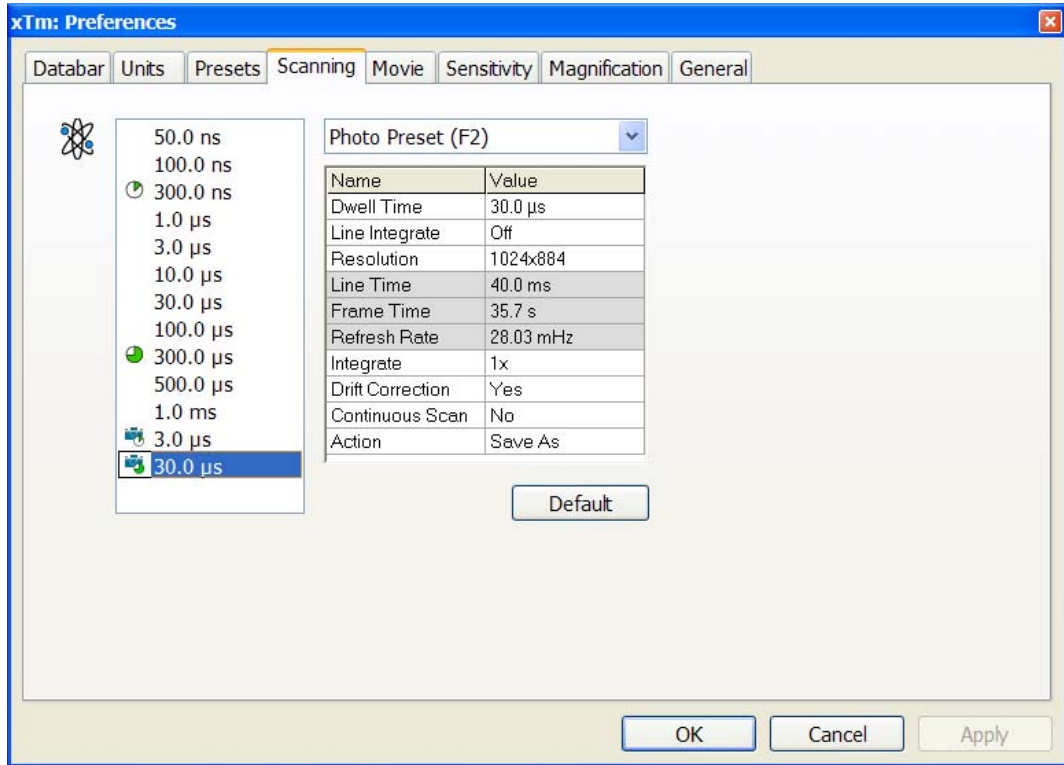
On the left side of the module there is a dwell-time preset list with the fixed number of entries. Selected **Preset** values can be changed in the Property editor on the right side of the module. The following properties are editable (depending on the kind of the preset):

- **Dwell Time:** one point beam duration time
- **Line Integrate:** no. of line scanning repetition
- **Resolution:** no. of points, Width × Height (imaging 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 averaging filter is active. When activated, the text below the blinking quad pause icon notifies an 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:** quad scan duration time,
- **Refresh Rate:** imaging refresh frequency.

Slow (tortoise / large green sector) / Fast (hare / small green sector) preset icon indicates the matching dwell-time value. To change it move an icon up or down just by clicking-and-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). The setting differ for the beam (Electron / Ion) selected for the active quad.

FIGURE 3-22 SENSITIVITY PREFERENCES
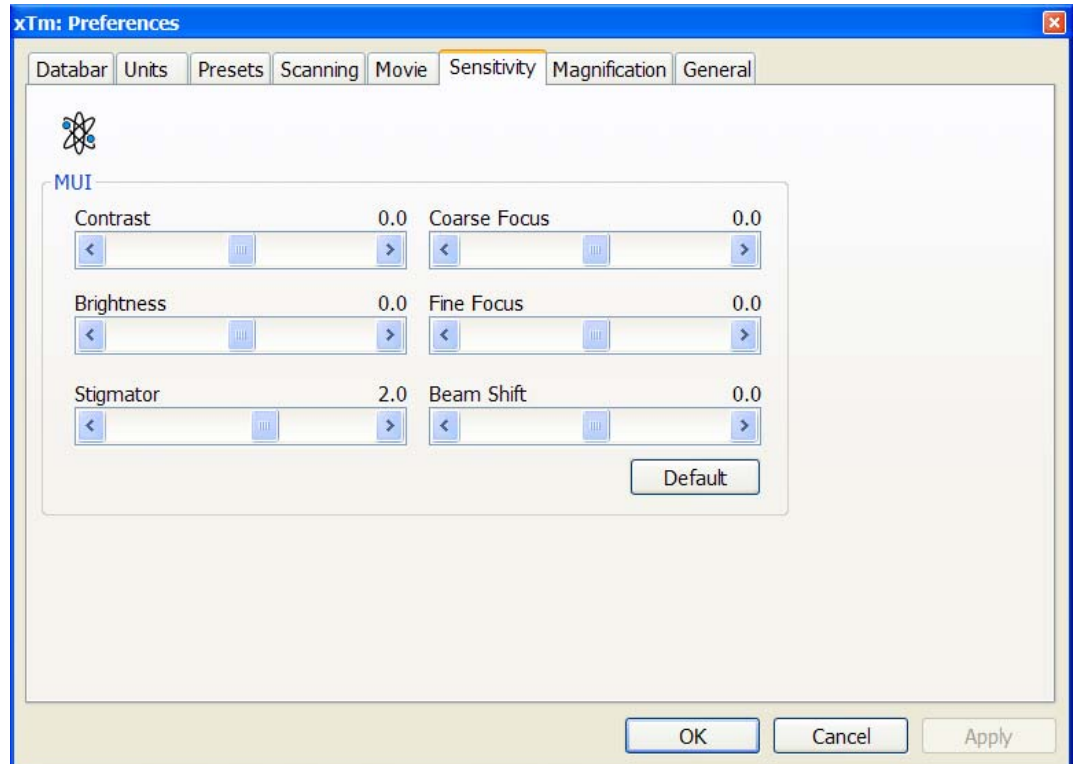
All MUI controls are represented except the Magnification. The **Default** button sets the original settings.

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 3-23 GENERAL PREFERENCES
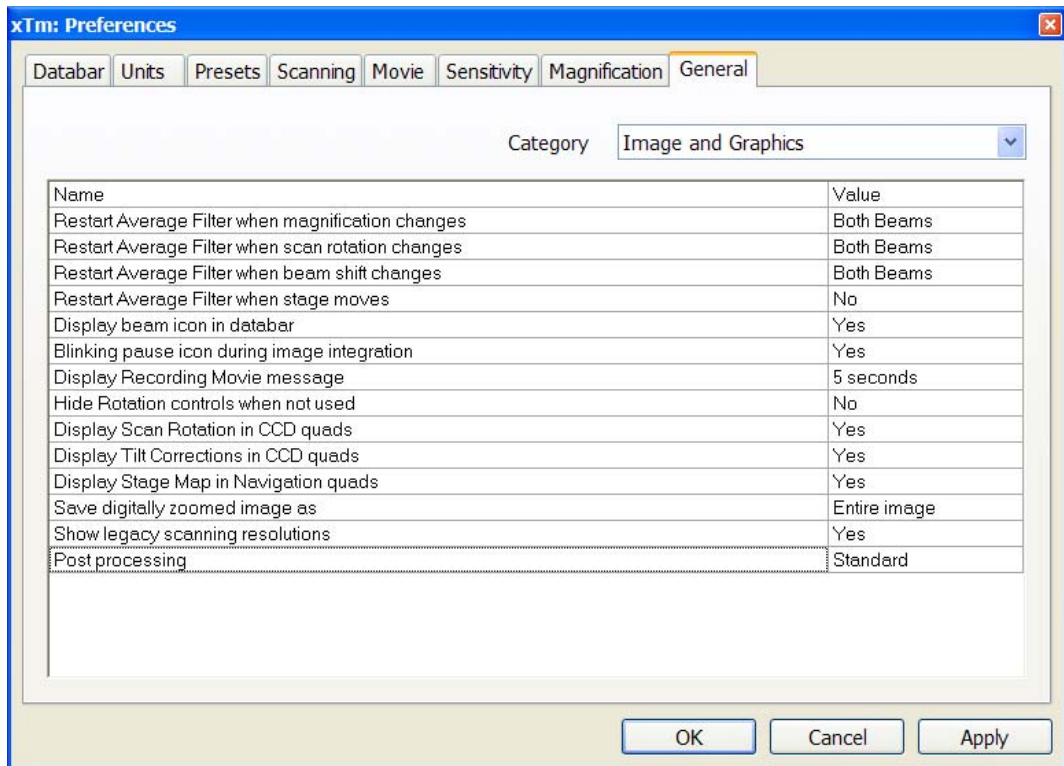
Each item of the General Preferences is represented by single line displayed in the property editor. Clicking on the corresponding **Value** displays a drop-down list with the settings available for that item.

Note:
Some changes become visible after the next UI start.

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.
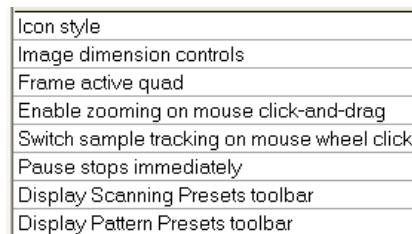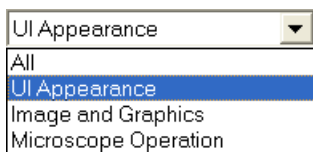
UI appearance

*   **Icon style** (Nova / Quanta)
    Selects appearance of the toolbar icons.
*   **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 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.
*   **Pause stops immediately** (Yes / No)
    The Pause function acts instantly / waits for the complete scan.

- **Display Scanning Preset toolbar** (No / Yes)
  Enables to show 6 scanning preset parameters at the toolbar.
- **Display Pattern Preset toolbar** (No / Yes)
  Enables to show 6 pattern preset buttons at the toolbar.

Image and graphics

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 changes** (*)
- **Restart Average Filter when scan rotation changes** (*)
- **Restart Average Filter when beam shift changes** (*)
- **Restart Average Filter when stage moves** (*)

  * – (No / Yes)

  These items enable to choose whether the imaging averaging should be restarted when the indicated parameter changes. Restarting the average filter causes the imaging 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 active beam icon to the first data bar position.
- **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)
  At the beginning of the movie recording, this message could be displayed in the recorded quads for a selected time period.
- **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 a digitally zoomed image, this option enables to save the zoomed area or the entire scanned area.
- **Show legacy scanning resolution** (Yes / No)
  enables to display old format screen resolutions in the toolbar drop-down list (see Chapter 3).
- **Post Proccessing** (Standard / None / Custom...)
  Sets the default Post Processing setting.

Microscope operation

Interactive Databar
Scan Rotation sensitivity
Lower stage when venting the chamber
Change magnification when pumping
Switch off CCD automatically
Pause beam quads when switching off HV
Continuous reduced area scanning in iSPI mode
Allow Beam Shift in Get mode
Blank E-Beam during long stage moves
Blank I-Beam during long stage moves
Reverse Joystick movement
Auto switch stage measurement system
Optimized collection efficiency
Venting valve opening time
Automatic Nav-Cam photo after sample loaded
Move to zero tilt for Nav-Cam photo
Default quad for Nav-Cam image
ICE saturation suppression

- **Interactive Databar** (On / Off)
  Turns image databar fields to be active (when possible) / inactive.
- **Scan Rotation Sensitivity** (0.1 /0.01)
  Choose the Scan Rotation setting sensitivity.
- **Lower stage when venting the chamber** (Yes / No)
  Specifies if the stage should automatically go to a low Z values when venting the chamber. This is a recommended (not default) setting,

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 200x)
Specifies whether the magnification for electron imaging 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 camera and infrared LED's should be automatically switched off. The countdown starts when resuming the optical quad and continues regardless of the operator activity.

- **Pause beam quads when switching off HV** (Yes / No)
Specifies if the electron imaging should be automatically paused when switching the High Voltage off.

- **Continuous reduced area scanning in iSPI mode** (Yes / No)
If yes is selected and the reduced area and iSPI mode is on, Snapshot or Photo function scanning must be stoped by an user instead of automatic stop after the pre-defined number of scans.

- **Allow Beam Shift in Get mode** (Yes / No)
Enables / disables automatic using of Beam Shift when an user requires very small point-to-point movements (double-click the sample point at high magnifications).

- **Blank E-beam / I-beam during long stage moves** (Yes / No)
Specifies if the electron beam should be 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 equipments (EDS detectors etc.).

- **Optimized collection efficiency** (Yes / No)
If yes, the inactive (paused) SE detector is prevent from taking the SE signal to the active one. This is not recommended to use while patterning, which can cause image quality decrease in SPI and iSPI mode.

- **Venting valve opening time** (value)
prolongs the venting time (default value is 300 sec) to eliminate residual vacuum which makes impossible to open the chamber door or shortens the venting time.

- **Automatic Nav-Cam photo after sample loaded** (Yes / No)
When Loadlock is installed and setting is Yes, the Nav-Cam navigation image is automatically acquired after sample loading.

- **Move to zero tilt for Nav-Cam photo** (Yes / No)
Sets the stage tilt to 0° automatically when grabing the Nav-Cam navigation photo. The stage stays at 0° tilt when finished.

- **Default quad for Nav-Cam image** (Quad 1 / Quad 2 / Quad 3 / Quad 4 / Active) this option sets the default Nav-Cam imaging quad.

- **ICE saturation suppression** (On / Off)
Areas not patterned are displayed in selected color.

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 3-24 MAGNIFICATION PREFERENCES
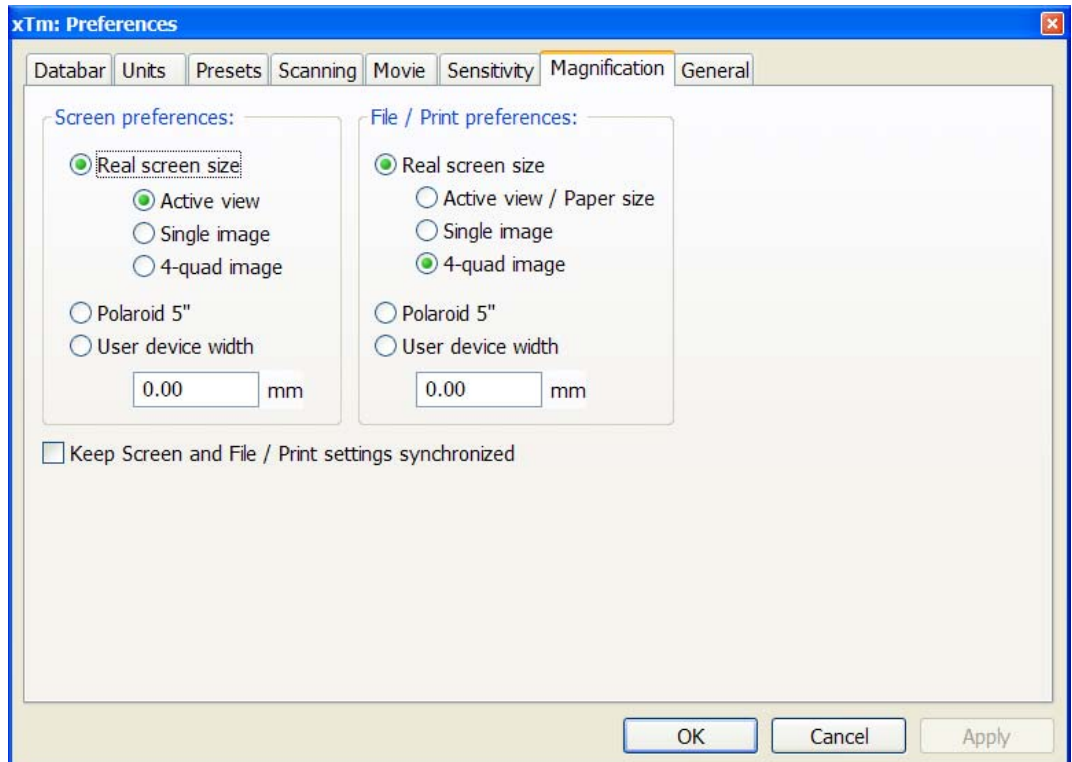
The **Screen preferences** area sets the imaging databar magnification display behaviour while the **File / Print preferences** area sets the storage / printing databar magnification display behaviour. Selecting the radio button activates its functionality:

- 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 an 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.

Entering Commands in Summary

USING MOUSE
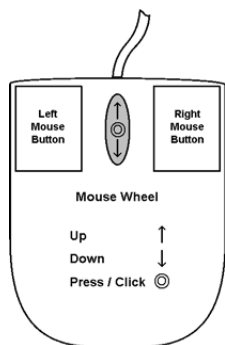
Keyboard + Mouse button	Function
(Shift +) Click	*single-arrow cursor* **Control Areas:** makes a selection of a control element. **On Screen:** (multiple) selection of elements
Click & drag	**On Screen:** drag a selected area to zoom in – to fill an imaging area with the selection (selectable in Preferences).
Doubleclick	**Electron imaging:** moves the selected point to the middle of the quad. **Optical imaging:** 4 mm marker placement.
Click & drag + Shift	**On Screen:** drag a selected area to zoom out – to fill an imaging area with the selection.
Shift + Click	Pauses / Activates all quads when clicking the toolbar pause icon.
Shift + Click & drag	*hand-cursor* Activates Beam Shift.
Right-click & drag	*double-arrow cursor* To focus drag the mouse to the left or right.
Shift + Right-click & drag	*four-arrow cursor* To correct imaging astigmatism, drag the mouse to the left / right (X stigmator) or up / down (Y stigmator).
Ctrl + Click & drag	Activates Detectors Contrast (left-right move) / Brightness (up-down move) control.
Ctrl + Right-click & drag	*four-arrow cursor with circles* Activates the Lens Alignment.
Shift + Wheel-scroll Up / Down	**Fine Control:** increases / decreases the magnification.
Ctrl + Wheel-scroll Up / Down	**Coarse Control:** increases / decreases the magnification.
(Ctrl+) Wheel-click & drag	**Electron / Ion imaging:** activates the Track mode for joystick-like movement over the sample surface. **Optical imaging:** activates the live stage Z - up / down move (stage Tilt - left / right move).

Mouse diagram:

Left Mouse Button

Right Mouse Button

Mouse Wheel

Up ↑
Down ↓
Press / Click ◎

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 OK in a dialogue box.
Esc	1. Equivalent to the Cancel button. 2. Cancels the press and drag function. 3. Stops the stage motion at that point. **Note:** During some procedures (Home Stage for instance) use the software Cancel or Stop button!
Tab	Step key to highlight items in a dialogue box.
(Shift +) Arrows	1. Use to select between items in a group when in a list box. 2. When quad is active and selected, the stage moves approximately (40%) 80% of the field of view in any direction by clicking the appropriate keyboard Arrow key.
Alt (or F10)	Activates menu of the active application. Hitting the underlined character in the menu bar pulls-down the corresponding menu.
Alt + Tab	Use to switch between running applications. This starts from the last used one, continue to press the TAB key (while holding down the ALT key) and applications are shown one by one. Releasing the ALT key at any time makes application just listed active.
Alt + F4	Exits active application or Windows operating system.
Del(ete)	Deletes selected text or items.
Ctrl + A	Select all items
Ctrl + C **(Ctrl + Insert)**	Copy to clipboard
Ctrl + V **(Shift + Insert)**	Paste from clipboard
Ctrl + X **(Ctrl + Delete)**	Cut to clipboard

TABLE 3-4   FUNCTION BUTTONS AND SPECIFIC SHORT-CUTS

Key (+ Key)	Function
F1	Displays documentation
Shift + F1	Opens Image Properties window
(Shift +) F2	Starts Photo (from all quads at once)
Ctrl + (Shift +) F2	Starts / Stops Active Preset Snapshot (from all quads at once)
(Ctrl +) F3	Toggles Videoscope (in all quads) On / Off
Shift + F3	Starts Home Stage procedure
F4	Starts / Stops Electron imaging Snapshot
(Shift +) Ctrl + F4	Starts / Stops Ion imaging Snapshot (in all quads)
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
Ctrl + (Shift +) F7	Starts / Undoes Image Post Processing
Ctrl + F8	Calls up Direct Adjustment window with Beam / Stigmator Centering / UC tabs
F9	Starts Auto Contrast and Brightness procedure
Shift + F9	Link Z to FWD
F11	Starts Auto Focus procedure
Shift + F11	Toggles Display Saturation function
(Shift +) F12	Toggles Compucentric (Scan) Rotation tool
Ctrl + 0 - number	Center Position (moves stage to X=0, Y=0)
Ctrl + B	Toggles Beam Blank function
Ctrl + D	Set Default Parameters
Ctrl + E	Tilt stage to 0°
Ctrl + F	Sets beam focus to WD = 4 mm
Ctrl + I	Tilt stage to 52°
Ctrl + K	Sets Spot scanning conditions
Ctrl + M	Sets Full Frame scanning conditions
Ctrl + Shift + M	Starts movie recording dialogue
Ctrl + N	Toggles Sample Navigation
(Ctrl +) Shift + N	Starts to mill (previous) next pattern line
Ctrl + O - letter	Opens Preferences dialogue
Ctrl + P	Opens Print dialogue

TABLE 3-4   FUNCTION BUTTONS AND SPECIFIC SHORT-CUTS

Key (+ Key)	Function
Shift + P	Next pattern
Ctrl + R	Restarts scan
Ctrl + (Shift +) S	Save image(s) (from all quads)
Ctrl + T	Toggless ion and electron beams imaging
Ctrl + Z	Moves stage to the Last position
Ctrl + Shift + Z	Starts Take Nav-Cam Photo procedure
Pause key	Starts / Stops patterning
Ctrl + Pause key	Reset patterning
Ctrl + (Shift +) ,	Set one step slower (preset slow) scanning
Ctrl + (Shift +) .	Set one step faster (preset fast) 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 the magnification 2×
*	Rounds off the magnification / HFW to the nearest round value
Ctrl + +/-	Scales up / down the imaging 2× (Digital Zoom)
Ctrl (+ Alt) + arrow	Moves the digital zoom area (the pattern) by one screen pixel in the respective direction

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 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 **End** button moves an user to the last step (by clicking the **Next** button) to be able to finish the alignment procedure.
- 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.
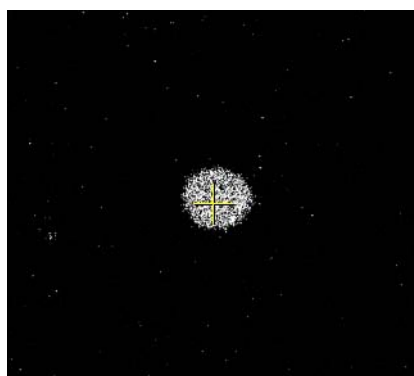
ALIGNMENT LIST
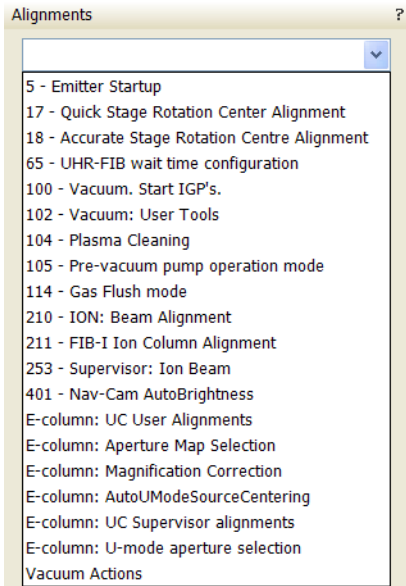
The list of alignments accessible for a Supervisor is represented, the User alignments list is reduced and is represented by (U) sign.

- **5 - Emitter Startup**
  Enables IGP's and electron gun - Emitter switching On / Off.
- **17 - Quick Stage Rotation Centre Alignments (U)**
  Sets the stage rotation center for the correct functionality of the compucentric rotation feature.
- **18 - Accurate Stage Rotation Centre Alignments (U)**
  Sets exact stage rotation centre necessary for compucentric rotation function
- **65 - UHR-FIB wait time configuration**
  Sets an immersion lens stabilisation time.
- **100 - Vacuum: Start IGP's**
  Enables all IGP's (electron and ion column) switching On / Off.
- **102 - Vacuum: User Tools (U)**
  Offers special vacuum actions not available from the UI
- **104 - Plasma Cleaning**
  Enables the chamber plasma cleaning and sets time of specimen plasma cleaning
- **105 - Pre-vacuum pump operation mode**
  Enables to start / stop buffer cycle in order to control prevacuum pump operation
- **114 - Gas Flush Mode (U)**
  This procedure is necessary when external plasma cleaner is used.
- **210 - ION: Beam Alignment**
  Sets the ion source parameters.
- **211 - FIB-I Ion Column Alignment**
  Brings SEM lens to Immersion mode.
- **253 - Supervisor: Ion Beam**
  Ion beam service page
- **254 - Supervisor: GIS**
  Resets the GIS crucible filling lifetime counter after its exchange. Sets the GIS heating temperature.
- **E-column: UC User Alignments (U)**
  Set of User level electron beam adjustment procedures
- **E-column: Aperture Map Selection**
  Enables to set a second set of final lens apertures in case the image quality deteriorates when using the first one (one or more actually used apertures are worn out).
- **E-column: Magnification Correction (U)**
  User magnification calibration (see Beam menu item).
- **E-column: AutoUModeSourceCentering**
  Automatic alignment centers the beam through U-mode aperture.
- **E-column: UC Supervisor alignments**
  Set of Supervisor level electron beam adjustment procedures
- **E-column: U-Mode aperture selection**
  Enables to set one of three U-Mode defining apertures in case the imaging quality is poor.
- **Vacuum Actions (U)**
  Set of utilities for vacuum control.

Alignments

	?
	⌄

5 - Emitter Startup
17 - Quick Stage Rotation Center Alignment
18 - Accurate Stage Rotation Centre Alignment
65 - UHR-FIB wait time configuration
100 - Vacuum. Start IGP's.
104 - Plasma Cleaning
114 - Gas Flush mode
210 - ION: Beam Alignment
211 - FIB-I Ion Column Alignment
253 - Supervisor: Ion Beam
254 - Supervisor: GIS
401 - Nav-Cam AutoBrightness
E-column: User Alignments
E-column: Aperture Map Selection
E-column: Magnification Correction
E-column: Supervisor Alignments
Vacuum Actions

Model difference:

Helios NanoLab 600i has individual alignment list and some of the procedures are different.
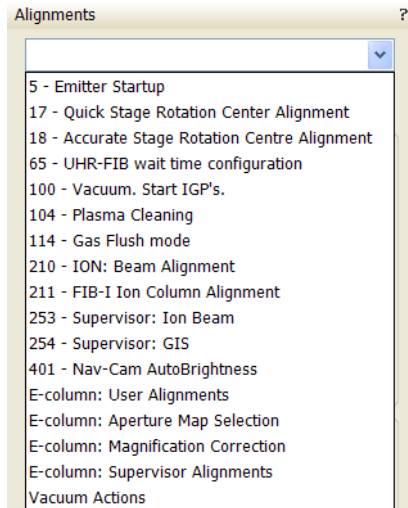
5 - Emitter Startup

This procedure enables IGP's (Ion Getter Pumps) and electron source switching On / Off in cases of emergency shut down or the microscope mains switch off.

Note:

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

Alignments   ?

5 - Emitter Startup   ▾

                        Start

Instructions

This procedure starts or stops the emitter.

No step

Alignments   ?

5 - Emitter Startup   ▾

                        Next

Instructions

Press the **IGP's On** button to start the pumps and wait until electron gun vacuum is reached (see the Status module).

Note: In case the **IGP's On** button is disabled, proceed with the next step (the pumps are already started).

Step 1 of 2

Electron Column

| Upper IGP On | Upper IGP Off |
| Lower IGP On | Lower IGP Off |

IGP Upper: 1.52e-007 Pa

IGP Lower: 3.65e-005 Pa

                        Cancel

Alignments   ?

5 - Emitter Startup   ▾

Previous   Finish

Instructions

Press the **Emitter On** button to start or the **Emitter Off** button to stop the emitter. Wait until the target state is reached.

Step 2 of 2

Emitter control page

Emitter On	Operate
Restart	Safe start	Shut down
Emitter Off	Off

Remaining time: 0 min 00 s

Suppressor: 200 V

Extractor: 4056 V

Filament: 2.390 A

Emission: 91.0 µA

Emitter Life Time:

1501 h 30 min 38 s

                        Cancel

FEI Limited Rights Data   FEI   C O N F I D E N T I A L

17 - Quick Stage Rotation Center Alignment

Panel 1

Alignments   ?

17 - Quick Stage Rotation Center Alignment ▾

[Start]

Instructions

This alignment sets the stage rotation center to allow the correct use of Compucentric Rotation.
Click on the Start button.

No step

Panel 2

Alignments   ?

17 - Quick Stage Rotation Center Alignment ▾

[Next]

Instructions

The accuracy of the stage center resulting from this alignment is not sufficient in all cases.
If compucentric rotation does not center a feature according to expectation, a more accurate stage center determination can be obtained by performing alignment 18.
Be aware that continuing with this alignment wil overwrite the current stage center with a new value.

Step 1 of 4

Alignment 18 is especially beneficial for Strata 400(S) and Helios 400(S) systems.
Be aware that continuing with this alignment wil overwrite the current stage center with a new value.

[Cancel]

Panel 3

Alignments   ?

17 - Quick Stage Rotation Center Alignment ▾

[Previous] [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 2 of 4

Position X = -0.005182 m

Position Y = 0.000840 m

[Cancel]

Alignments   ?

17 - Quick Stage Rotation Center Alignment ▼

| 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 3 of 4

Position X = 0.001897 m

Position Y = -0.002154 m

Cancel

Alignments   ?

17 - Quick Stage Rotation Center Alignment ▼

| 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 4 of 4

Cancel

18 - Accurate Stage Rotation Center Alignment

Panel 1:

Alignments   ?

18 - Accurate Stage Rotation Centre Alignmer ▾

[Start]

Instructions

This alignment sets the stage rotation center to allow the correct use of Compucentric Rotation.
Click on the Start button.

No step

Panel 2:

Alignments   ?

18 - Accurate Stage Rotation Centre Alignmer ▾

[Next]

Instructions

Optimize the image with Focus, Magnification, Contrast and Brightness.
In the UI, move the stage to position 0,0 and set the the sample height to eucentric.
Focus the image and re-link WD.
Magnification 500x.
Set UI preference 'Restart Average Filter when stage moves' to No.
Set high tension to 30 kV, Switch Averaging ON, using 32 frames and set the dwell time to 200 nano seconds.

Step 1 of 2

Set high tension to 30 kV, Switch Averaging ON, using 32 frames and set the dwell time to 200 nano seconds.
Click on the Next button to move to the next Step.

[Cancel]

Panel 3:

Alignments   ?

18 - Accurate Stage Rotation Centre Alignmer ▾

[Previous]   [Finish]

Instructions

Click the "Rotate stage axis button On/Off" button.
A concentric pattern will appear on the screen formed by the image averaging of the oscillating stage.
Optimize the settings, number of averaging frames, dwell time and C and B, to make the center of the pattern more visible.
Center the rotation center in the field of view by a double click on the center of the concentric pattern.

Step 2 of 2

[Rotate stage axis On/Off]

Position X = -0.005182 m

Position Y = 0.000840 m

Center the rotation center in the field of view by a double click on the center of the concentric pattern.
Repeat rotating and centering while enlarging the magnification to 2500 or 5000 times step by step.
In the end stage rotation center should be within app. 5 micrometer of the centre of the FOV.
Click the finish button to store stage rotation center.

[Cancel]

65 - UHR-FIB wait time configuration

FEI Limited Rights Data   FEI   C O N F I D E N T I A L

100 - Vacuum: Start IGP's

102 - Vacuum: User Tools

Alignments   ?

102 - Vacuum: User Tools ⌄

Start

Instructions

Vacuum: User Tools
This procedure enables to perform either of
the less common Vacuum actions:

- Vent the Loadlock chamber

- Pump down the TMP buffer"

No step

Alignments   ?

102 - Vacuum: User Tools ⌄

Finish

Instructions

Press **Vent Loadlock** to start venting the
Loadlock chamber
and/or
press **Pump Buffer** to start the TMP
buffer pumping cycle.

If either of the buttons is disabled, the
corresponding action is not allowed at the
current system conditions.

Note: Finishing or Canceling the
procedure does not stop the started

Step 1 of 1

Vent Loadlock

Pump Buffer

Note: Finishing or Canceling the
procedure does not stop the started
vacuum action!

Cancel

104 - Plasma Cleaning Alignment

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

Warning!
Do not use Chamber cleaning 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. Do not leave sensitive samples (including Au-C resolution test samples) in the chamber during Chamber Cleaning (it may be damaged).

105 - Pre-vacuum Pump Operation

FEI Limited Rights Data   FEI   C O N F I D E N T I A L

114 - Gas Flush Mode

210 - ION: Beam Alignment

Panel 1 (Start)

Alignments   ?

210 - ION: Beam Alignment

[Start]

Instructions

Integrated ion column alignment.
Press the Start button.

No step

-**StigSin:** Minimize Image movement with adjuster. To copy aligned values for all beam currents, press CopyStig button at the bottom of the page.
-**StigCos:** Minimize Image movement with adjuster. To copy aligned values for all beam currents, press CopyStig button at the bottom of the page.
-**Stigmator Alignment:** Optimize image with two dimensional corrector, mouse or MUI.

-**Beamshift:** Adjust beamshifts of all beamcurrents using the 93 pA (index 5) as a reference. Use adjuster, mouse or MUI.

In-between saving/loading of the whole alignment table is possible by pressing the save/load button.

Press finish to store all modified alignments.

Panel 2 (Next)

Alignments   ?

210 - ION: Beam Alignment

[Next]

Instructions

Select the ion beam in quad 2, set the eucentric working distance and stage tilt 52 deg.
Optimize the image with Focus, Contrast and Brightness.
Bring a recognisable feature under the centre cross with the stage.
Select a high voltage.
Press the Next button.

Step 1 of 2

[500 V]

[1 kV]

[1.2 kV]

[2 kV]

[5 kV]

[8 kV]

[16 kV]

[30 kV]

Selected Aperture[1..15] = 5

[Cancel]

Panel 3 (Previous / Finish)

Alignments   ?

210 - ION: Beam Alignment
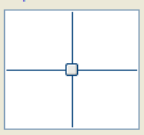
[Previous]   [Finish]

Instructions

For each aperture index (selected in menu bar) :
-**Focus alignment:** Adjust Focus with L2 Slider, mouse or MUI.
-**Aperture Alignment:** L1 wobble is automatically turned on. Minimize wobble by aperture movement (preferred manually using AAM wheels).
-**Quad Alignment:** L2 Wobble is automatically turned on. Minimize wobble using the adjuster.
StigSin: Minimize Image movement with

Step 2 of 2

[AperPos]
[Quad]
[StigSin]
[StigCos]
[Stig]
[BShift]

Wob_ampl   1000
[<][▮][>]   [L1 Wobble]

Wob_ampl   50
[<][▮][>]   [L2 Wobble]

L1_Corr (V)   0
[<][▮][>]   L1 = 18600 V

L2_Corr (V)   -88
[<][▮][>]   L2 = 18935 V

[Save]   [Load]   [CopyStig]

Contrast   69.57
[<][▮][>]

Brightness   41.37
[<][▮][>]

[Cancel]

  FEI Limited Rights Data   FEI   C O N F I D E N T I A L

211 - FIB-I Ion Column Alignment

Alignments

211 - FIB-I Ion Column Alignment   Start

Instructions

FIB-Immersion integrated ion column alignment. This alignment will bring the SEM lens to Immersion mode.
Switch to SEM, unpause the quad then press the Start button.

No step

Alignments

211 - FIB-I Ion Column Alignment   Next

Instructions

Select the electron beam in quad 1, ion beam in quad 2. Optimize the electron beam UHR image at **EBeam.HV = 3 kV**, set the eucentric working distance and tilt the stage to 52 deg.
Optimize the ion beam image at **IBeam.HV = 30kV**
Bring a recognisable feature under the centre cross with the stage for both beams (avoid using beamshifts).
Should this not be possible **cancel** this procedure now and run again procedure E-

Step 1 of 6

FIB HT:

| 30000 V |

SEM UHR LE:

| 3000 V |

Should this not be possible **cancel** this procedure now and run again procedure E-**column: UC alignments** to align HR and UHR image and procedure **210 ION: Beam alignment** to align HR SEM and FIB.
Press the **Next** button.

Erase alignment tables

BShift	point count: 1
Quad	point count: 0
Stig	point count: 0

Cancel

Alignments

211 - FIB-I Ion Column Alignment

Previous   Next

Instructions

Set FIB Magnification to 1500. Select SEM landing energy for alignment, start with 3000V. Repeat for every SEM HT value: Optimize the SEM image with focus and bring the recognizable feature under the centre cross with the stage.
Pause the SEM scanning in quad 1 and click Next.
Select **Finish Procedure** to leave the alignment procedure.

Step 2 of 6

| Finish Procedure |

SEM UHR LE:

| 350 V |
| 500 V |
| 1000 V |
| 1500 V |
| 2000 V |
| 3000 V |

Cancel

Panel 1 (Step 4 of 6)
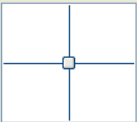
Alignments   ?

211 - FIB-I Ion Column Alignment ▼

[Previous]   [Next]

Instructions

Switch to Quad 2 with FIB and bring the same feature as on the paused SEM image in Quad 1 under the centre cross by adjusting the Beam shift adjuster. Use the 80 pA (index 5) as a reference.
Press **Next** to continue with further alignments.

Step 4 of 6

[Cancel]

Panel 2 (Step 5 of 6)
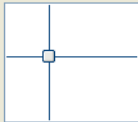
Alignments   ?

211 - FIB-I Ion Column Alignment ▼

[Previous]   [Next]

Instructions

-**Beamshift:** Switch to Quad 2 with FIB and bring the same feature as on the paused SEM image in Quad 1 under the centre cross by adjusting the Beam shift adjuster. Use only beam current 80 pA (index 5).
-**Quad Alignment:** L2 Wobble is automatically turned on. Minimize wobble using the adjuster.
-**Stigmator Alignment:** Optimize image with two dimensional corrector, mouse or MUI.

Step 5 of 6

Tables

[BShift]   6 pts
[Quad]   4 pts
[Stig]   4 pts

Wob_ampl   1000
[<] [====] [>]   [L1 Wobble]

Wob_ampl   50
[<] [====] [>]   [L2 Wobble]

L1_Corr (V)   0
[<] [====] [>]   L1 = 18600 V

L2_Corr (V)   -88
[<] [====] [>]   L2 = 18935 V

[Save]

Contrast   69.57
[<] [====] [>]

Brightness   41.37
[<] [====] [>]

-**Stigmator Alignment:** Optimize image with two dimensional corrector, mouse or MUI.

Press **Next** to store alignments and to proceed further.

Panel 3 (Step 6 of 6)

Alignments   ?

211 - FIB-I Ion Column Alignment ▼

[Previous]   [Finish]

Instructions

Press **Finish** to finish the procedure.

Step 6 of 6

[Cancel]

253 - Supervisor: Ion Beam

Alignments   ?

253 - Supervisor: Ion Beam   [v]

                                    [Start]

Instructions

Press Start button

No step

Alignments   ?

253 - Supervisor: Ion Beam   [v]

                                    [Finish]

Instructions

Ion Beam Service page.
Press Zero Offset to reset AAS user
settings to zero
Press Offset Reset to transfer AAS user
settings to service settings and reset user
settings to zero
Press Heat to heat the ion source
With the Emission Current slider the
current can be changed
The Fib source status is indicated by the
yellow button

Step 1 of 1

[Zero Offset]   [Offset Reset]

Aperture mechanism:

[Home AVA]

FIB Source: [Heat]

Act. Emission Current = 2.0 uA

Emission Current   2.0000000 µA
[<] [_____■____] [>]

Ion Source Status:

[Offline]   [Disabled]

[Idle]   [Acquire]

[Maintain]   [Heat]

[Shutdown]

                                    [Cancel]

254 - Supervisor: GIS

The time under the GIS name displays operation periods (valve opened) for an actual GIS. Click the **Lifetime reset** / **GIS 1** / **GIS 2** / **GIS 3** … button to reset a corresponding GIS time display.

Change target crucible temperature for a particular GIS by the **T** slider.

Note:
The Working Temperature unit varies according to **Preferences…** / **Units** setting (see Chapter 3), but the **Actual Temp.** unit is always °C.

E-Column: / Vacuum Actions

Alignments not numbered run in a different environment, they are actually the set of alignments. Most of the procedures could run automatically by checking the **Automatic** check box placed next the red star. During the procedure informational windows could be turned on / off by the **Show** / **Hide Window** button. **Cancel** the alignment sequence or continue by the **Next** button.

Caution!
Read carefully the instructions provided by the system before proceeding with any alignment!

If you have selected any e-beam alignment procedure and you want to select any other one, you must **Finish** or **Cancel** an actualy opened procedure first. To start alignment procedure or to stop one in progress right-click over the red star and select required action (**Start** / **Stop**). A confirmation dialogue is displayed.

By clicking the **Cancel** button, by selecting the **Stop** item in the menu (see above) or by Closing the UI nothing is saved (see Restore old results below). In all cases the alignment windows over the quads disappear and the **Stop Execution** dialog appears.

FIGURE 4-1   STOP EXECUTION DIALOG
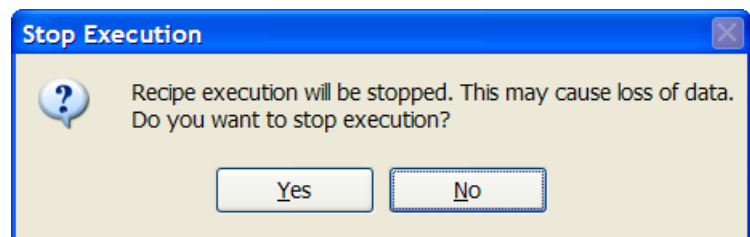
The last page of every alignment offers one or more of the following possibilities:

*   **Restore old values and finish**: undoes the adjustments, nothing will be saved.
*   **Save new results and finish**: keeps new adjustment values and saves them. Also creates a new **Restore Point**.

FIGURE 4-2   LAST PAGE CHOICES
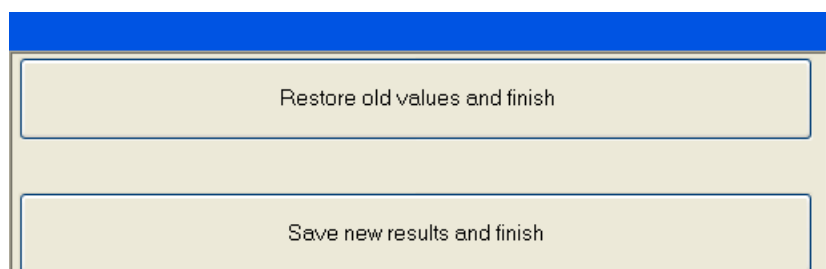
RESULTS

The result of every step is shown by means of an icon in the result list when performing alignment steps.

FIGURE 4-3   ALIGNMENT RESULTS

		Description	Result	Time
✓	0	C0Deflection	This step gave reliable results	10:53 AM
✓	1	SourceTiltAndShiftNMode	This step gave reliable results	1:39 PM
✓	2	C1CenteringUMode	This step gave reliable results	1:36 PM
◇	3	FineTuningC0DeflUMode:		
✓	4	SourceTiltAndShiftUMode	This step gave reliable results	10:17 AM
✓	5	StigmatorHR	This step gave reliable results	5:43 PM
✓	6	AlphaZoom	This step gave reliable results	9:58 AM
◀▶	7	LensAlignAndStigmatorUHR: S...	OutOfRange	11:33 AM
◀▶	8	LensAlignAndStigmatorUHR: S...	OutOfRange	6:02 PM
✓	9	WDCalibrationHR	This step gave reliable results	12:15 PM
✓	10	UCCondenserCalibrationHighC...	This step gave reliable results	9:51 AM
✓	11	WDCalibrationUHR	This step gave reliable results	6:22 PM

Unavailable: ◇
The result has never been obtained, at least not by this
procedure. This may mean that it has never run, or that it failed to do
anything meaningful (the difference between these two is not
important).

Reliable: ✓
The result is trusted by the automatic procedure
OR
the user has passed the alignment step manually (i.e. we trust that
the user actually performed the alignment step).

Unreliable: ?
The automatic procedure has done meaningful work,
but could not decide whether the obtained result can be trusted. This
suggests to review the result manually.

Out of range: ◀▶
the automatic procedure trusts that the optimal outcome
is outside the range of the variable to be aligned. A value is set that is
near the border of the range.

Note:
User alignments change settings for the time of operation and do not
affect permanently the higher level alignments (supervisor).

E-Column: UC User Alignments
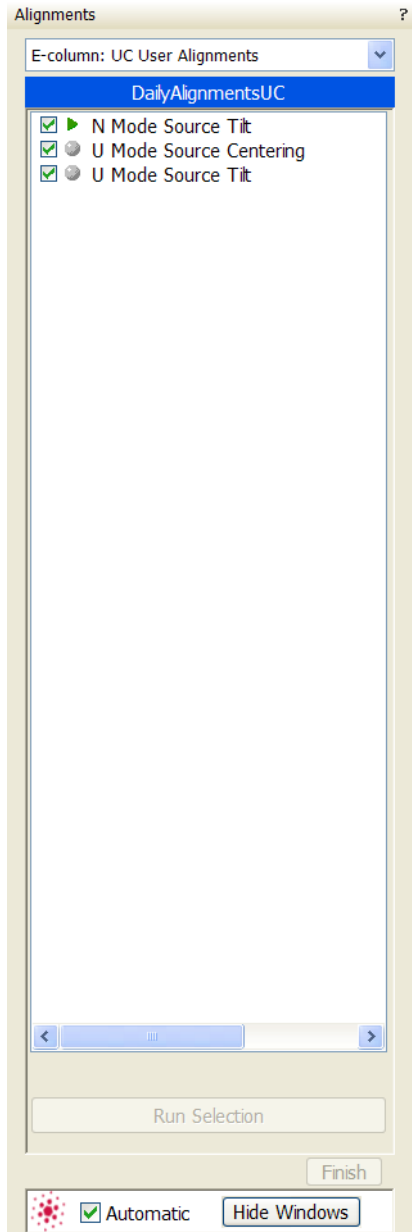
- **N / U Mode Source Tilt**
  This alignment will set up the Source Tilt values to get the beam through the EBA (Electron Beam Limiting Aperature) for different HV and UI probe values, and the source Shift values to direct the beam through the center of the HR lens.

- **U Mode Source Centering**
  This automatic alignment centers the UC beam through U-mode slits.

E-Column: User Alignments

Helios NanoLab 600i

Centers the electron source tilt and shift.
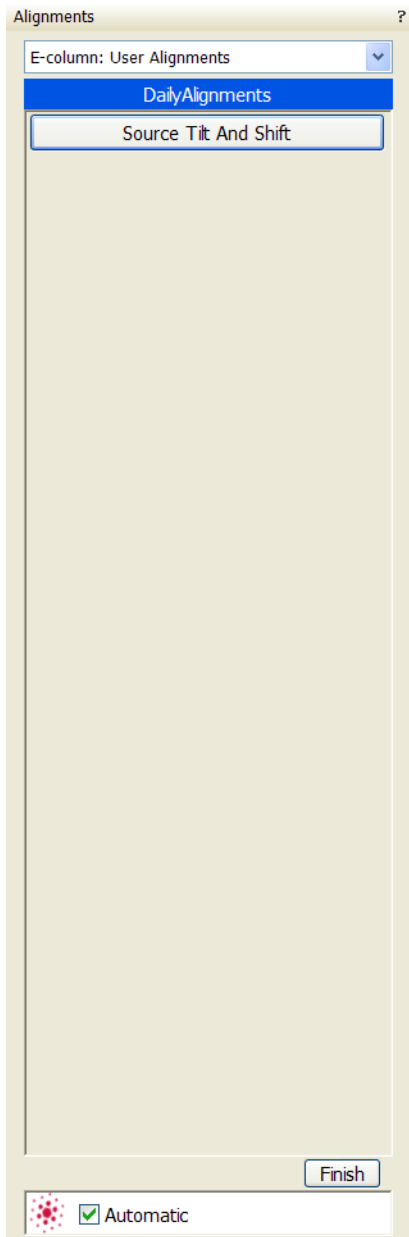
FIGURE 4-4   SOURCE TILT AND SHIFT DIALOGUE
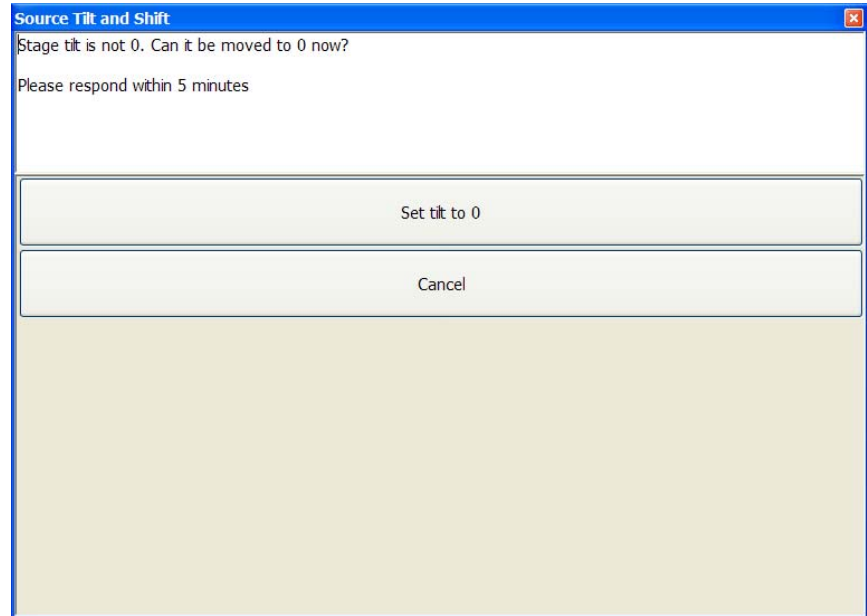
E-Column: Aperture Map Selection
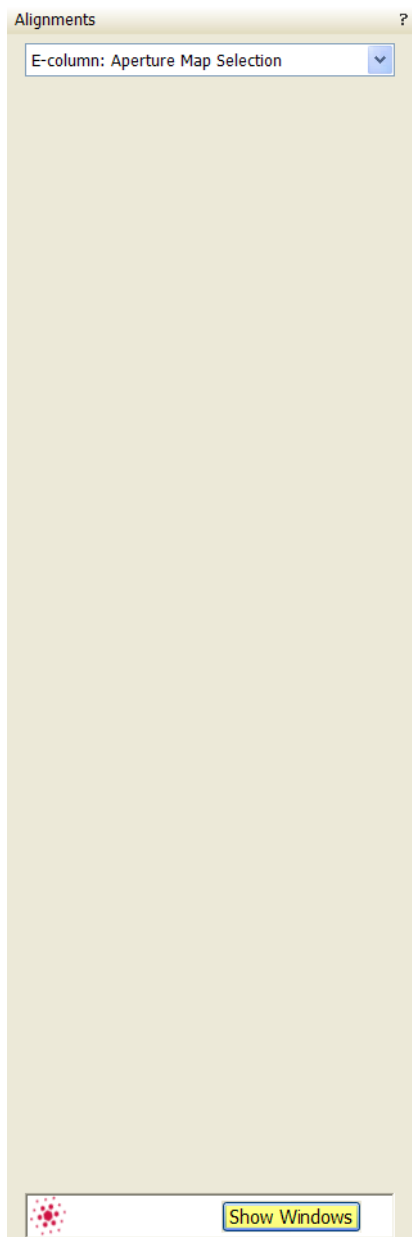
Try to change the aperture map when imaging is poor or the astigmatism is not possible to correct.

Aperture Map Selection

Step 1 of 1:
With this adjustment one can select one of the four available EBA aperture maps.
The only difference between map 1-A and 1-B is the 22.6um aperture that is used at HV < 3kV, UHR mode.
Idem for 2-A and 2-B. This is the most sensitive aperture because it is used for high resolution at low kV.
The difference between map 1 and 2 concerns almost all apertures.

- Select an Aperture Map.

Select Aperture Map

1-A

Cancel   Next

Alignments   ?

E-column: Aperture Map Selection

Show Windows

E-Column: Magnification Correction

This utility is intended to enhance factory calibration acuracy under particular, user selectable conditions.

Note:
Switch the **Beam** menu / **Magnification Correction** item on only for calibrated conditions, otherwise it could worsen magnification accuracy.
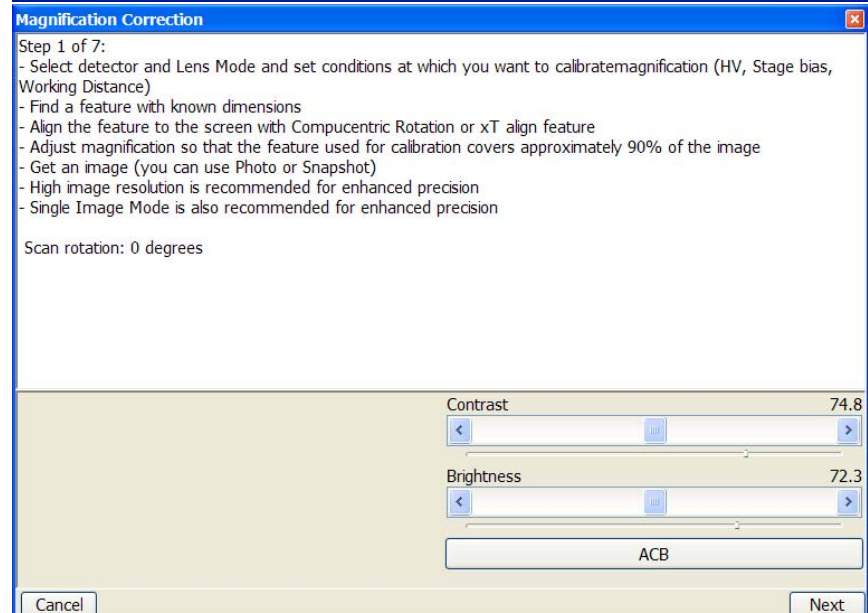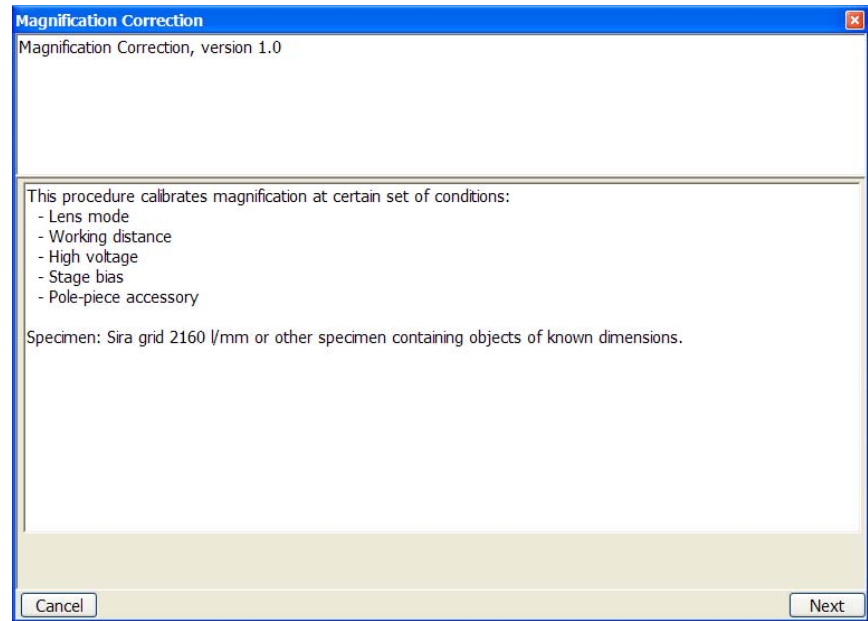
E-column: Auto UMode Source Centering

Alignments ?

E-column: AutoUModeSourceCentering
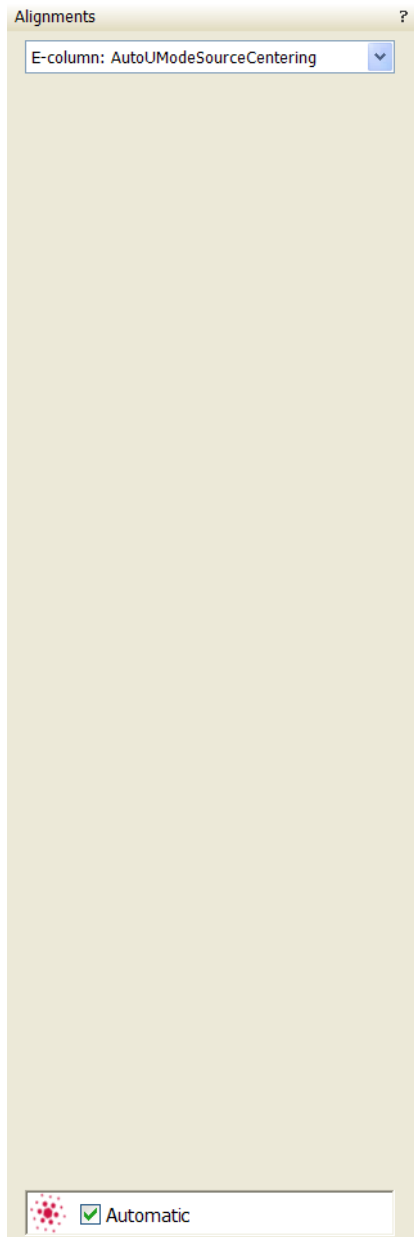
☑ Automatic

This automatic alignment centers the UC beam through U-mode aperture.

Note:
This alignment needs to be done every 2 days.

E-Column: UC Supervisor Alignments

- **Alignment Range Editor**
- **Auto Couple Z to WD**
- **Source Tilt and Shift N-Mode / U-Mode**

  This alignment will set up the Source Tilt values to get the beam through the EBA (Electron Beam Limiting Aperature) for different HV and UI probe values, and the source Shift values to direct the beam through the center of the HR lens.

- **U-Mode Source Centering**

  This automatic alignment centers the UC beam through U-mode slits.

- **Stigmator HR**

  This adjustment will set up the table values for different HV of the Stigmator balance and astigmatism correction in HR mode.

- **Lens Alignment and Stigmator UHR**

  This adjustment will set up the table values for different HV on the Lens Alignment, Stigmator balance and astigmatism correction in UHR mode. Eliminates image shift during focusing and/or normal astigmatism correction in UHR mode.

- **Switch E Beam Off**

E-Column: Supervisor Alignments

Helios NanoLab 600i
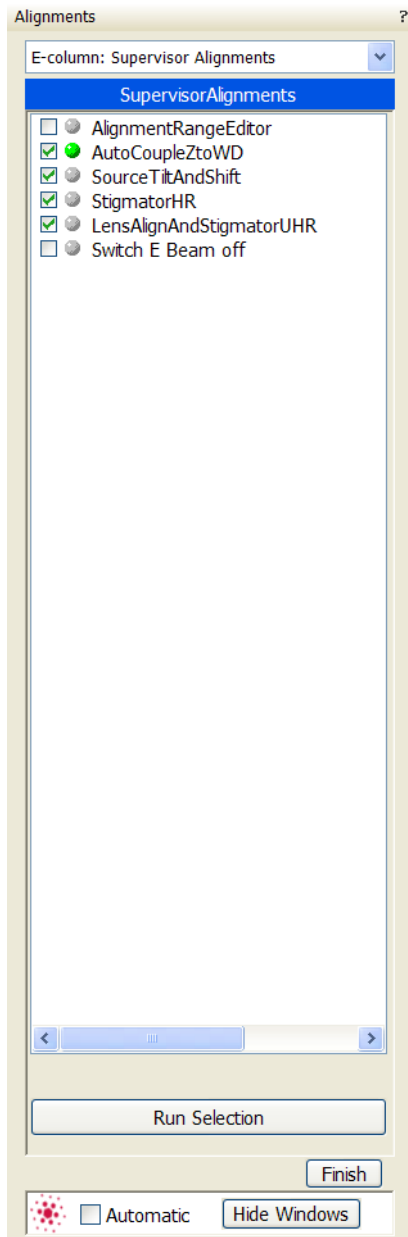
- **Alignment Range Editor**
- **Auto Couple Z to WD**
- **Source Tilt and Shift**

  This alignment will set up the Source Tilt values to get the beam through the EBA (Electron Beam Limiting Aperature) for different HV and UI probe values, and the source Shift values to direct the beam through the center of the HR lens.

- **Stigmator HR**

  This adjustment will set up the table values for different HV of the Stigmator balance and astigmatism correction in HR mode.

- **Lens Alignment and Stigmator UHR**

  This adjustment will set up the table values for different HV on the Lens Alignment, Stigmator balance and astigmatism correction in UHR mode. Eliminates image shift during focusing and/or normal astigmatism correction in UHR mode.

- **Switch E Beam Off**

E-column: U-mode Aperture Selection

Try to change the aperture when imaging is poor.

U-mode Aperture Selection

Step 1 of 1:
When the image quality in the U-mode is insufficient, you may consider to improve it by selecting a different U-mode aperture.
With this adjustment one can select one of the 3 available U-apertures. If you change the U-mode aperture, you need to redo the SourceTiltAndShiftUMode again.

- Select an U-mode aperture.

U-mode aperture

2

Cancel   Next

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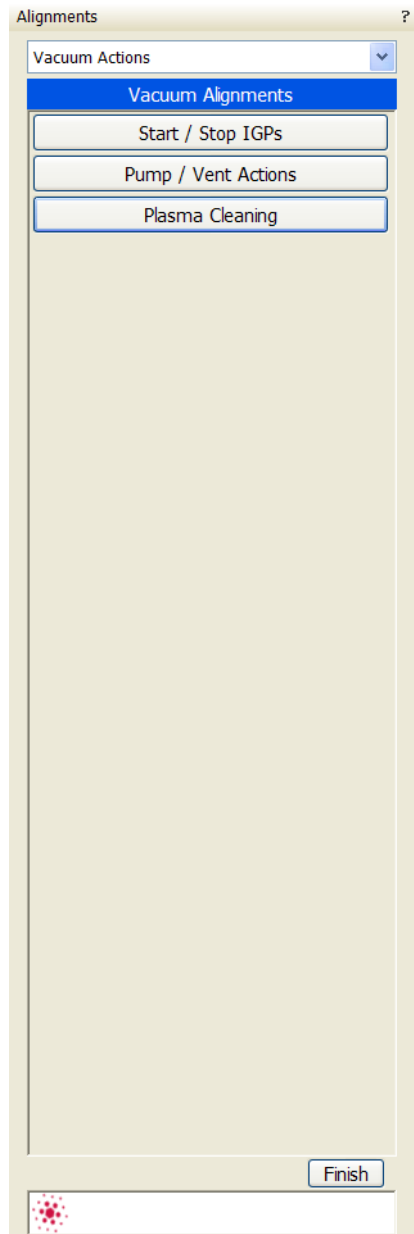
- **Start / Stop IGP's**
- **Pump / Vent Action**
- **Plasma Cleaning**

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
- Imaging Optimising
- Detector types and usage
- Capturing and Handling a Single Image
- Recording Movies (Saving Multiple Images)
- Stage Control
- Nav-Cam
- Loadlock
- Multiloader
- Measurement and Annotation Functions
- Patterning
- X-ray Analysis
- Plasma Cleaner

C a u t i o n !
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 or ions. 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 nad FIB 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

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 ON 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. If you are using another way to mount a specimen, 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.

Inserting / Exchanging Specimen is possible with LoadLock also for some microscope models (see below).

Caution!
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 an FEI Customer Service.

※ FEI

Microscope Control

OPERATION PRE-CHECK

To ensure correct operation check the following list before continuing.
After obtaining a preliminary imaging, you can then experiment with your
own settings.

TABLE 5-1   SETUP CONDITIONS

Adjustment	Electron beam setting	Ion beam setting
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 = (10–30) kV	30 kV for imaging, milling, depositing 5 kV for cleaning 5–10 kV for large field of view
Beam Current	100 pA at 30 kV	100 pA at 30 kV
Scan rate	Fast scan (dwell time 0.1 - 0.3 µs)	Fast scan
Working Distance (FWD)	Set the highest specimen point to approximately 4 mm, tilt to 0°. (yellow mark in an optical beam quad) and press Ctrl + F (set FWD to 4 mm function).	Set the stage into the eucentric position and tilt to 52°.
Eucentric Height	4 mm	16.5 mm
Magnification	Set to lowest – from 50× to 200×	Set to lowest – from 50× to 200×
Standard Detector	ETD (SE) / ICE (SE)	ETD (SE) / ICE (SE)
Filtering	Live	Live
Contrast and 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 imaging. Increasing brightness and decreasing contrast produce softer imaging and vice versa.	See Electron beam setting
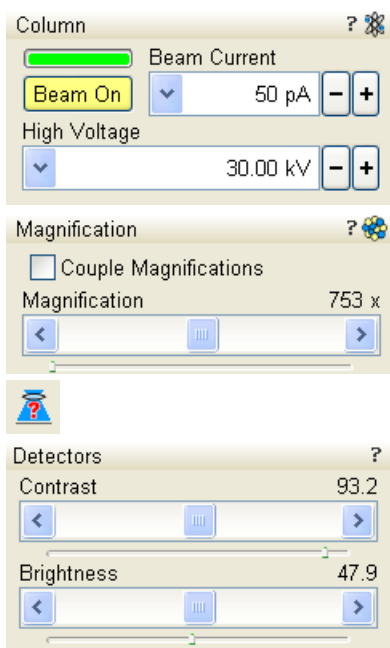
OBTAINING IMAGING ON SCREEN

The following assumes that the electron emission is on.

1. Select an appropriate detector (see below) and resume the chosen quad.
2. Click the **Column** module / **Beam On** button to ramp up the accelerating voltage. An image appears in the active quad.
3. Focus the image and **Link Z to FWD** (see Chapter 3).
4. Adjust to a suitable magnification, optimize the image with **Contrast** and **Brightness, focus, Stigmator**.
5. Adjust to a suitable magnification, optimize the image with **Contrast** and **Brightness, focus, Stigmator** (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, you get 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

| 100x |
| 500x |
| 1 000x |
| 5 000x |
| 10 000x |
| 30 000x |
| 100 000x |
| 1 200 000x |
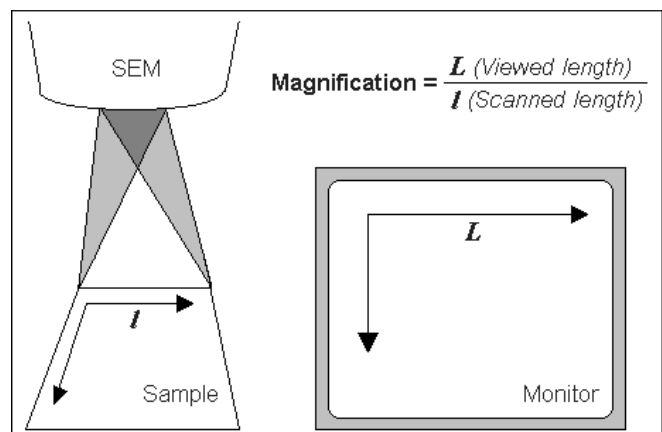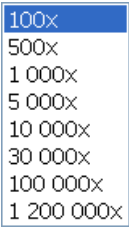
Changing Magnification

- 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 moving 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. Press into the imaging area and drag to make a dotted box over the area of interest (the cursor changes to a magnifying glass with a + sign). Release the mouse and the selected area increases to fill the whole quad (window) with respect to the sides ratio. Shift + pressing 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

Detectors	?
Contrast	93.2
Brightness	47.9
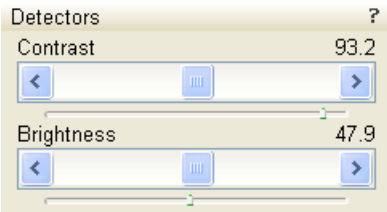
The contrast and brightness can be set manually either by adjusting the **Detectors** module controls (see Chapter 3) or using the MUI (option):

1. Select a medium speed scan in an selected 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 sample 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 greyscale imaging level range.

Three yellow horizontal lines (placed over the quad) indicate white (top line), grey (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 selected 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 clips 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 touches 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-press** (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.
   Note:
   Magnification changes during focusing but returns to the original value after mouse button release.

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 at one side of the screen, move the mouse cursor to the opposite one and right-press 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-press 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.

   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 an aperture is dirty (see Chapter 6), the magnification may be too high for the beam spot size (see below) or the sample is charging (apply conductive layer).

DIRECT ADJUSTMENTS (CTRL + F8)

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

Note:
Ion beam Direct Adjustments are available only for accelerating voltages under 8.06 kV.

Ion Beam tab
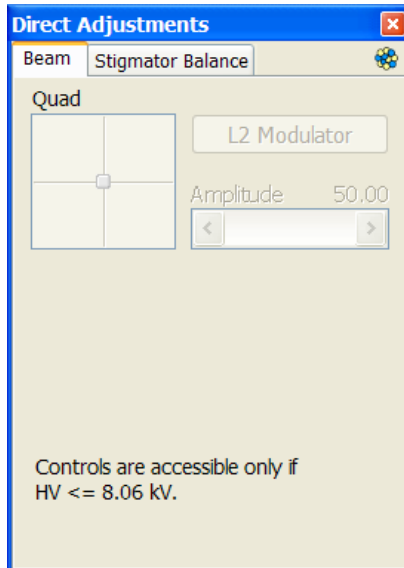
- The **Quad** 2D box minimizes the objective imaging shift during focusing.
- The **L2 Modulator** button starts automatic L2 voltage oscillation (periodically under- and over focuses imaging in a narrow range) to facilitate the process.

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

Ion Stigmator Centering tab
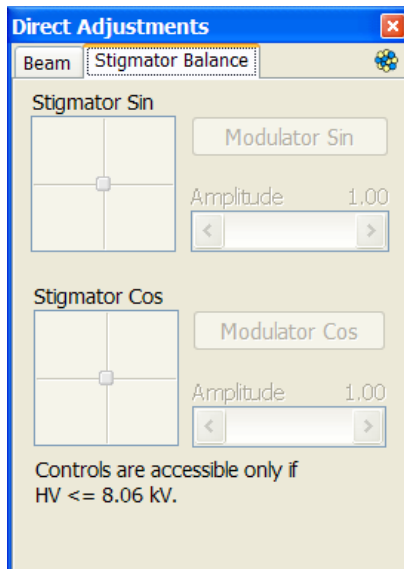
- The **Stigmator Sin** / **Cos** 2D box sets the astigmatism lenses to bring the beam into the center. The crosshair indicates the actual stigmator setting. This minimizes imaging shift during astigmatism correction.
- The **Modulator Sin** / **Cos** button starts modulation of stigmator lenses in X / Y axis.
- The **Amplitude** slider sets the modulation amplitude.

Electron Beam tab

Model difference:
Helios NanoLab 600i does not have the UC 2D Box.
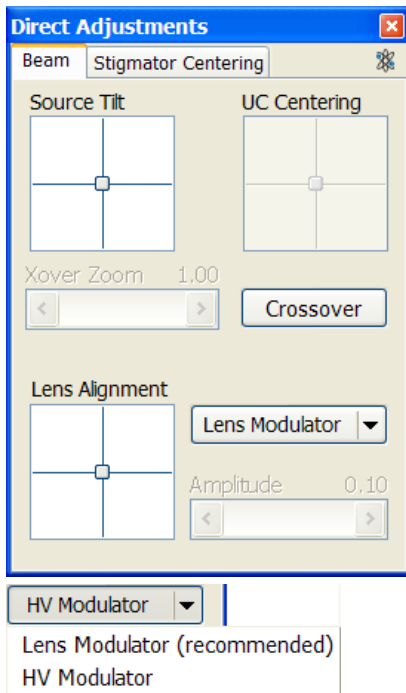
- The **Source Tilt** 2D box corrects an imaging illumination drop by changing an effective angle of the beam coming from the gun area into the electron column.
- The **UC Centering** 2D box centers UC beam through U-mode aperture.
- In the **Crossover** mode (activated with the button) the imaging shows the electron source 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** (useful for HV > 3 kV) / **HV Modulator** (useful for HV < 3 kV) button starts automatic objective current / voltage oscilation (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).
- The **Amplitude** slider sets the modulation amplitude.

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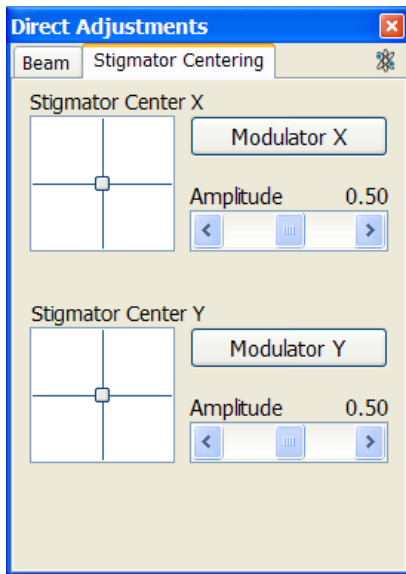
- The **Stigmator Center X** / **Y** 2D box sets the astigmatism lenses to bring the beam into the center. The crosshair indicates the actual stigmator setting. This minimizes imaging shift during astigmatism correction.

  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 stigmator electrodes voltage oscilation (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 image enhancements.

Note:

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

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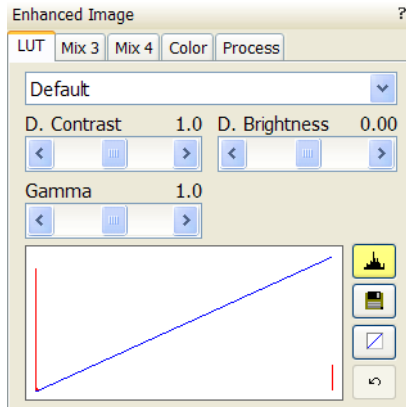
enables to monitor and modify a grey level distribution (histogram).

- 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 contrast in the range from -10 to +10 (negative values lead to an inverse imaging).
- The **D. Bright.** continuous adjuster sets a 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 **Graph** window graphically displays (blue line) an 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 gray 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.

The Mix 3 / Mix 4 Tab
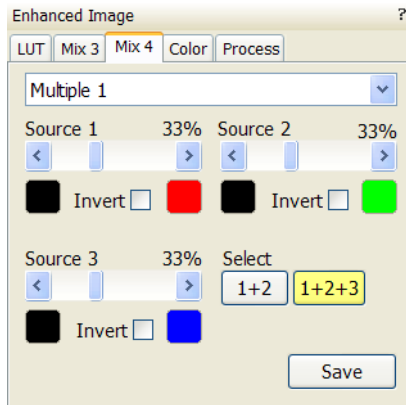
The Mix feature operates in quad 3 / quad 4 and are enabled only if the **Detector** menu / **Mix** is selected for a quad 3 / 4. It uses the processed images (Average / Integrate, Digital Contrast, Digital Brightness, Digital Zoom), not the raw detector signals. Any combination of live and paused images 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 / Resume influences the mixed image 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 images. The adjuster % values shape correspondingly the resulting image. Changing any Source value influences the other ones 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 gray scale is linearly transformed to a new color spectrum before it is mixed with other image(s).

Note:
Color images (see below – the Color tab) are converted to greyscale ones before mixing.

- The **Invert** check boxes inverts the corresponding source image 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.

The Color Tab

enables to colorize a gray 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 active quad image histogram and enables to create a color profile.

  Right-clicking into the histogram area adds the vertical borderline with a divided triangle on top (right-clicking onto an existing one removes it). Pressing and 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 gray scale between two borderlines is linearly transformed to a new color spectrum.

- The **Hand** button enables to select and color a particular image gray level. Clicking it opens the color selection dialogue: select a color and press 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 on 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 on 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.
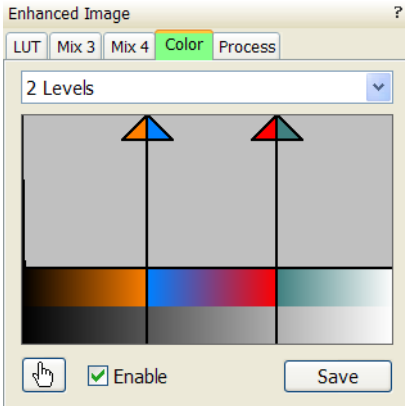
The Process Tab

Here the 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 strenght** (0 / 1 / 2 / 3 / 4) removes dust and scratches from the image.
- The **Sharpening strenght** (0 / 1 / 2 / 3 / 4) corrects the imag7e sharpness.
- The **Undo** / **Redo** button applies the processing again.
- 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.
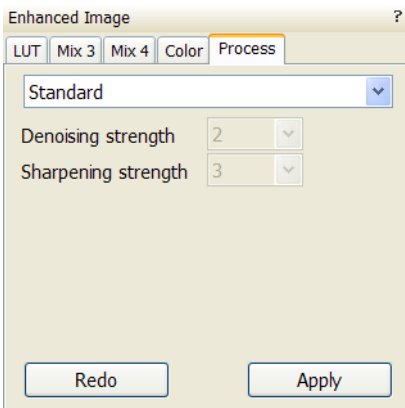
Standard Detectors
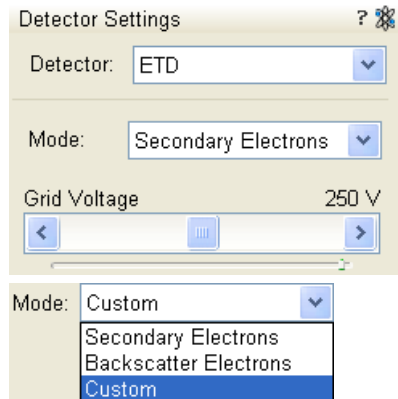
EVERHART THORNLEY DETECTOR (ETD)

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.
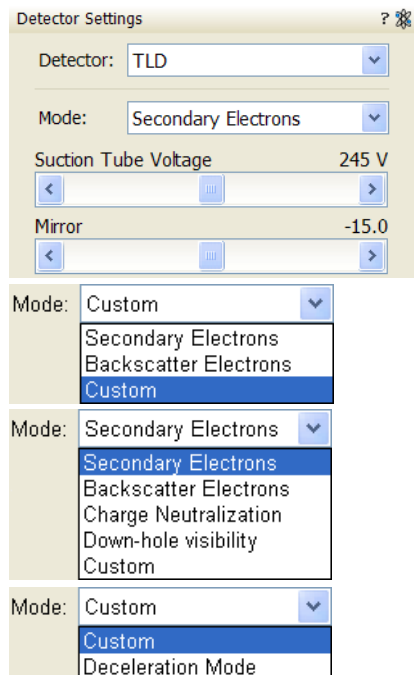
THROUGH LENS DETECTOR (TLD)

The TLD 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 the highest value
- Custom
- Deceleration Mode is available, when it is on (see below)

TLD Settings

- The **Suction Tube Voltage** adjuster enables to modify electron collection. When the voltage is negative, low energy secondary electrons are repelled from the TLD detector and only backscattered electrons are detected. When the voltage is positive, low energy secondary electrons are collected by the TLD detector. The Suction Tube Voltage capability is from -150V for only backscattered electrons to +150V for secondary electrons collection.
- The **Mirror** adjuster deflects the acceleration path of the SE's into the detector in Secondary Electrons mode. It also can be used to convert high energy BSE's to SE's in Backscatter Electron mode.

Note:
When using the FIB Immersion utility (see Chapter 3) the Custom Mode Suction Tube Voltage for electron imaging is copied to the Custom mode for ion imaging.

SECONDARY ION / ELECTRON DETECTOR (ICE)

The ICE is a charged particle detector mounted near the end of the ion column. It collects secondary ions (SI) or electrons (SE, BSE) to form an imaging signal.

The Electron beam and Ion beam imaging (which is distinguished by the beam icon in the module header) have different **Mode**s.
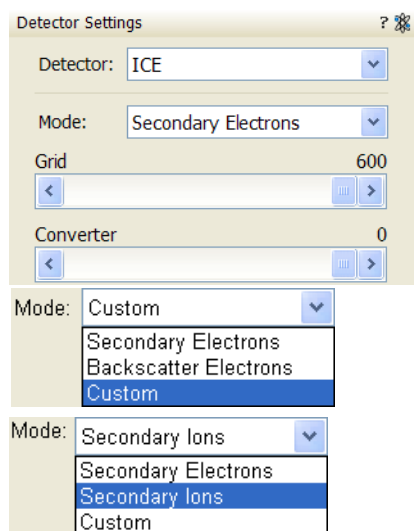
Electron beam modes:

- Secondary Electrons (SE)
- Backscatter Electrons BSE)
- Custom
- Deceleration Mode – available, when the Deceleration Mode is on (see below)

Ion beam modes:

- Secondary Electrons (SE)
- Secondary Ions (SI)
- Custom

ICE Detector Settings

When changing any of the adjuster, the **Custom** mode is activated for any beam, enabling to change values.

- The **Grid** continuous adjuster: positive voltage for SE imaging, negative voltage for BSE and SI imaging
- The **Converter** continuous adjuster: 0 for SE and BSE imaging, negative for SI imaging

Note:
Changing the beam current adjusts the detector contrast automatically.

ICE & ETD COLLECTION EFFICIENCY

ICE and ETD detectors are both able to collect SE signal. In order to prevent the inactive (paused) SE detector from taking the SE signal, set the **Preferences** dialogue / **General** tab / **Optimized collection efficiency** item to **Yes**, which provides more SE signal to the active SE detector. This is advantageous for common imaging but it is not recommended to use while patterning, because image quality decreases in SPI and iSPI mode.

Note:
Large changes to the custom conditions on biased detectors (such as the ETD and the ICE) could cause beam shift, which in turn affects the coincidence of the two beams. Therefore it is not advisable to change custom conditions while patterning (if coincidence is affected then re-calibration is necessary before starting to pattern).

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.

SEM Imaging Modes

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

FINAL LENS MODES

Mode 1: Field-Free
Mode 2: Immersion
Mode 3: EDX

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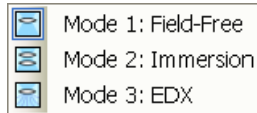
- **Mode 1: Field-Free**

  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.

  Caution!
  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.

ELECTRON SOURCE MODES

Beam Patterning Stage Tools Wir
Electron Beam
Ion Beam
CCD Camera
Nav-Cam
Toggle E-I Beam   Ctrl+T
Magnification Correction
Home SEM Apertures
Home FIB Apertures
SEM Mode   ▶
✓ Do Not Degauss
UC On
UC Auto
Lens Alignment   Shift+F4
Direct Adjustments...   Ctrl+F8
✓ Show FIB Heat Alert

This mode can be switched on in the **Beam** menu / **UC On** item.

Model difference:
Helios NanoLab 600i does not have the UC On and UC Auto items.

- In the Normal mode (**UC On** not ticked) the full system HV and beam current range is available.
- In the UniColor mode (**UC On** ticked) maximum HV is 10 kV and maximum beam current is 25 pA. Electrons are supplied with the energy spread less than 0.2 eV, which improves image quality at low HV and low beam currents.

  Ticking the **UC Auto** switches UC-mode on automatically, when HV and beam current values are in the allowed range.
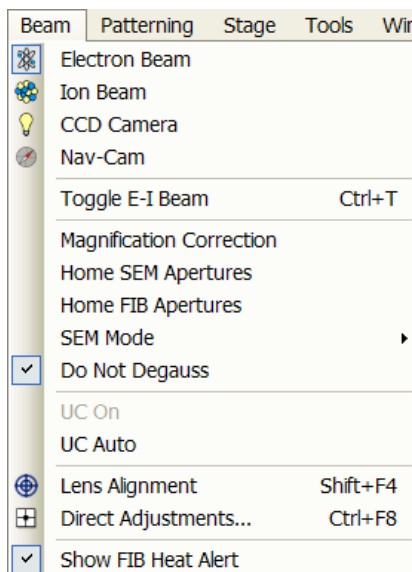
BEAM DECELERATION MODE

Model difference:
BD is option for the Helios NanoLab 600i.
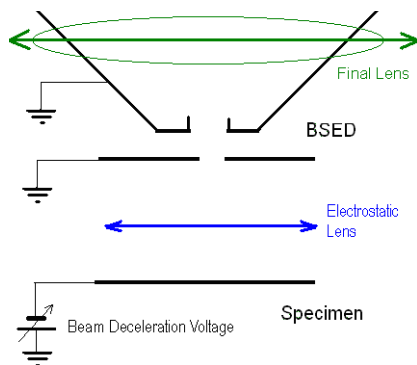
The Beam Deceleration mode (BDM) method is based on a negative voltage **Stage Bias** (**bias**) applied to a stage (i.e. a sample). The electrical field between the sample and the nearest surface over (a column bottom or a detector) is formed, acting as the additional electrostatic lens. Its power is 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
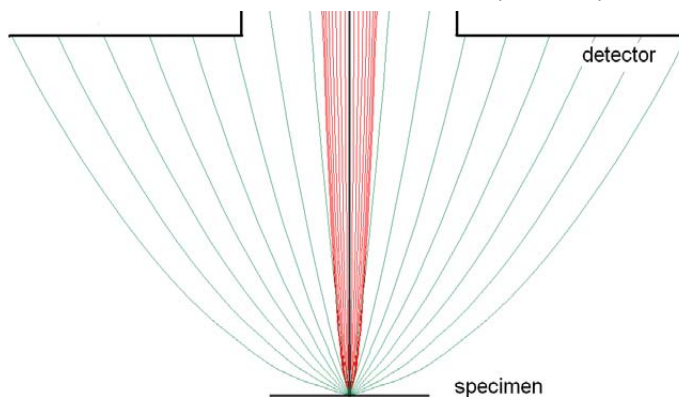
Detectors most convenient for the Beam Deceleration are BSE ones, placed closely under or directly inside the column. Their efficiency depends on their active area: the smaller the active area inner diameter the better. The standard ETD could also be used, but its efficiency is low.

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

- 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
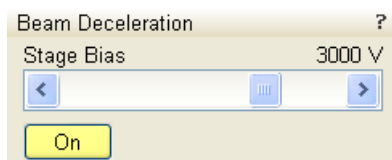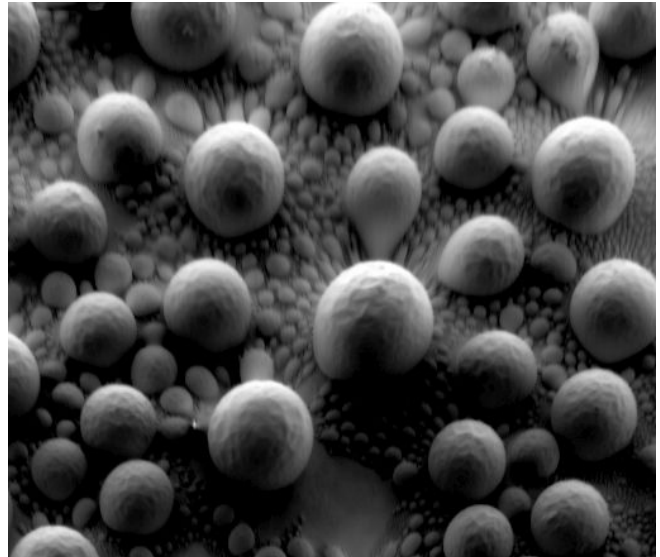
Beam Deceleration Module

The **Beam Deceleration** module has following features:

- The **On** button switches the BDM on / off. This is available only with the Beam On. When switching the beam off, the BDM switches off too automatically.
- The **Stage Bias** (bias) reflects the negative voltage applied to a stage. Minimal value is 50 V, maximal is 4 kV.
  Note:
  It is possible to control the stage bias by the active image databar menu (see Chapter 3).

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.

   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 above) and tune an imaging with the **Beam** menu / **Lens Alignment** and the **Beam** module / **Stigmator** 2D control (see Chapter 3). In various quads select the SE and BSE to observe different imaging simultaneously.

3. Click the Mode 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:
   When the retractable vCD detector is inserted, stage tilt is restricted via the UI. Override it by manual control to keep the dark area 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.
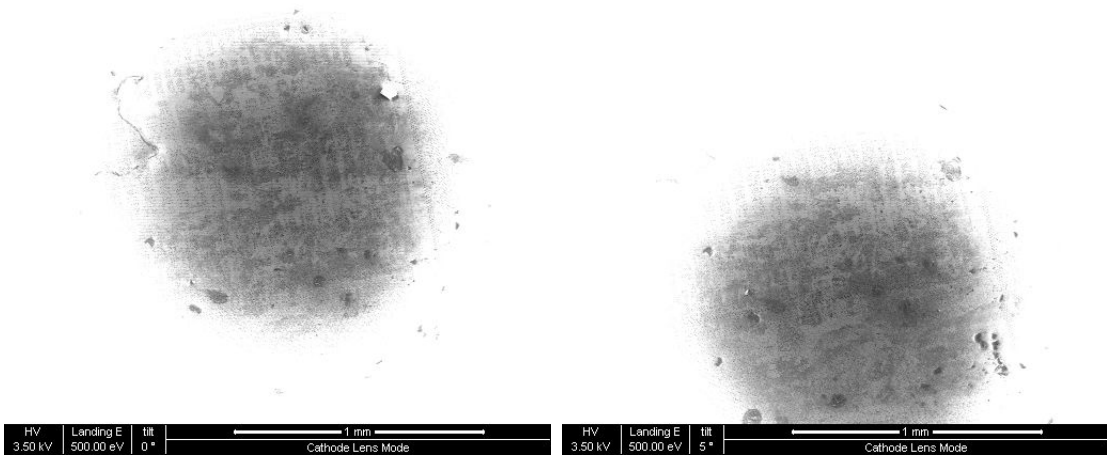
4. Set the Stage Bias considering the sample material (charging compensation, material contrast) and to optimize the signal. Set the brightness, contrast and WD according to the requirement.

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

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

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.

  Colored digital overlaid graphics (Measurement and Annotation) are possible to be saved with / without an image (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.
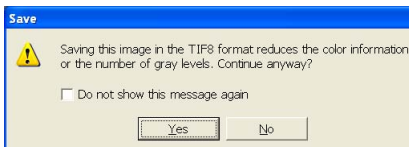
- The **TIF** 8 / 16 – greyscale image type
- The **TIF** 24 file – color image type

  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 an uncompressed file format. The 8 / 24 bit depth is automatically selected when saving the greyscale / color image file.

SAVING / OPENING / PRINTING
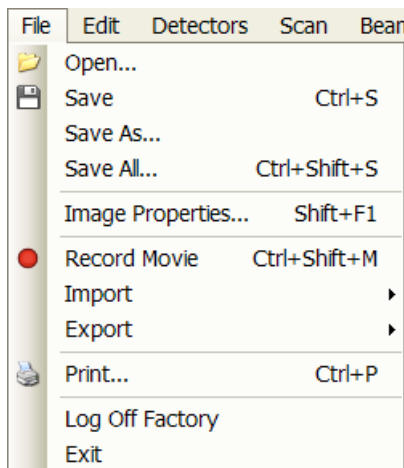
The following universal file handling functions could be used:

- **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.
- **Print… (Ctrl + P)** opens the printer setup dialogue so that the choice of printer and settings can be established to print the selected quad. Clicking the OK button in the printer setup dialogue activates the printer to print the job.

Image Capturing Procedure

1. Select the area of interest and set the **Magnification**, the **Scan condition**, the image pixel **Resolution** and the Databar informations that are required in the saved image.
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.
4. The image can now be saved by
   File menu / **Save (Ctrl + S)** / **Save As…** functions.
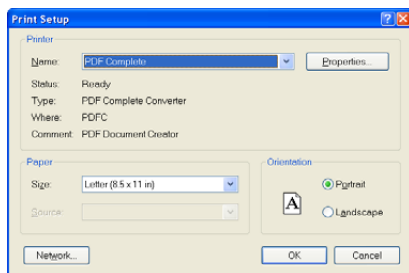
Image Printing Procedure

1. Select the area of interest. Set the **Magnification**, the **Scan condition**, the image pixel **Resolution** and the required databar informations.
2. Capture the image or open a saved one.
3. Click the **File** menu / **Print… (Ctrl + P)**, a print dialog appears.
4. Complete the print setup and click the **OK** button.

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 768 × 512 or 1536 × 1025
- 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 5-4 MOVIE PREFERENCES
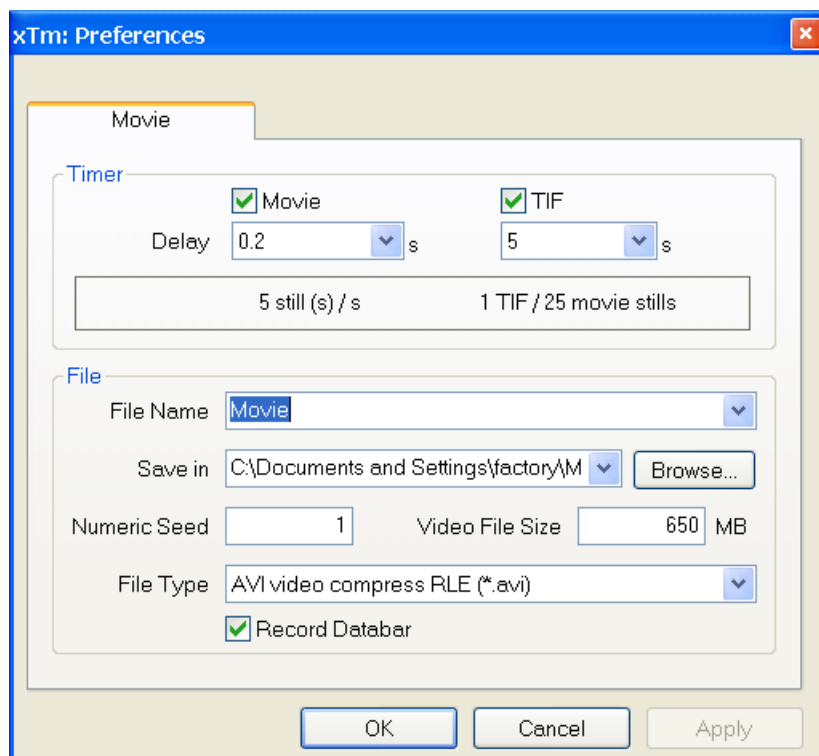
Timer module

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 non 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 2000) 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).

RECORD MOVIE

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 pressed, it turns to a **red square**, representing 'Stop'. Pressing 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.
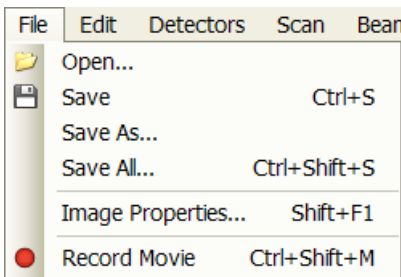
5. Choose either of the offered **Resolution** values at which the movie starts to record.
6. Select the **File** menu / **Record Movie** again or click the toolbar / red square button to stop the movie recording.

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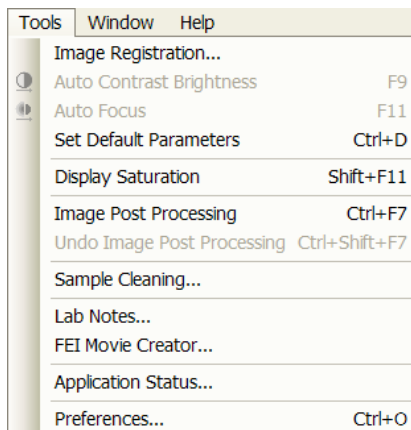
This is a separate program that creates a movie from a sequence of TIF images. Click the **Tools** menu / **FEI Movie Creator…** to activate the tabbed dialogues.

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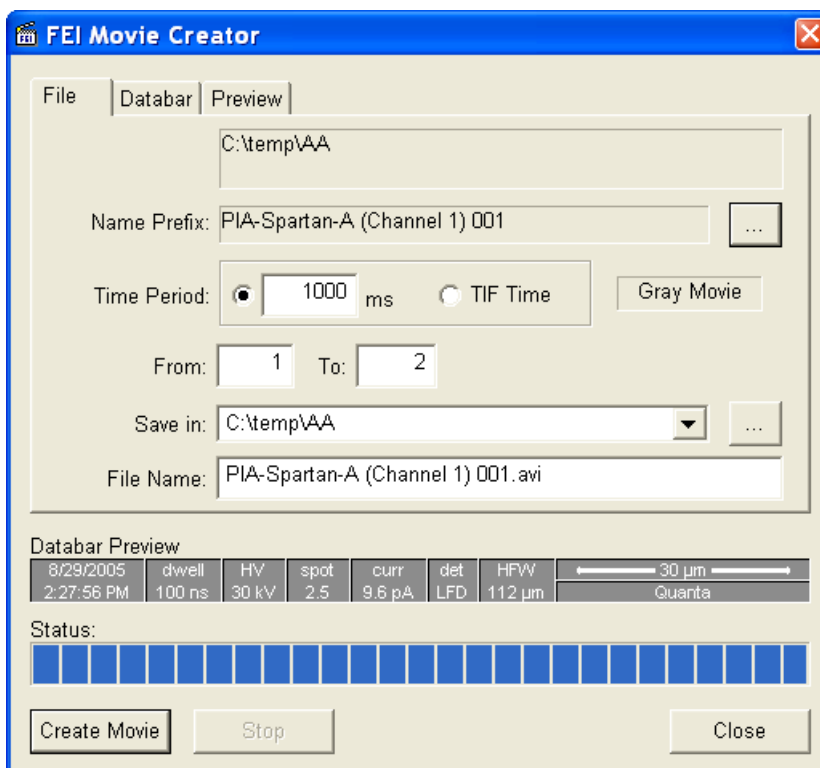
- The **Name Prefix** – click the **…** button to browse the TIF files (with the desired sequence prefix) directory. It is not necessary to choose the first file in a row.

FIGURE 5-6 BROWSE DIALOGUE
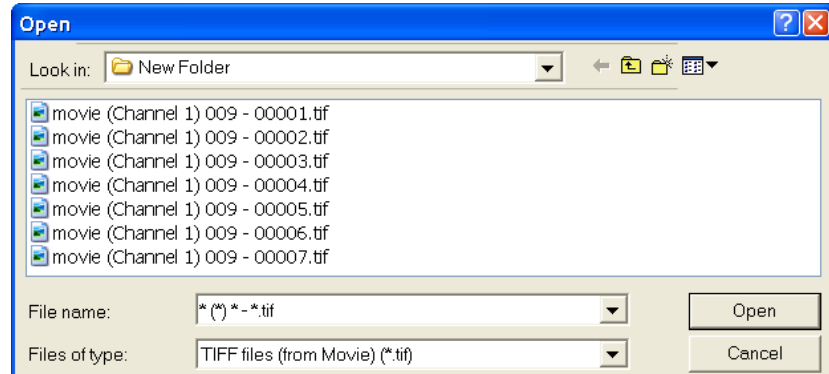
- The **Time Period** – select the **ms** radio button to select a custom timing for the movie playback. One may experiment (200 ms is good for most movies to speed it up). Select the **TIF Time** radio button to select a real timing for the movie playback.
- The **Gray Movie** button suppresses the 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 xTUI.

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

FIGURE 5-7 FEI MOVIE CREATOR TAB: DATABAR
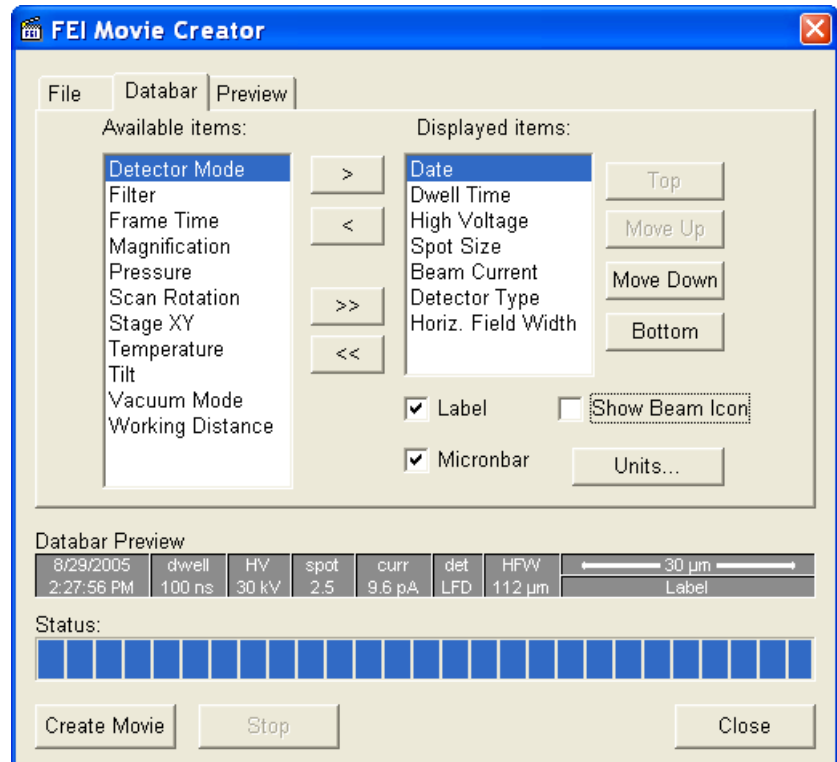
- The **Available** / **Displayed items:** lists – all items that can be entered in the databar / are already present in the databar.
- **> / >> (< / <<)** buttons adds one / all item(s) from the Available list to the Displayed list (removes one / all item(s) from the Displayed list back to the Available 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 5-8 FEI MOVIE CREATOR TAB: PREVIEW
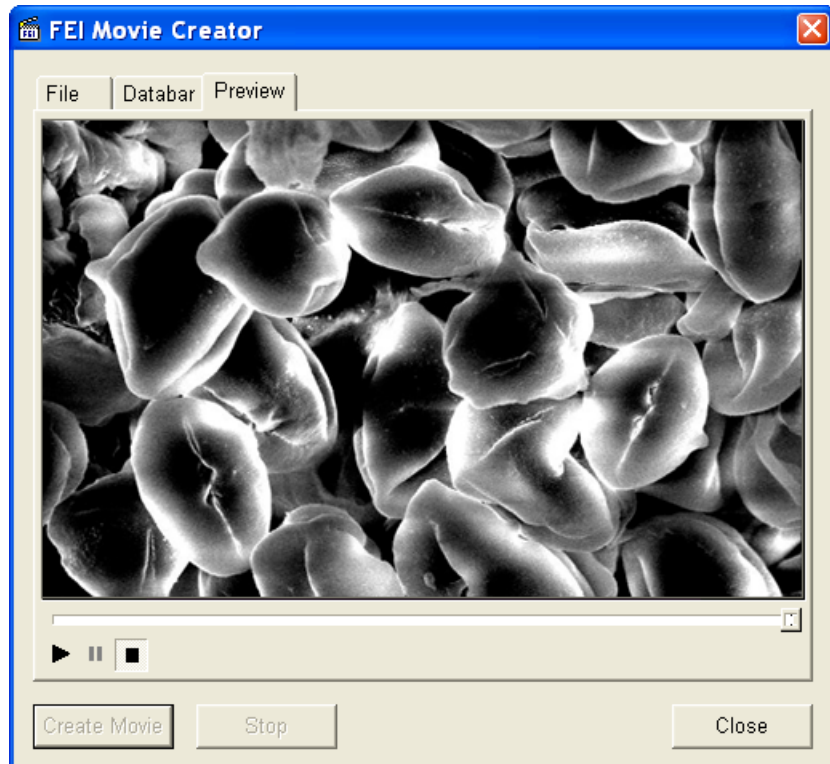
- The **Start** / **Pause** / **Stop** button starts / pauses / stops the movie play back. By dragging the adjuster one can run forward or backward through the movie.

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 height 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, Omniprobe).

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 5-9   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.
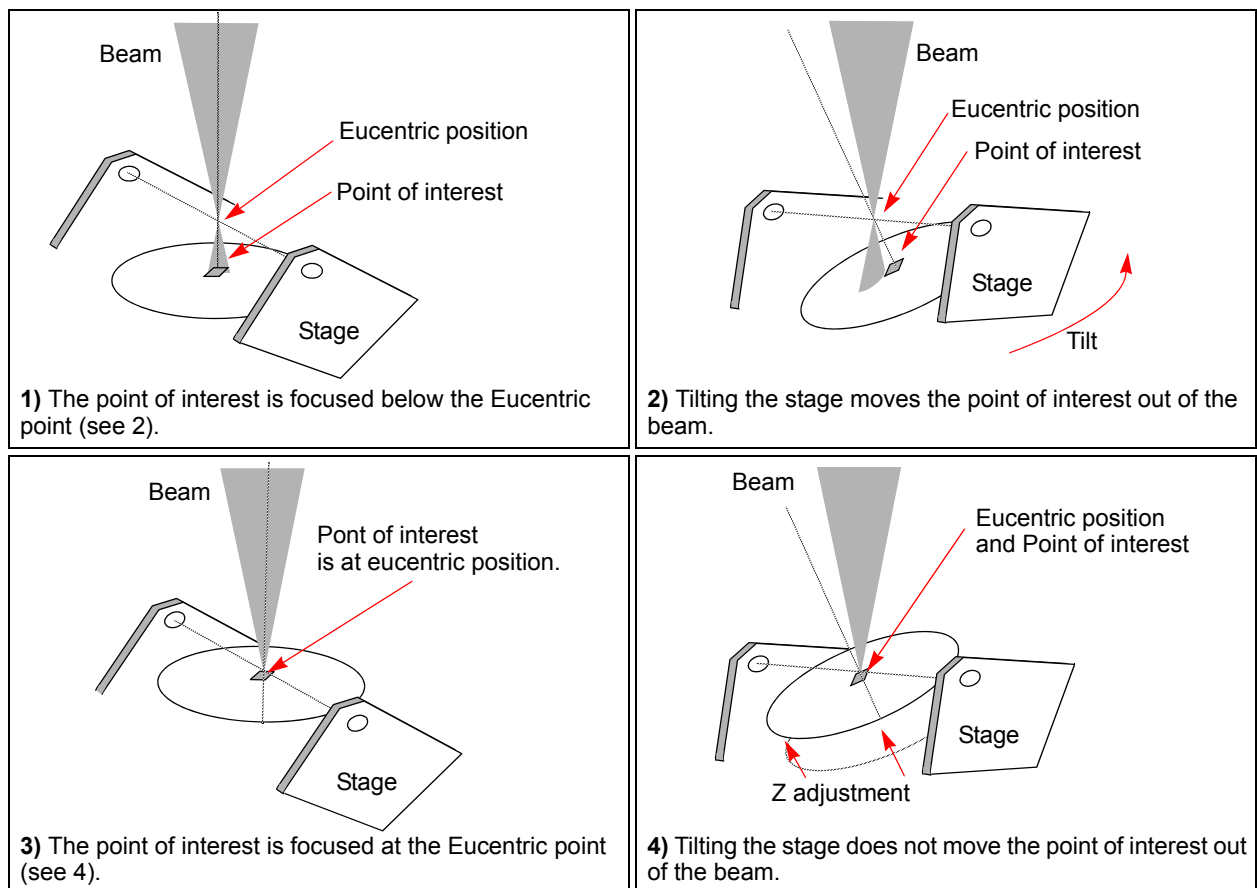
Setting Procedure

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 1000x, 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

Helios NanoLab 450 / Helios NanoLab 650 / Helios NanoLab 600i

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.
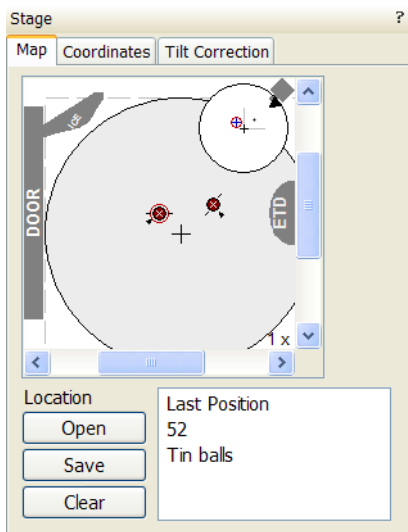
FIGURE 5-10 MAP AREA ELEMENTS
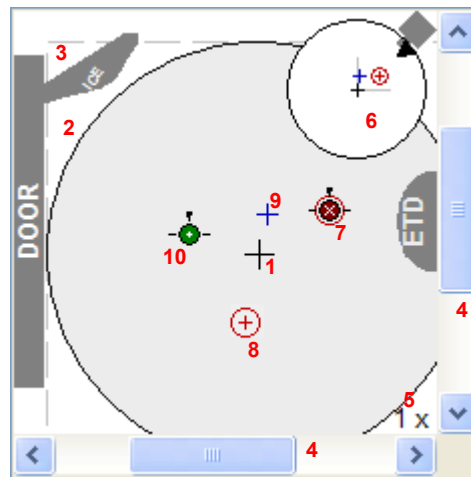
TABLE 5-2 MAP AREA ELEMENTS

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 a X / Y (stage) direction at different magnification factors.
5.	**Magnification** factor of the map area (1x–100x).

TABLE 5-2   MAP AREA ELEMENTS

No.	Function
6.	**Radar view:** **Black triangle:** the moveable rotation angle positioner. **Grey perpendicular lines:** denote rotation position. **Grey +:** stored positions as on the map. **Red + in a red circle / Blue +:** 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 active 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, press on the circle perimeter triangle. Move it round and release the mouse 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 an 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 to disk.

  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 5-11 THE MAP DIALOGUE
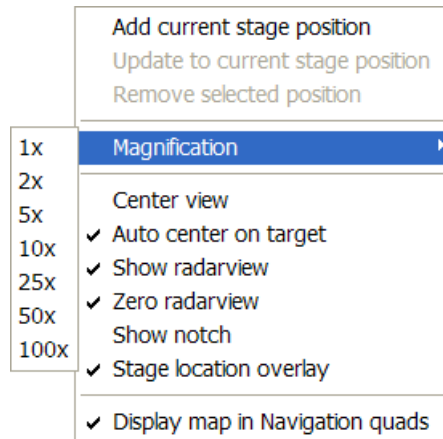
- Clicking the **Add current stage position** item adds a new Location list entry, using the actual active position. The new entry is named **Position X** (**X** = 1, 2, 3…). If a name already exists (because an user loaded a Map list from a Stage Map file), the value is heightened until a unique name 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 a 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 triangel 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 naviagtion images.

 FEI™ CONFIDENTIAL
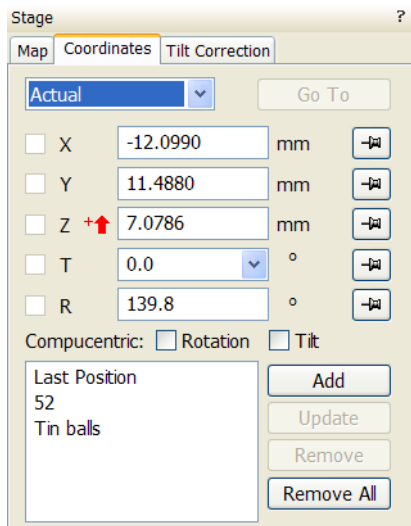
Coordinates tab

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). Pressing 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.
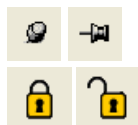
The units of measure follow the **Preferences…** / **Units** setting, unless the **Stage** menu / **User Units** function is active, in which case UU is displayed for X and Y.

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.
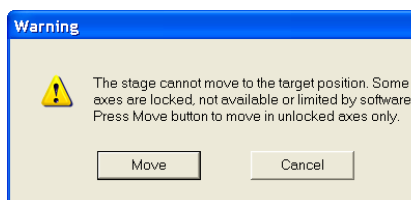
When any axis is locked and the stage movement is required in that direction (trying to move to the stored position), the warning dialogue appears.

When the **Compucentric: Rotation** check box is ticked, the **R** coordinate operates as the Compucentric Rotation function.

In case the **Compucentric: Tilt** check box is ticked and the stage is tilted, the system compensates for observed sample point shifting during a stage Z-axis movement with a stage Y-axis movement.

Note:
Because this functionality invalidates the stage eucentric position setting (see above), do not check the Compucentric: Tilt check box when setting it!

Note:
The R coordinate is permanently locked and its homing is disabled when the heating or cooling stage is plugged in.

Tilt Correction tab

When the appropriate check box is ticked, the function becomes active.
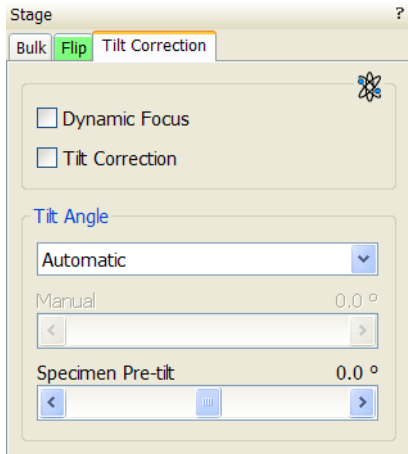
- The **Dynamic Focus** check box ticked – the focus automatically changes as the beam scans from the image top to its bottom, trying to follow the tilted specimen working distance change.

- 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 **Automatic** check box – switches between automatic and manual tilt angle settings. If ticked, 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).

- The **Manual** 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 non-zero, an indicator is displayed in the optical quad.
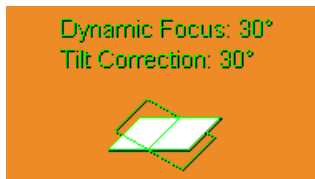
Notes:

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 non-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).

SOFTWARE CONTROL

Helios NanoLab 450S / Helios NanoLab 450ML

Microscope models equipped with the Flip Stage have the **Navigation** page / **Stage** module consisted of **Bulk / Flip / Tilt Correction** tabs. Active stage (Bulk or Flip one) is highlighted by a green tab header. Most elements corresponds to ones mentioned above.

FIGURE 5-12 THE STAGE MODULE
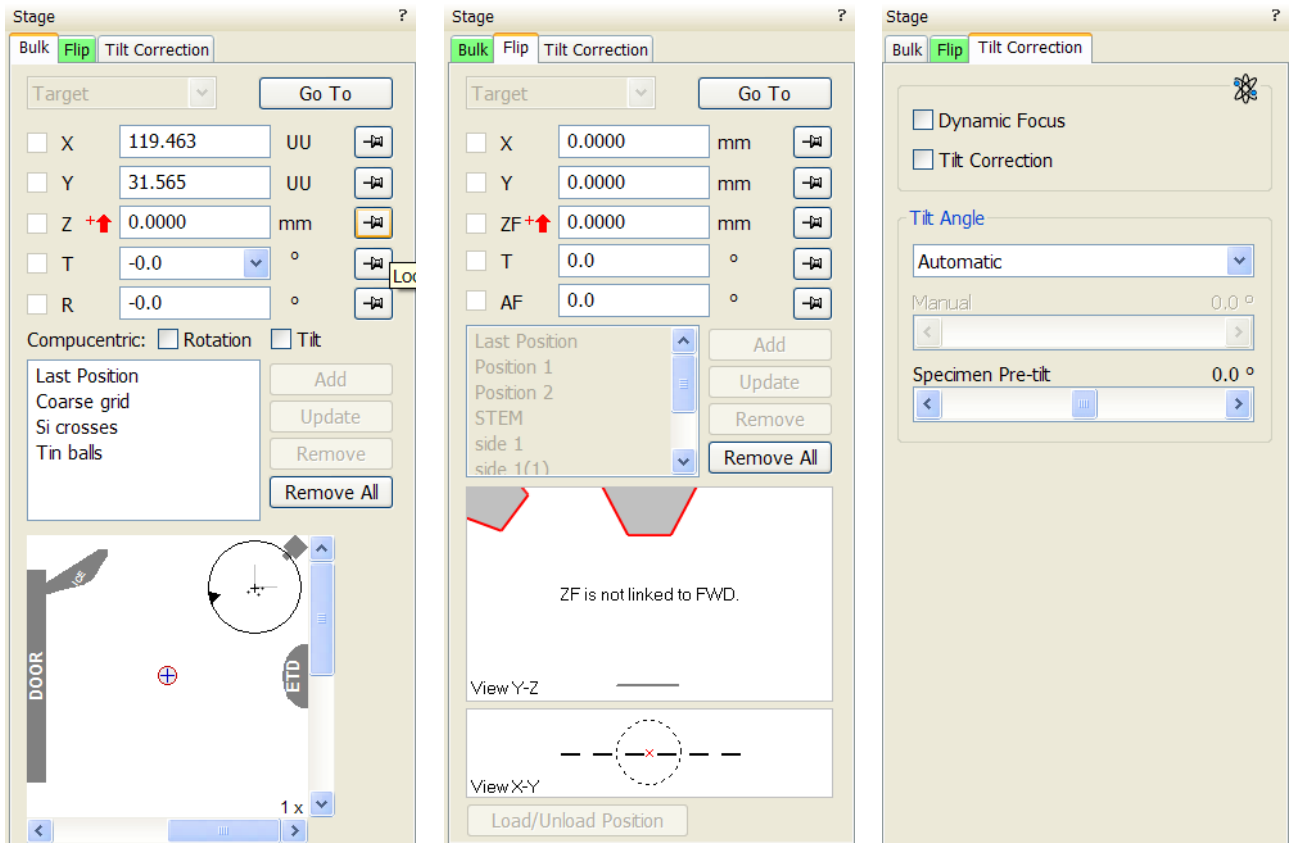
Bulk tab

The Bulk tab allows to control the Bulk stage similarly to the Map and Coordinates tabs control.

Flip tab

The Flip tab contains particular functions to operate the Flip stage:

- **ZF** represents the Flip stage Z-coordinate.
- **AF** (Alpha Flip) represents a Flip stage tilt (from -55° to 100°).
- **T** represents Bulk stage tilt (from -3° to 60°).
- **View Y-Z** shows the row holder arm schematically at the eucentric height (blue line marker, WD = 4 mm) with the tilt angle 0° (black contour).

Helios NanoLab 450S

- **View X-Y** shows a selected row holder grid position. Doubleclick a required grid position to quickly move the row holder in X-axis direction.
  The Flip stage X / Y move is restricted compared to Bulk stage.
- The **Load/unload Position** button moves the stage to a row holder exchange position.

HARDWARE CONTROL

Manual User Interface (MUI)

Model difference:
MUI is option for the Helios NanoLab 650 / Helios NanoLab 600i.

The 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 5-13 MUI

The MUI offers additional flexibility for controlling magnification, beam shift, focus, astigmatism, contrast and brightness.

Joystick

Model difference:
Joystick is option for the Helios NanoLab 650 / Helios NanoLab 600i.

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 5-14 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.
• The button **3** speeds up the stage motion:
  - 10× in X / Y axis
  - 5× in Z axis
  - 2× in R / T axis
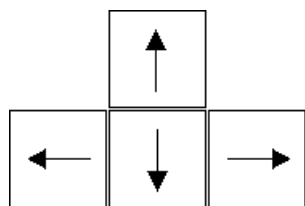
STAGE RELATED FUNCTIONS

Stage Movements – Keyboard Shift

The stage can be moved about 80% of the field of view in perpendicular direction by clicking the appropriate keyboard **Arrow key** (with the **Shift** button pressed simultaneously about 40%).

Stage Movements – Track

This function allows continuous directional stage movements at a variable speed.

Wheel-press over an selected electron image quad – the yellow **dot** appears onscreen at the mouse cursor point. Move the mouse to the direction intended for an observation – an 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.

In the second possible mode the mouse wheel does not need to be held, just click it to start the Track motion and click it again to stop it.
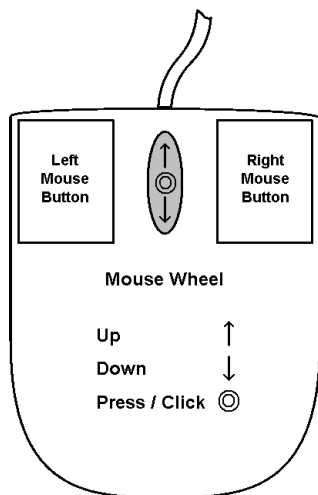
FIGURE 5-15 TRACK FUNCTION

| 2/13/2001 | Mag | HV | Spot | ├──────10.0µm──────┤ |
| 3:18:06 PM | 4205x | 0.00 V | 5.0 | Test label |
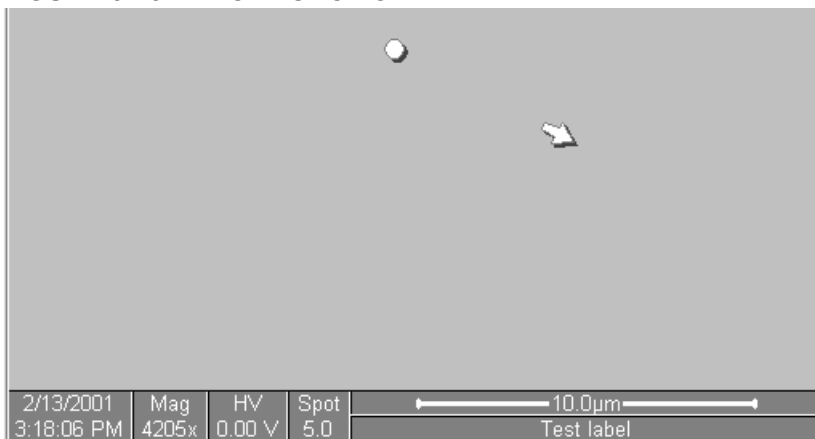
In the optical quad pressing the mouse wheel activates the stage Z movement, which can be seen live.

- When **Wheel-pressed**, moving the mouse up / down moves the stage up / down (Z-coordinate).
- When **Ctrl + Wheel-pressed**, moving the mouse left / right tilts the stage left / right.

The direction is indicated by a yellow arrow, either pointing up / down from the horizontal line or left / right from the vertical line.
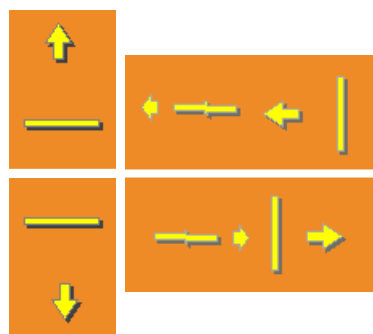
Stage Movements – Get

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.

FIGURE 5-16 GET FUNCTION
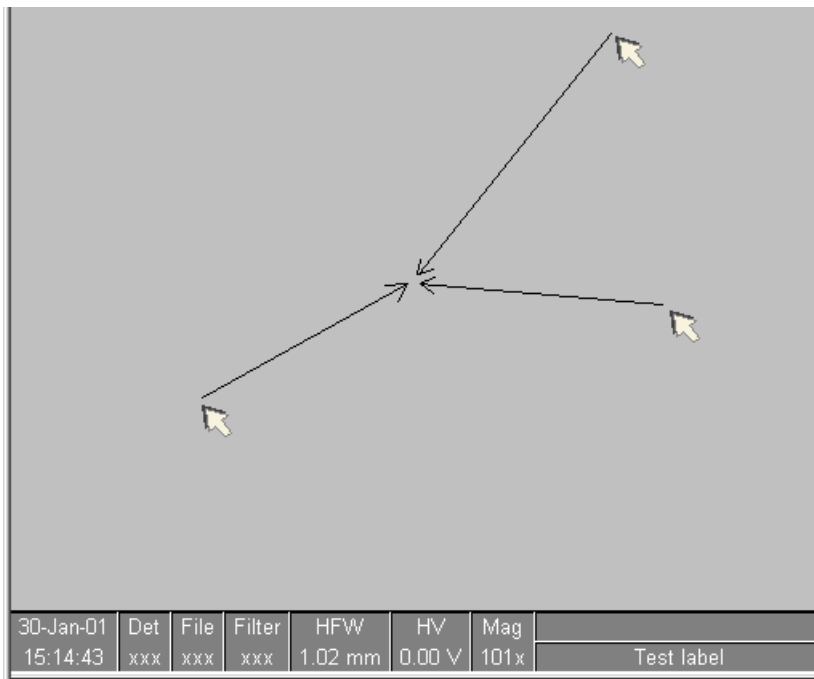
Beam Shift

When you want to employ the beam shift only (which is suitable for higher magnifications), click an image point while holding the **Shift** button pressed. The **Hand** cursor allows to move the image 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 stops the action.

xT Align Feature…
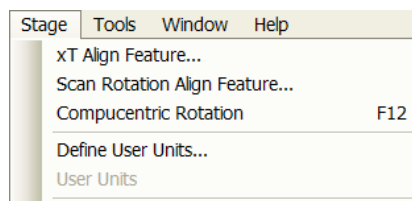
This utility is designed specifically for long features, extending off the screen at the magnification required for an observation. It applies the mapping process bringing the long feature either to the horizontal or vertical axis to make the navigation easier. This can be performed at any point within 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.
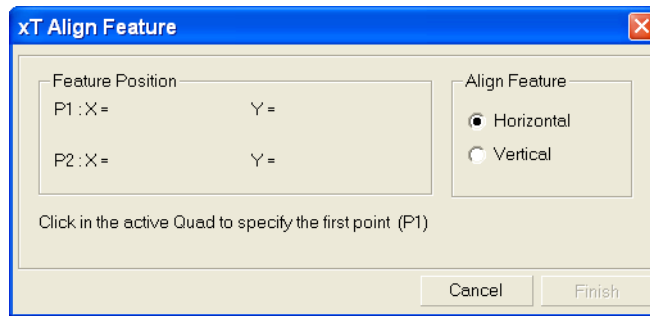
3. Click the second point along the feature, the **P2** coordinates update. Right-clicking anywhere in the imaging area deletes points, enabling to define them again.
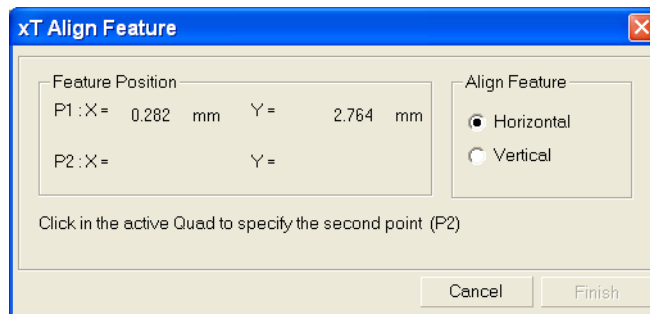
4. Drag any point to change its position, if needed. Click the **Finish** button to orientate the feature either **Horizontal** or **Vertical**, as selected previously. Click the **Cancel** button any time to cancel the function.
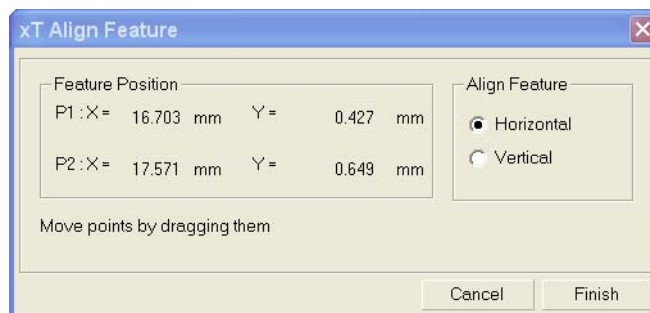
Scan Rotation Align Feature

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.
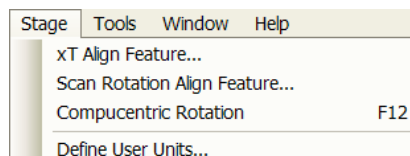
1. Click the **Stage** menu / **Scan Rotation Align Feature**. Choose either **Horizontal** or **Vertical**, which relates to the desired final sample orientation. Click the first point along the feature, the **P1** coordinates update.
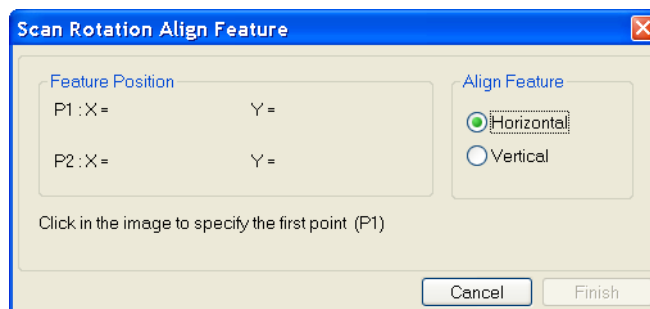
2. Click the second point along the feature, the **P2** coordinates update. Right-clicking anywhere in the imaging area deletes points, enabling to define them again.
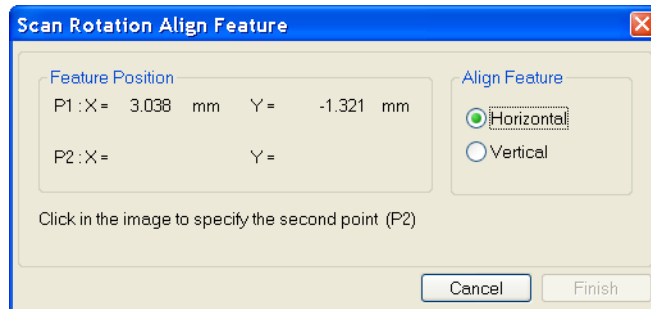
3. Drag any point to change its position, if needed. Click the **Finish** button to orientate the feature or click the **Cancel** button any time to cancel the function.
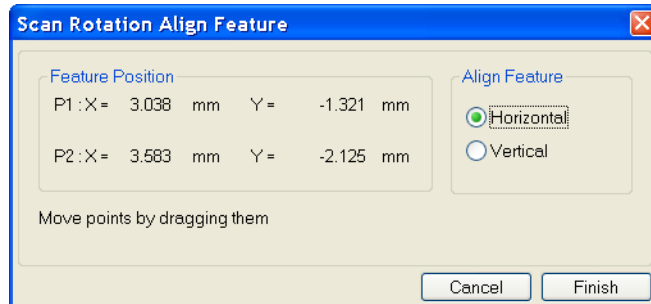
Compucentric Rotation (F12)
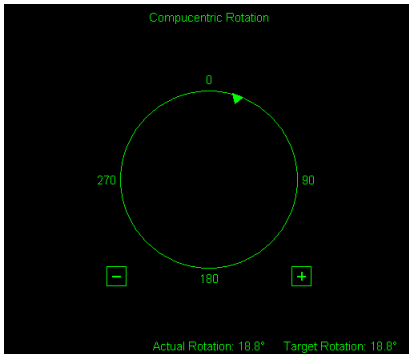
Clicking the **Stage** menu / **Compucentric Rotation** places a green circle in the image window. The green triangle on its perimeter denotes, by its position, the sample rotation relative to its original position when mounted on the stage. Initially, this is in the 12 o'clock position. Press and drag 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.
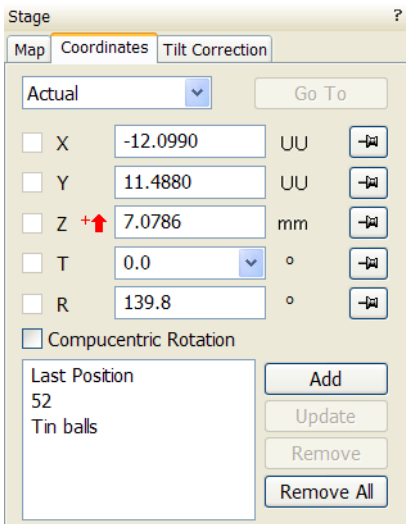
User Units

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.

The **Define User Units…** 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.

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.

xTm: Define User Units - Start

Make Selection:
- ● Define New User Units
- ○ Redefine User Units
- ○ Redefine User Units with Shift
- ○ Reset User Units so that they are equal to Stage Units
- ○ Show how User Units are now defined

Details...   Cancel   Next   Finish
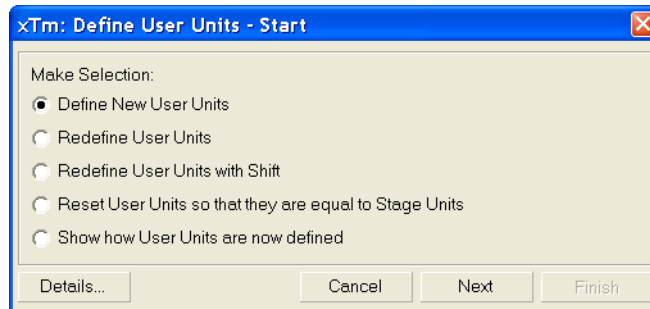
Redefine User Units – for changing or updating User Units.

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.

xTm: Define User Units - Alignment Point One

User Units Definition:
Move to user point (0,0) to define, then click on feature.

Details...

User point in specimen coordinates:

X = -0.174   mm   Y = 0.082   mm

Details...   Cancel   Previous   Next   Finish

4. Repeat the step 3 for the sample user point (1,0).

xTm: Define User Units - Alignment Point Two

User Units Definition:
Move to user point (1,0) to define, then click on feature.

Details...

User point in specimen coordinates:

X = 0.010   mm   Y = 0.086   mm

Details...   Cancel   Previous   Next   Finish

5. Repeat the step 3 for the sample user point (0,1).

xTm: Define User Units - Alignment Point Three

User Units Definition:
Move to user point (0,1) to define, then click on feature.

Details...

User point in specimen coordinates:

X = -0.029   mm   Y = 0.010   mm

Details...   Cancel   Previous   Next   Finish

6. Check the **Details** if needed or **Finish** the procedure.
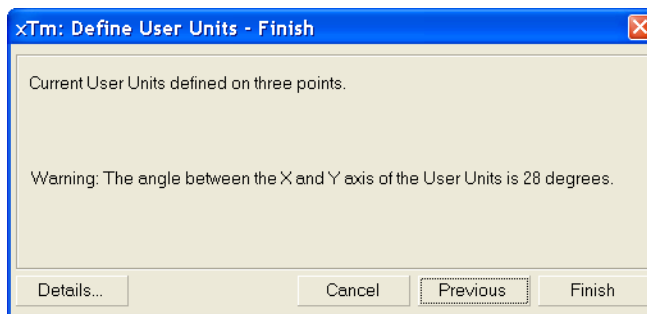
Particular dialogue buttons

- **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.
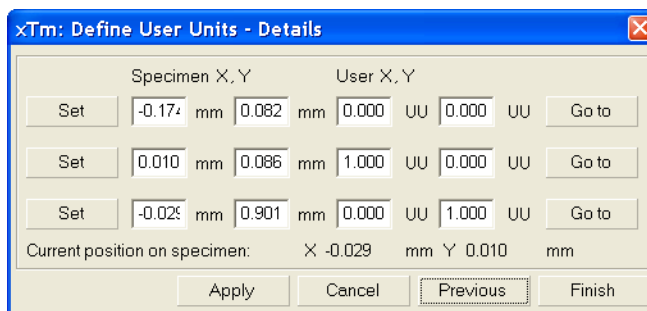
Using 1-, 2- or 3- Point Alignments

TABLE 5-3 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

Scan Rotation (Shift + F12)
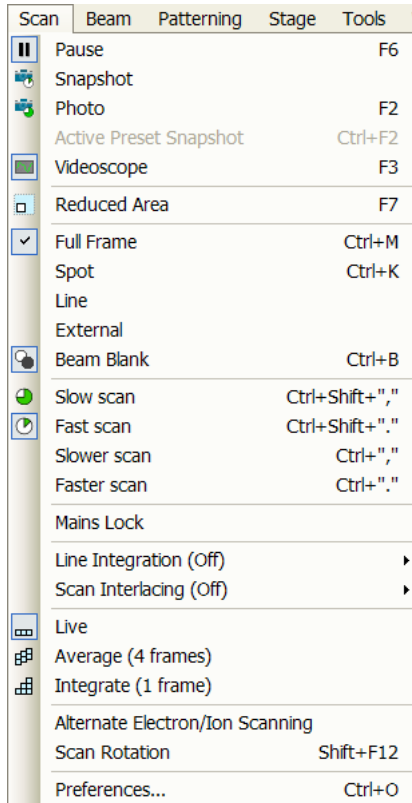
This function activates the onscreen tool to rotate the scan and align the image. Because it is solely a scan coil function, it has no effect on the stage movements. It is used to orient the image relative to mechanical rotation and detector direction.

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. Press and 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).

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.

FIGURE 5-17 SCAN ROTATION
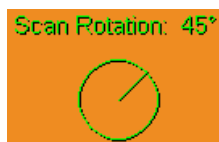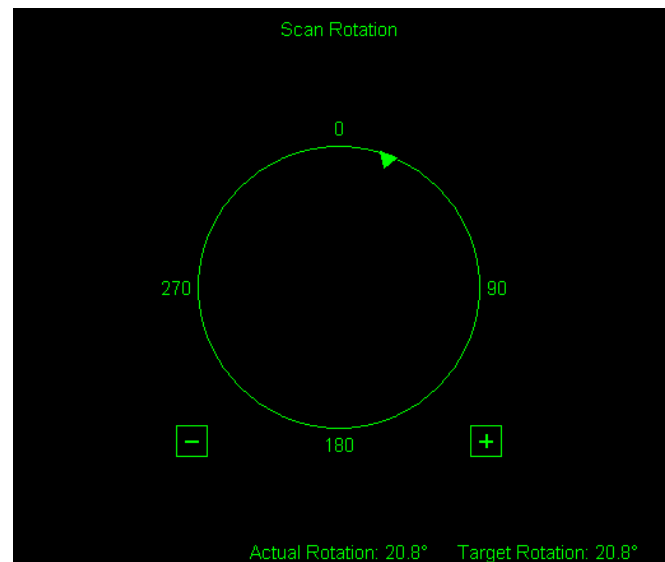
The smaller circle in the top right of an optical quad remains onscreen when the Scan Rotation angle is different from 0°.

Sample Navigation / Navigation Montage...
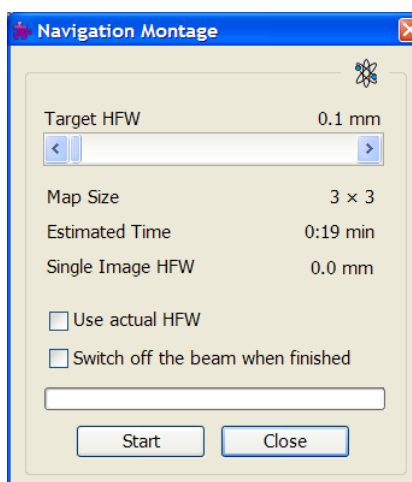
This software feature enables to navigate along the sample surface when the field of view is smaller than desired (limited by an aperture for instance). For this purpose it is possible to use up to 3 images which could be changed dynamically (capture, save or load any time).

Set the **Target HFW** (Horizontal Field Width) range, which influences informations fields: the tiles number – **Map Size**, the **Estimated Time** for the procedure and the HFW of each tile – **Single Image HFW**.

When the **Use actual HFW** check box is ticked, 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 **Stage** menu / **Sample Navigation** mode is then automatically set. For the selected quad the upper right corner green icon indicates the functionality.

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.

Notes:

The basic condition for a correct functionality is an equal stage rotation value for both captured and corresponding live images. In other case the upper right corner red icon indicates no functionality in the respective quad.

Navigation Alignment...

This procedure aligns Navigation image according to Reference image.

Warning

The distance between alignment points in Navigation image shall be more than 25 pixels (5% of the image), selected points have distance only 2 pixels. More distant points shall be chosen to achieve higher accuracy of the alignment.

Retry   Ignore

FIGURE 5-18 NAVIGATION ALIGNMENT

Nav-Cam (in-chamber)

Electron Beam
Ion Beam
CCD Camera
Nav-Cam

xTm: Nav-Cam Photo

Moving stage to Nav-Cam position

Cancel

Helios NanoLab 450 / Helios NanoLab 450S / Helios NanoLab 450ML

On the contrary to Navigation Montage feature, which navigates across the sample surface, this functionality represents a possibility to navigate across a larger stage movement area, which is convenient when investigating large area samples or several samples with the use of any multi sample holder.

CAPTURING NAVIGATION IMAGE PROCEDURE
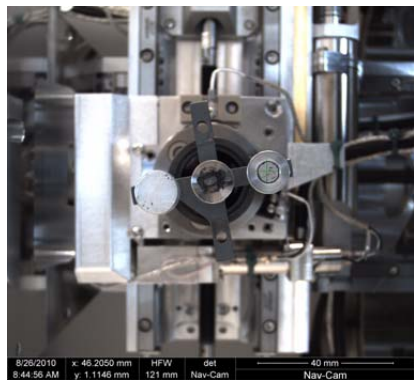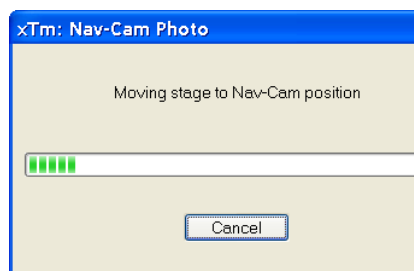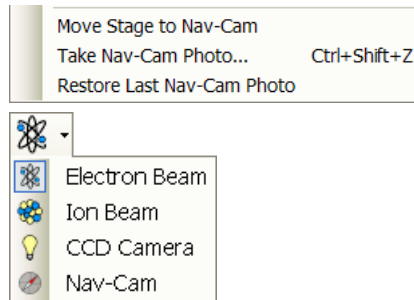
1. Insert a sample with a LoadLock (if present) or vent the chamber, open the chamber door, insert a sample and pump the system.
2. Select the **Stage** menu / **Move Stage to Nav-Cam** function to move the stage to Nav-Cam position.

   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).

   DANGER!
   Retract all retractable detectors to prevent equipment damage!
   Note:
   In case you do not want to control the entire procedure, select 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 a navigation image (with the high resolution of 3072 × 2207 pixels) by using the Snapshot / Photo function. The image could be saved or adjusted like any other image acquired from the microscope (image enhancement, process etc.).

   Note:
   Wait untill 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:
If the Nav-Cam observation takes longer time then 10 minutes, software protection switches illumination off for one minute to cool down. To proceed the operation release the quad.

Note:
Nav-Cam usage is not possible to operate (but a navigation is still possible) in the SEM Immersion mode (see above).
Nav-Cam usage is restricted for highly shiny and simultaneously planar specimens (Si wafers, mirrors etc.).

Besides a navigation image one can use also 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).

In case an user log off and the sample and its stage loading position did not change, use the **Stage** menu / **Restore Last Nav-Cam Photo**.

For a dark or shiny specimens a Nav-Cam image quality could be bad. In this case run the 401 - Nav-Cam AutoBrightness alignment (see Chapter 4).

Loadlock

Helios NanoLab 450 / Helios NanoLab 450S / Helios NanoLab 450ML

The Loadlock enables a specimen exchange through the pre-pumped Loadlock chamber, eliminating the need to vent and evacuate the entire specimen chamber.

Note:
It is recommended to run the Home Stage procedure each time the specimen chamber has been opened/closed. Start the procedure after the chamber is evacuated.
When the **Preferences… / General / Automatic Nav-Cam photo after sample loaded** option is set to yes (see Chapter 3) the Nav-Cam navigation image (see above) is automatically acquired after sample loading.

LOADLOCK PARTS

The Docking station

has to be mounted to enable the Loadlock use. Use two alignment pins to position it and three screws to attach it onto the stage rotation base.

Note:
Be careful not to drop any screw into the rotation table central hole!

Holders

Specimens stub / wafer holder is attached to the carrier, that fits into the Loadlock arm and to the Docking station.

- The Stub Holder enables to attach six 1/2" stubs and one 1" stub in its central hole using the inbus set screw; tighten it by a screwdriver placed in the suitcase with holders.
- The Wafer Holder can hold large area samples. It is especially designed to hold silicon wafers with a diameter up to 6", which can be attached to the holder using any suitable SEM vacuum-quality adhesive (liquid silver, carbon or double-sided tape). The specimen must be electrically grounded to the holder to minimize its charging.

FIGURE 5-19 DOCKING STATION /
CARRIER with STUB HOLDER INSTALLED

FEI
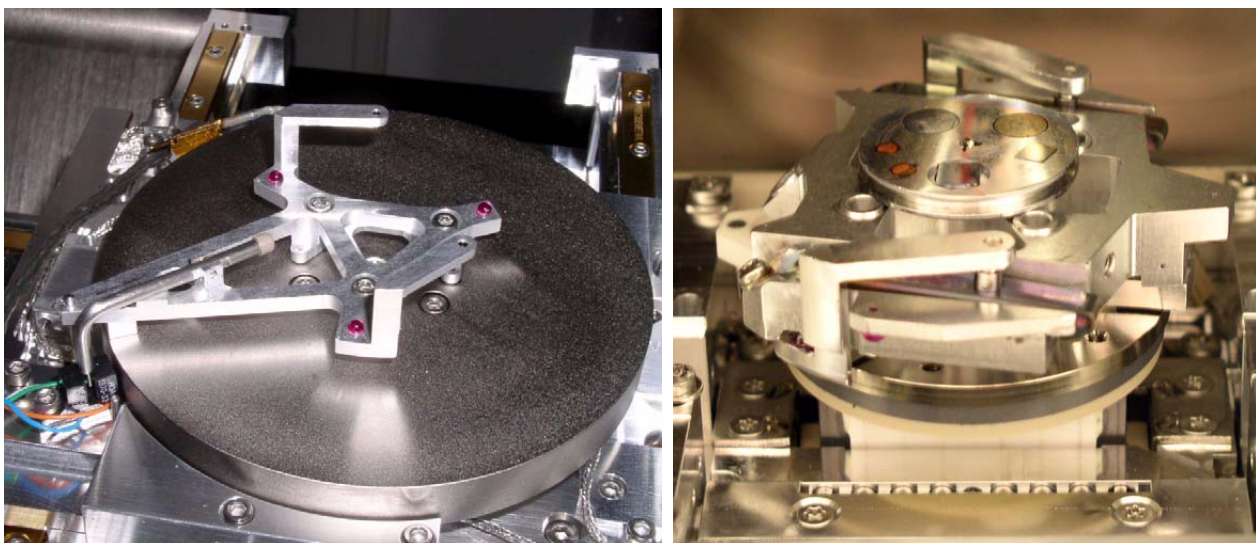
FIGURE 5-20 CARRIER / WAFER HOLDER / STUB HOLDER

Sample Height Gauge

Prior to a loading any sample through the Loadlock, the sample height should be checked. The height gauge indicates the maximum height of a sample and holder that can be loaded through the Loadlock port.

When using the carrier with the Stub holder, the specimen height is limited to 5 mm.

FIGURE 5-21 SETTING OF SAMPLE HEIGHT

> ## WARNING!
>
> *The maximum specimen height can be further limited by a detector mounted on the objective pole piece. This limitation depends on the actual Loadlock alignment. Start the alignment 251 - Loadlock Transfer Positions to find out the actual limits (see below).*

EXCHANGING SPECIMEN

Note:
Always wear clean lint-free gloves when handling the specimen holders or reaching into the Loadlock chamber to prevent vacuum contamination.

Note:
Loading / Unloading sequences are enabled only when the vacuum status is pumped (green icon).

Loading sequence

• Initial conditions: the lid is opened, the Loadlock arm is empty, both buttons are disabled (lit is off).

1. Place the carrier on the Loadlock arm. The **Clamp / Load** button becomes enabled (lit is on).

   Note:
   When placing the carrier, make sure that all 3 alignment sapphires are positioned properly.
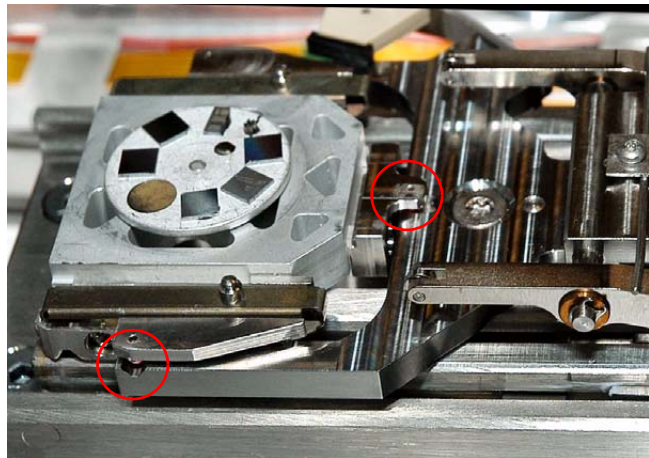
2. Close the lid and push the **Clamp / Load** button. The loading sequence starts (lit is blinking).

   When the **Clamp / Load** button is pushed and the lid is opened, the holder is clamped onto the Loadlock arm only. In order to continue, close the lid and push the **Clamp / Load** button again, when it becomes enabled.

• Final conditions: the carrier is in the Docking station, the Loadlock is under vacuum, the **Clamp / Load** button is disabled, the **Unload / Release** button is enabled.

Unloading sequence

• Initial conditions: see the Loading sequence / Final conditions.

1. Push the **Unload / Release** button to start the unloading sequence (lit is blinking). After finishing, the Loadlock is vented and the lid can be opened. Both buttons are enabled.

2. Open the lid, the **Clamp / Load** button becomes disabled. Push the **Unload / Release** button to release the carrier from the Loadlock arm.

3. Take the carrier out from the Loadlock arm.

LOADLOCK SOFTWARE CONTROL

Loadlock is possible to fully control from the xT Microscope Control software via the Loadlock module, which appears on the new page after the Loadlock installation.

Loadlock Module

Instead of pushing the hardware buttons on the Loadlock body, it is possible to click the UI toggle buttons with the same functionality.

- Clicking the **Clamp** button attaches the carrier onto the Loadlock arm. In case the vacuum status is pumped and the Loadlock lid is closed, this action is automatically followed with the load sequence.

  When the holder is clamped onto the Loadlock arm, the button label changes to **Load**. Clicking it starts the load sequence (see above).

- Clicking the **Unload** button starts the Unload sequence. The holder is transferred to the Loadlock chamber, which is vented lastly.

  The holder remains clamped to the Loadlock arm, and the button label changes to **Release**. Clicking it loosens the carrier from the Loadlock arm.

- The **State** info field displays the actual Loadlock state.

- The progress bar visually indicates loading states from an Unloaded (empty bar) to Loaded (green bar). Red progress bar indicates an undetermined or error state (see below).
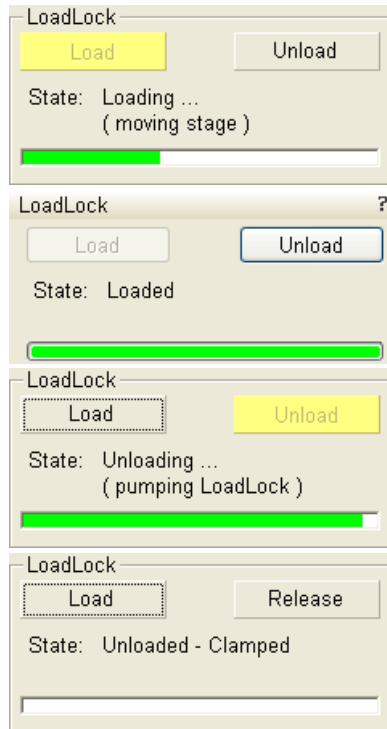
TROUBLESHOOTING

Hardware problems are indicated by a red progress bar, an **Loadlock** module / **State** field / **Indeterminate** state and by the automatic **LoadLock Recovery** dialogue poping-up. When closing this dialogue, the red progress bar is replaced by the **Show Recovery Dialog…** button. Clicking it opens the LoadLock Recovery dialogue again.

When the Load / Unload cycle fails due to a Touch Alarm, check the correct specimen holder placement, the specimen size (particularly its height) and run the Home Stage procedure before attempting another Load / Unload action.

Note:
When Loadlock is in any unknown state, the Load / Clamp and Unload / Release buttons are disabled.

There are 4 types of the LoadLock Recovery dialogues corresponding to the different error levels:

- The **1. level error** indicates the software is not sure about the Docking station state. It appears after venting / pumping the specimen chamber or after recovering from any higher level error.

  The **Loadlock Recovery** dialogue / **Determine** button moves the stage to determine a presence of the Docking station and of the holder.

- The **2. level error** indicates a hardware error during Loadlock inactivity.

  Check the hardware, try to recover with the use of Loadlock Recovery dialogue buttons. If it is not possible, call the service.

- The 3. level error indicates a hardware error during Loading / Unloading sequence.

  The Loadlock Recovery dialogue offers a step sequence leading to a successful recovery. Repeat clicking the **Execute Step** button until the dialogue closes.
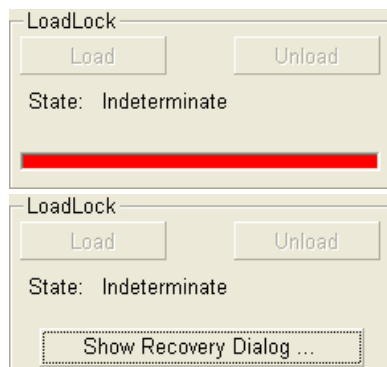
- The **4. level error** indicates a hardware error which is not possible to identify. This appears mostly during the recovering actions.

  Only Supervisor or service engineer can recover from this error level. Using the enabled buttons in the recovery dialogue with care and according to a particular situation may lead to full recovery. Otherwise it is necessary to call the service.

FIGURE 5-22 LOADLOCKS RECOVERY DIALOGUES
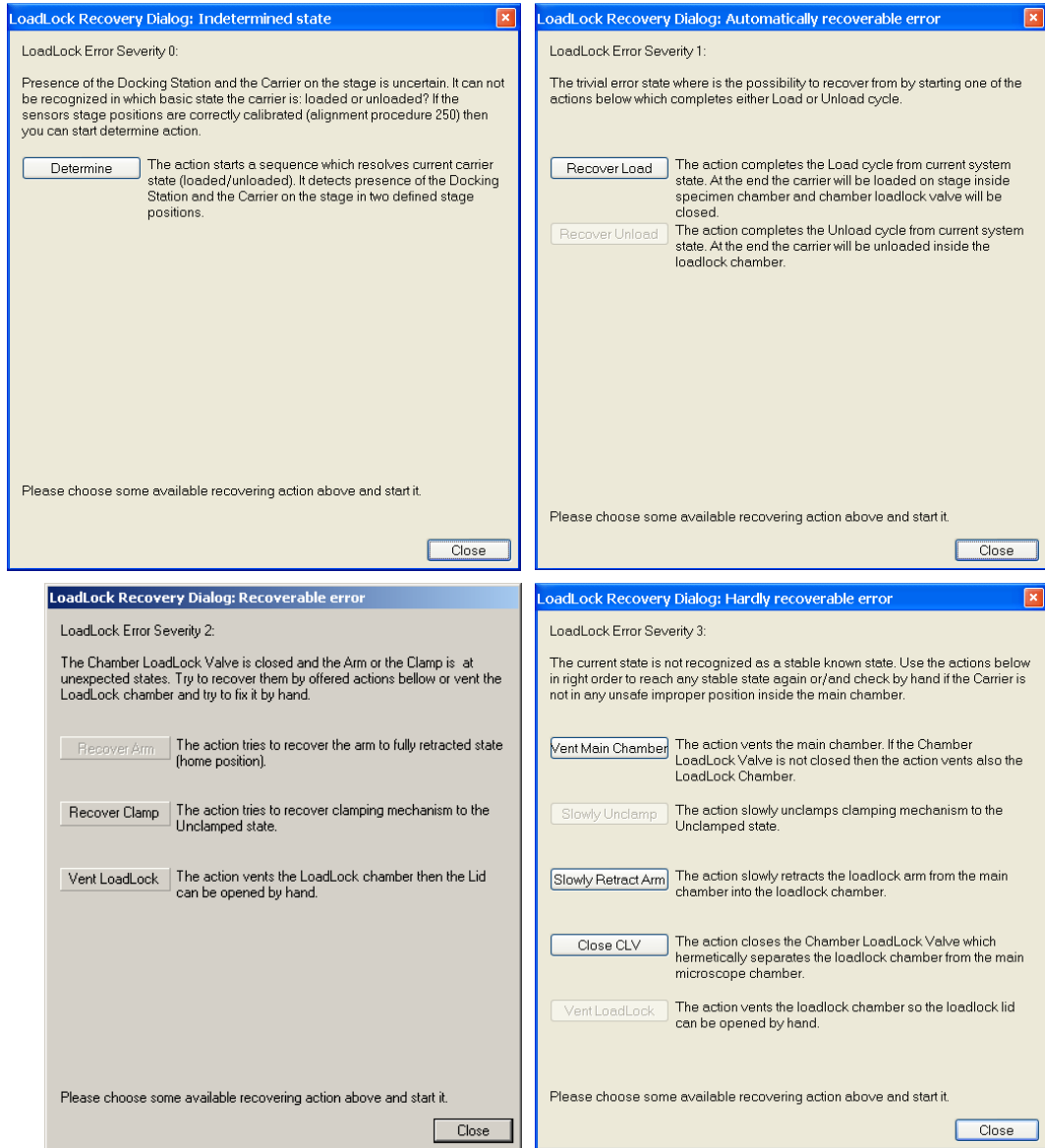
Multiloader

Helios NanoLab 450 ML

The Multiloader is a specimen exchange unit for the upgraded Flip stage. This Flip stage contains only one site for attaching TEM samples.

TEM samples are placed on a cartridge, which is then loaded on the Flip stage via the Transfer Gripper (displayed below with its protective cover.

FIGURE 5-23 TRANSFER GRIPPER / LIFT-OUT CARTRIDGE

After putting the sample on the cartridge (located on the Flip stage), the sample can be unloaded from the system with help of the transfer gripper.

Note:
There is also equipment available to support the handling of cartridges, TEM grids, and the transfer gripper itself. A description of this whole process, including the different cartridges possible and a process to get the TEM sample onto a TEM microscope, is available as a separate (offline) user manual.

LOADING / UNLOADING GENERAL REMARKS

- During the whole process, user suggestions are displayed on the application window.
- Canceling a started load is done by reverting the load actions.
- Canceling a started unload is done by reverting the unload actions.
- If the white LED on the multiloader base is lit, the multiloader base is in an error state and service is needed to repair the multiloader base.
- A multiloader (un)load is only possible in a pumped state.

Loading Cartridge

1. Place the transfer gripper (loaded with a cartridge) in the multiloader base.
2. Press the LOAD button and wait until the button stops blinking.

   The stage of the microscope moves to the position at which the transfer of the cartridge from the transfer gripper to the Flip stage can take place. This takes awhile, so wait for a message in the application window to indicate the movement is complete.
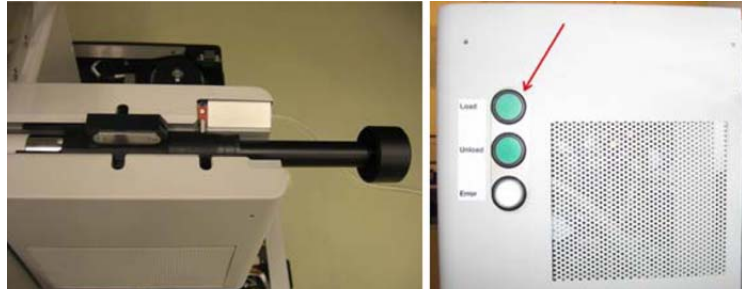
3. Rotate the transfer gripper counterclockwise and let it slide into the microscope.
4. Rotate the transfer gripper clockwise and let it slide out of the microscope.
5. Rotate the transfer gripper clockwise.

The transfer gripper is now locked in the multiloader base, until a successful load is done.

The cartridge is loaded and the system is ready for normal use.

Unloading Cartridge

1. Press the UNLOAD button and wait until the button stops blinking. In this time period, the stage of the microscope moves to the position at which the transfer of the cartridge from the Flip stage to the transfer gripper can take place.
2. Rotate the transfer gripper counterclockwise and let it slide into the microscope.
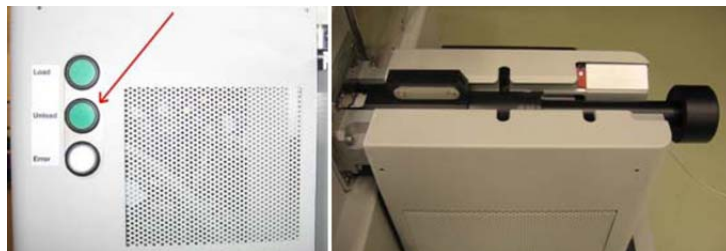
3. Rotate the transfer gripper counterclockwise and let it slide out of the microscope.
4. Rotate the transfer gripper clockwise.
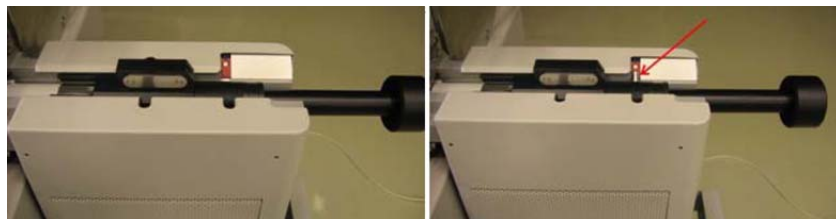
5. Pull the transfer gripper backwards to remove it from the microscope.

The cartridge is unloaded and the system is ready for normal use.

Measurement and Annotation Functions
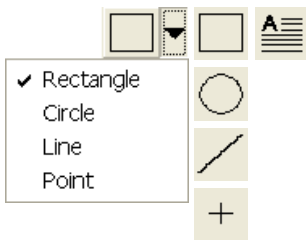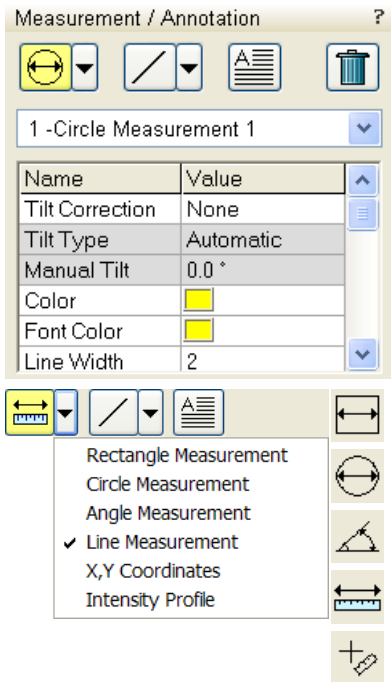
The **Processing** page / **Measurement / Annotation** functions give an user many capabilities to measure distances, angles, diameters and areas as well as locating and labelling items that are of significant interest on the sample area.

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 **Annotations** enable to graphically label items of interest.
- The **Text** enables to add further information.
- The **Trash can** button deletes selected item(s).
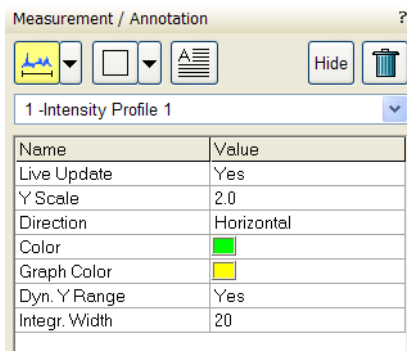
The **Measurement** / **Intensity Profile** delineates the imaging profile across a freely selected line with a set of properties.

Property Editor

enables to change a lot of properties of a selected Measurement / Annotation / Text graphic by selecting from the drop down list or by a direct editing of a text or a value. Each graphical element has its own set of appropriate properties.
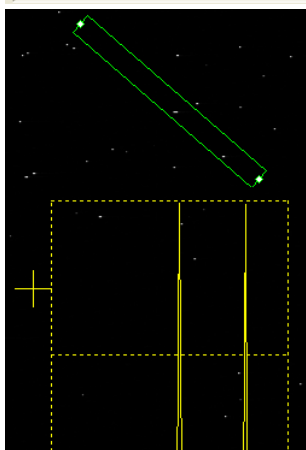
Shape Creating

1. Choose the suitable **Measurement / Annotation** graphic tool.
2. Draw the graphic over the area of interest. This can be done by:

   – pressing and dragging the cursor from the top left corner to the right lower corner of the shape.

   – SHIFT + pressing and 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).
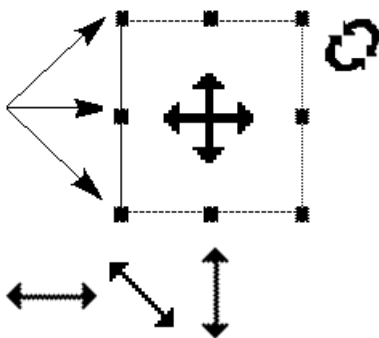
Size and position the graphic correctly over the area of interest.
A number of other choices are available in the **Property editor** for each graphics drawn.

- **Move / Rotate graphic:** press the cursor inside the boundary of the pattern / in the vicinity of a corner and 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:** press and 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 an selected quad)**:** press **Ctrl + A**.
- **Delete selected Item(s):** click the **Trash can** icon or press the **Delete** key.

Patterning
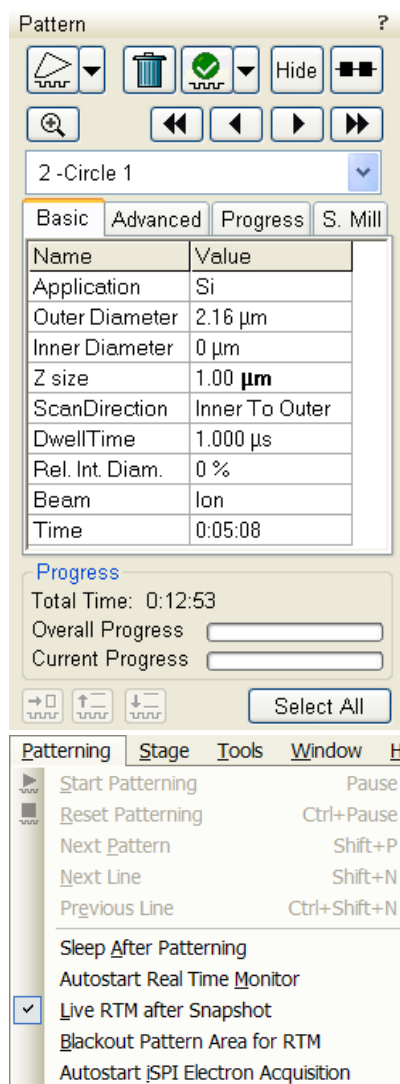
Patterning is the process of moving a beam over the defined pattern along the specimen surface (while leaving other areas untouched) with the purpose of:

- the **milling** – removing well-defined amounts of existing material (the pattern is displayed in yellow color),
- the **deposition** of well-defined amounts of new material (the pattern is displayed in color appropriate to the GAS selected - see below).

The electron beam is generally used for deposition while the ion beam for both processes.

The **Pattern** module (see below) and the **Patterning** menu (see Chapter 3) controls the entire proces.

Caution:

When patterning or milling a large volume of material at higher ion currents, it is recommended to remove any detector (both lens mounted and retractable one) if it is not used. There is a risk of its efficiency decrease by a material deposition.

The system provides additional monitoring possibilities:

- the **Simultaneous Patterning and Imaging (SPI)**

The SPI provides an electron imaging (in different quad from patterning) during patterning. It is strongly influenced by secondary electrons generated by the ion beam (SE imaging). The higher electron currents (higher spot numbers) and averaging help to improve the imaging. In case the BSE detector is used this interference is less important (BSE imaging). The system remembers the brightness and contrast setting for each modes (SPI or normal imaging).

- the **Integrated Real Time Monitor (RTM)**

The RTM provides an immediate imaging (in the same quad with patterning) of the patterning process. The patterned area is observed and in case of relatively slow scanning, the scan trajectory can be inspected.

RTM is typically used as an end pointing device by observing brightness differences in the detector signal. These result from contrast differences (when milling through layers of different composition on a stack of multiple materials or releasing a TEM foil from the Omniprobe tip).

RTM can be used with electron or ion beam and with any of the pattern types that are available in the UI. When starting patterning with the RTM activated, the pattern in the UI will be updated with real time image information. The patterned area information is updated based on the detector signal which is displayed in synchronization with the beam trajectory.

Because the detector signal is synchronized with the scan of the patterning beam (usually FIB), the other beam cannot be used to make a live imaging while patterning. As an alternative, it is of course possible to grab snapshot with the electron beam during FIB patterning while using RTM.

Note:

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 artifacts (due to milling points and screen pixels mismatch) could occur. To prevent this try to change the field of view.

PATTERN MODULE

There are several tool icons, **Basic** / **Advanced** / **Progress** / **S. Mill** tabs and the **Progress** monitoring area within the module.
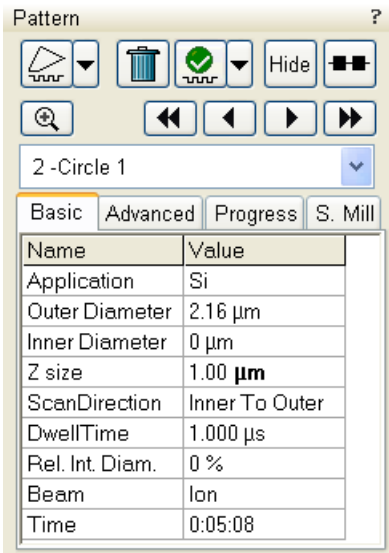
Tool Icons

Clicking the icon activates (highlighted with an yellow background) / deactivates (normal backgroud) the tool. If no icon is selected, the pattern selection cursor (arrow) is active.
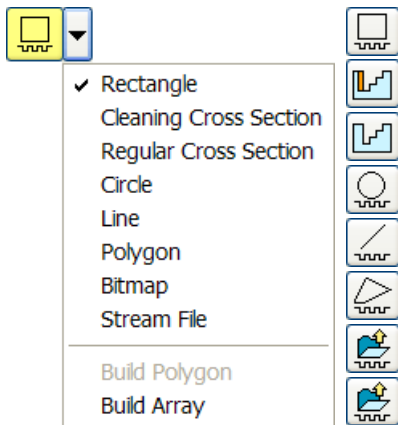
- The **Pattern type selector:** Clicking the arrow next to the icon activates the drop down list to select a pattern type (see below): **Rectangle / Cleaning Cross Section / Regular Cross Section / Circle / Line / Polygon / Bitmap / Stream File**.
- The **Trash Can (Delete)** button deletes the selected pattern(s).
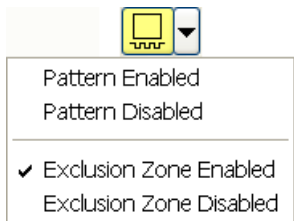
- The **Pattern / Exclusion Zone** (overlapping area of the two patterns) **Enable / Disabled** button sets selected pattern / exclusion zone to be / not to be processed.
- The **Hide / Show** button hides all patterns in the selected quad.
- The **Patterning Serial / Parallel sequence** button switches between two possibilities (see below).
- The **Zoom** button enlarges selected pattern / patterns to fill entire quad.
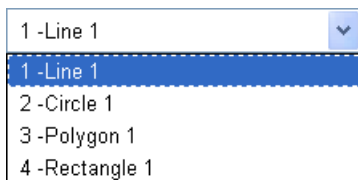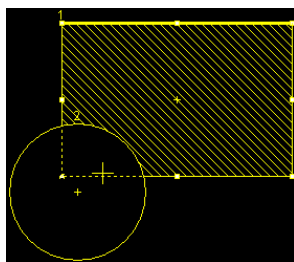
- The **Patterning sequence** buttons set the process order.

  Patterns are milled in the order they are created. Numbers are displayed close to the pattern and in front of its name to indicate the actual milling order. This can be changed by clicking 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.
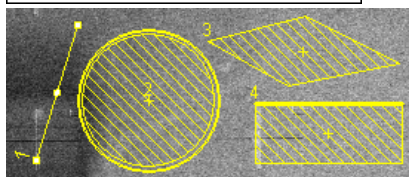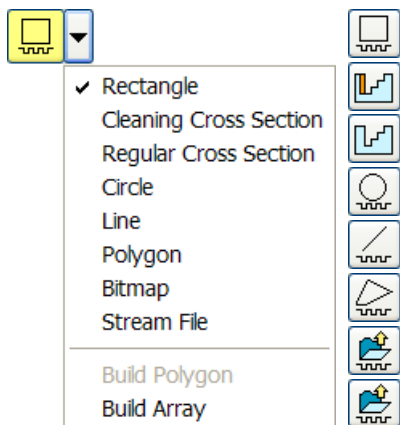
Pattern Types

Patterns are automatically assigned to one or more particular processes. They are distinguishable by a different cross-hatch.

The **Rectangle** pattern is dedicated to both milling and deposition.

The **Cleaning Cross Section** pattern is processed line by line (each line with set number of passes).

The **Regular Cross Section** pattern has two possibilities selectable in the property editor (see below):

- **Scan Method: Multipass** – processes entire pattern and starts again (with set number of passes).
- **Scan Method: Stairstep** – the pattern is created as a compilation of five rectangles with specified overlap between them. Each one is processed with the set number of passes.

The **Bitmap** pattern enables 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 the value is 0 no milling or deposition proceeds, if it is 255 the maximum dwell time is used. The dwell time for values in between is linearly interpolated and then assigned to a value from the table (124 entries from 100 ns to 4,6 ms) with respect to the actual value set within the UI.

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 (see below), depth, leading edge etc.

The **Stream File** pattern is created as an ASCII text or binary file that addresses directly the patterning DAC (Digital Analog Converter) and produces custom pattern files. The 16-bit DAC is used so the patterning field is divided into 65 536 steps in both X- and Y- axis, but imaging is restricted to only 12-bit which represents 4096 steps.

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 μs (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 cannot be created directly from xT UI, use any suitable text processor. There are several stream file types, which are recognizable by the first header line (s16 / s16,25ns / s16,DAC / s16,25ns,DAC).

When two patterns are overlapping, it is possible to join them into one pattern by use of the **Build Polygon** functionality.

Selected patterns could be multiplied by the use of **Build Array** functionality. The **Dimension** / **Pitch** means number of repetition / distance.
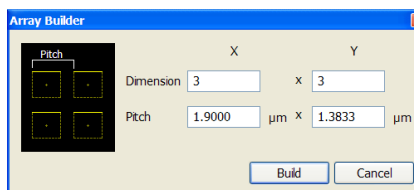
Serial Patterning

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 redeposition 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 an user changes to the Parallel mode, the following pattern properties in the group must necessarily be the same: Number of Passes, Beam, and Gas properties. The first selected pattern determines these values for all other ones.

Other properties (Application File, Overlap, Sputter Rate, Recovery Time and Depth) are also all set to those of the first selected pattern 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.

Patterns Processing

Select the pattern from the **Pattern type selector** drop down list. Once selected, the cursor is ready to draw a suitable pattern onscreen (quad or single screen).

- **Importing / Exporting Patterns**

Defined patterns may be imported via the File / Import / Patterns… menu item or exported (saved) via menu File / Export / Patterns… menu item (see Chapter 3).

The saved file (.ptf) contains all parameters found at the Patterning property editor (Basic / Advanced - see below) for all patterns drawn in the selected quad. It could be assigned to one of six (A - F) toolbar Pattern Preset buttons (available only if activated via the **Preferences… / General** tab) by right-clicking above the selected button (becomes yellow):

The **Apply** starts the patterning with the preset parameters (the same as clicking the button directly).

The **Edit…** opens the **Pattern File** (.ptf) selection process.

The set of toolbar Pattern Preset buttons could be saved / loaded by the File / Export / Import / System Parameters… menu (see Chapter 3).

- **Pattern Editing**

Once a pattern shape has been drawn, it can be modified.

Selected Pattern is denoted by the addition of resizing handles to the pattern outline (pointer cursor).

Move / Rotate Pattern: press the cursor inside the boundary of the pattern / in the vicinity of a corner and drag it (move / rotate cursor). Holding the Ctrl + Alt keys while hitting any arrow key moves a pattern in a respective direction for a fixed distance (one screen pixel).

Resize Patterns: press and 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.
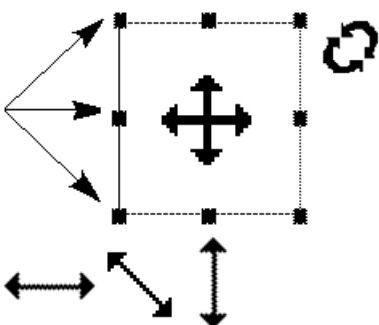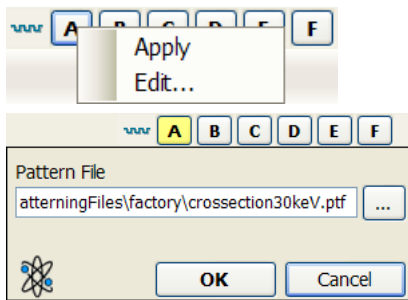
Select all Patterns (in an selected quad)**:** press **Ctrl + A** keys or click the **Select All** button.

Delete selected Pattern(s): click the **Trashcan** icon or press the **Delete** key.

Basic and Advanced tabs

A certain pattern could be selected by the list box with many associated parameters which could be set via the patterning property editor:

Name	Value
Application	Si
X size	79.59 μm
Y size	67.38 μm
Z size	1.00 μm
ScanDirection	Bottom To Top
DwellTime	1.00 μs
Beam	Ion
Time	382:00:45

Name	Value
Position X	18.67 μm
Position Y	25.67 μm
Rotation	0.0 °
GasType	none
OverlapX	50.0 %
OverlapY	50.0 %
PitchX	375.50 nm
PitchY	375.50 nm
Area Calculation	Pattern
Dose	1.61 nC/μm2
Vol per Dose	6.100e-1 μm3/nC
Sat Sput Rate	0.000
Refresh Time	0 s
Loop Time	26.1 ms
Area	3.57e3 μm2
ScanType	Serpentine
Fill Style	Solid
Passes	1653591
Defocus	0 μm
Blur	0 μm
Interaction D	0 μm
Total Diameter	751.0 nm
Max dose p A	0 nC/nm2
Sat cur dens	20.000 nA/nm2
Tot V sput r	8.357e-2 μm3/s
Selective Milling Enabl	No
Selective Milling Time I	2.0
Min Contrast Threshold	0.00
Max Contrast Threshold	1.00

- The **Application**: Clicking the value slot produces a drop down arrow bringing a list of applications. Choosing the required one sets the subsequent properties.
- The **X / Y / Z size**: dimensions of the pattern
- The **Scan Direction** (Bottom To Top / Top To Bottom)
- The **Dwell Time**: a time the beam spends on a single pixel per pass.
- The **Beam** to be used.
- The **Time** required to process this pattern
- 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 process the pattern (or None if no gas is to be used). This determines the pattern color onscreen.
- The **OverlapX / Y** sets the beam diameter overlap. The value of the overlap can be positive or negative depending on a particular application. The overlap parameter influences the Area Calculation and the Dose.
- The **PitchX / Y** sets the pitch between two spots.
- The **Area Calcualtion** 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 Calcualtion setting.
- The **Vol per Dose**: The volume of material that is removed per charge.
- 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 (read only).
- The **ScanType**: the **Serpentine** means the beam proceeds from left to right and back from right to left, while the **Raster** scans from left to right, then the beam is blanked and returns to the left starting point.
- The **Fill Style**: one can choose either to mill a **solid** or just a **frame** (box and circular types only).
- The number of **Passes** that the beam scans over the pattern
- The **Defocus** of the beam (WD change) - influences the Total Diameter and Area Calculation. It allows focusing above / below (negative / positive value) the sample surface.
- 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 OverlapX/Y and PitchX/Y values (read only).
- 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 **Selective Milling Enabled** / the **Selective Milling Time Interval** / the **Min Contrast Treshold** / the **Max Contrast Treshold** items corresponds to the Selective Mill Tab elements (see below): Enabled check box / Interval adjuster / left and right borders of the grey leve to be processed for the selected pattern.

Progress Tab

Here one can observe patterning progress and check some milling properties.
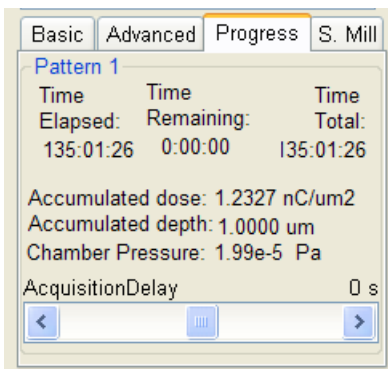
- **Time Elapsed**: elapsed patterning time
- **Time Remaining**: estimated remaining patterning time
- **Time Total**: estimated total patterning time
- **Accumulated dose**: total dose from the start of patterning
- **Accumulated depth**: entire milled depth of all processed patterns.
- **Chamber Pressure** displays actual chamber pressure.
- The **Acquisition Delay** continuous adjuster corrects defect imaging during patterning. Use 0 s when not sure.

Selective Mill Tab

It is possible to set a given grey level to be processed in the extent of the selected pattern area.
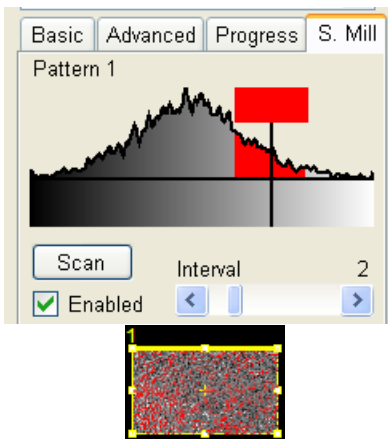
- The **Scan** button reads the pattern area grey level histogram.

  Move the vertical black line to a desired grey level position and also move the red rectangle edges to set the grey level extent.
- When the **Enable** check box is ticked the selective milling is enabled.
- The **Interval** continuous adjuster sets the time [s] after which the histogram is actualised.

PROGRESS AREA
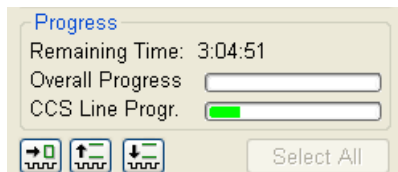
Information updated as the milling progresses are found here (captions change according to a running process):

- 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.

END POINT MONITOR (EPM) MODULE

The EPM gives visual feedback on the progress of a milling process. It displays the charge absorbed in the specimen (specimen current) and enables to monitor the specimen current changes as the ion beam interacts with different materials in the sample. For example the differences encountered when milling through some dielectric and striking another one are usually very subtle, but once the beam begins milling into metal, a dramatic difference in absorbed charge could be observed on the EPM graph.

iSPI Tab
(intermittent Switching between Patterning and Imaging)
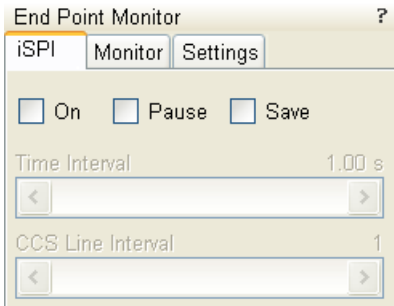
- Ticking the **On** check box starts the iSPI mode, in which the ion beam is paused during electron imaging to minimize the interferences.

  The graph of milling progress starts automatically to draw when patterning starts. When patterning is paused or stopped / resumed it stops / continues drawing the graph.

- The **Pause** check box pauses the electron quad after image acquiring.

- Ticking the **Save** check box saves all electron images grabbed during the process.

- The **Time Interval** slider sets the interval after which the system acquires an electron image and pauses the electron imaging.

- The **CCS Line Interval** slider sets the number of lines after which the system acquires an electron image and pauses the electron imaging.

  For a Cleaning Cross Section, select a CCS Line Interval to take an electron beam image every "×" number of slices. For all other patterns, select a Time Interval to take an electron beam image every "×" number of seconds.

Monitor Tab
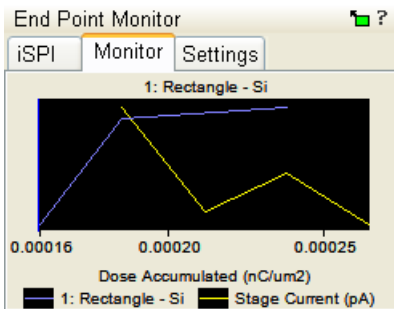
illustrates the milling progress as a colored graphical display, showing the accuracy for depth or material changes over the whole milled area.

Graphs can be saved by the **File** menu / **Export** / **End-Point Monitor Graphs** or loaded by the / **File** menu / **Import** / **End-Point Monitor Graphs**. All existing graphs are saved, loading adds saved graphs at the end of the list of graphs; it does not clear or overwrite existing ones. In case of name conflicts the loaded graph is renamed.

Clicking the **green rectangle** in the upper module corner provokes / hides a large graph window. It depicts:

- yellow line (right Y-scale) – Stage (specimen) current (see below)
- other colored lines (left Y-scale) – Grey Scale (RTM data) from patterned area (see below)

  When serial patterning mode is set, there is only one graph, when parallel one is set, there could be more of them.

- The **X-axis** menu (Dose Accumulated / Depth Penetrated / Time Elapsed) offers the choice for X-axis description.

- In the **Browse** menu (First / Previous / Current / Next / Last) one can list in all graphs stored (see **Browse** section icons).

- In the **Navigate** menu it is possible to handle the selected graph (see **Navigate** section icons):
  - **Zoom** (scale) **In** / **Out**
  - **Pan** (move graph to the desired position)
  - **Reset** to default values
  - **Measure line points positions** (see values on the left side).
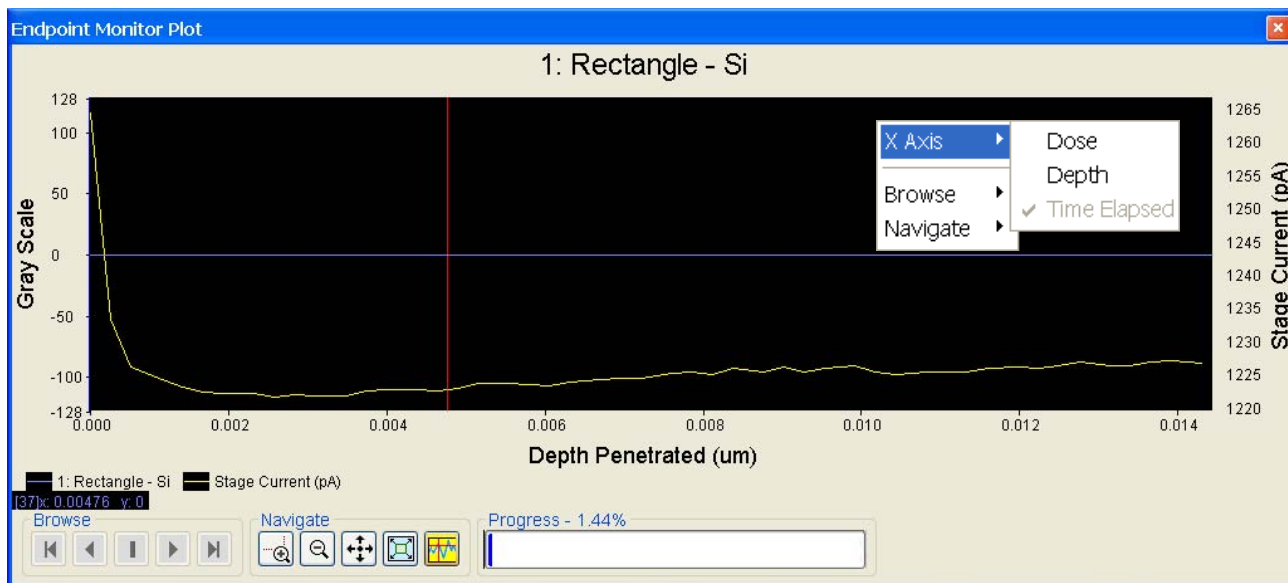
Notes:

Each time patterning is started the EPM automatically adds a new graph (if the EPM is switched on). Resuming patterning continues the graph that was created when patterning was started.

Initially the graph is Auto-Scale, meaning that the minimum and maximum of both axes are computed automatically so that all the graphs are completely visible. As points are added during patterning the graph may rescale to achieve this.

Dragging a rectangle in the graph when in Zoom In mode zooms in that rectangle and the graph switches to fixed-zoom. Switching back to Auto-zoom is possible via the **Navigate** menu / **Reset** item.

When the graph is zoomed-in a user can click & dragg the graph in the Pan mode.

Graphs can be selected by clicking any one; the selected graph is indicated by several black selection rectangles. Clicking outside any graph deselects all graphs. New graphs are selected by default so that the Options tab displays their properties. It is not possible to select multiple graphs.

The Settings Tab

- **Plot Mode / Auto-Scale** sets graph magnification according to **X Scale %** value.
- **Plot Mode / Auto-pan** moves present milling position in the graph window according to **Auto Pan %** value.
- The **SE** (Secondary electrons) check box: switches visibility of RTM curve on / off in Monitor graph.
- The **Stage Current** check box: switches visibility of stage (speciment) current curve on / off in Monitor graph.
- The **Reset** button resets values to default.
- The **Apply** button propagates new values.
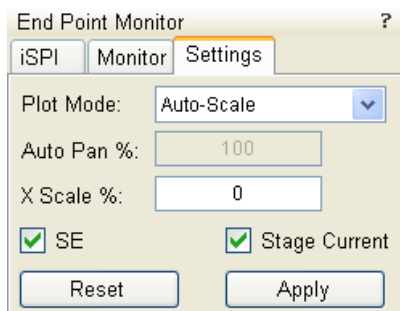
GAS INJECTION MODULE (OPTION)

Patterns 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 deliverred 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 type must be defined before an application 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.

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

Before the patterning with the GIS starts, the GIS needle must be inserted manually and the gas reservoir must be heated. The GIS valves opening / closing is automatic during patterning.

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.

Caution!
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.

Caution!
Logging off an actual user does not change conditions of GIS's.
It could be Warm, In and Opened even if the xT microscope control software is closed!

Caution!
When the vacuum status is vented, GIS needles are retracted automatically. In spite of that retract it/them manually before you start any activity inside the chamber (specimen exchange, detector mounting etc.).
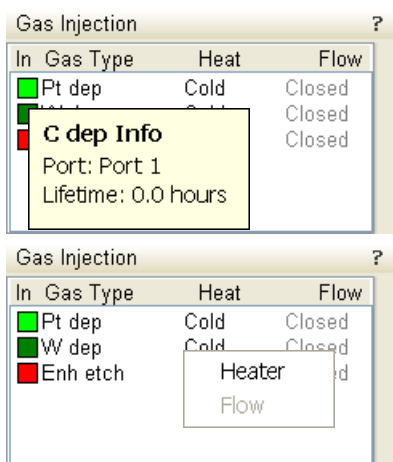
APPLICATION FILES

There are several application files delivered with the system which are intended for different use. Each one incorporates multiple parameters for particular patterning. Some of these application files use GIS's. With multiple GIS's installed on your system you can select a suitable application file for a given pattern. Processing specific materials without gas can be done by using no application file, or more efficiently with the appropriate scanning conditions using the dedicated Application file for that material. There are pre-defined (non-editable) and user-defined (saved) files.

Note:
A pattern must be defined before the Application file is selected, the pattern type automatically predetermines the set of possible application files (therefore a gas type).

Note:
Within the application files compilation there are former Si application file with Volume per Dose value determined in the past and the Si-New application file with values corrected for use with the silicon. Be aware about different results using these application files!

Application Files Editing

New application file can be created or an actual Application file can be edited in the Windows Notepad® in case any parameter of the process is insufficient. xT Application files (*.xml extension) are located in the *C:\Program Files\Fei\data\patterning application files* directory.

Note:
If any Application file is to be changed it is recommended to make a copy of the original one. Server restart is necessary after placing a new Application file to the above mentioned directory to be functional.

Examples

For clear arrangement there are comment lines within an xml files:

• the **comment line** filter

    <!-- Application file for milling silicon (Si) without any gas -->

In order to make the application files selection more comprehensible several filters has been implemented:

• the **beam type** filter

    The system only displays application files which are related to a beam type set (if an ion beam pattern type is selected, application files which have it designated are displayed).

    <Beam xmlns:dt="urn:schemas-microsoft-com:datatypes" dt:dt="string">Ion</Beam>

    This setting filters out all application files related to the electron beam. If the command is left blank the file is displayed for both beams.

    Note:
    The **I** in ion or **E** in electron must be capitalized.

• the **pattern type** filter

    The system only displays application files which are related to a given pattern type.

    <!-- Optional type, must be "Line, Circle, Rectangle, RCS, Bitmap, StreamFile, Polygon", can be a combination -->

    <PatternType xmlns:dt="urn:schemas-microsoft-com:datatypes"dt:dt="string"> CCS</PatternType>

    Multiple patterns can be designated in a list separated by comas. If the command is left blank the file is displayed for all pattern types.

- the **GIS type** filter

  The system only displays application files depending on GIS's installed on the system.

It is possible to edit / add / remove parameters (for instance Refresh Time - for filling vias, Blur - for depositing large areas etc.) if required for certain applications.

- the **Volume per Dose** variable can be edit at:

  <VolumePerDose xmlns:dt="urn:schemas-microsoft-com:datatypes" dt:dt="r8">

  $0.15e^{-9}$

  </VolumePerDose>

The Volume per Dose is material dependent. Using any application file for milling different material substrates results in a differnet **Z size**. The actual value can be measured and subsequently a new Volume per Dose value can be defined / set.

When using the ion beam (without any gas environment at 30 kV) the Volume per Dose values (Sputter Rates) for various materials can be found in the following table.

TABLE 5-4 MATERIAL SPUTTER RATES AT 30 kV

Material	Volume per Dose $[\mu m^3 / nC]$	Material	Volume per Dose $[\mu m^3 / nC]$
C	0.18	**Au**	1.50
Si	0.27	**MgO**	0.15
Al	0.30	**SiO$_2$**	0.24
Ti	0.37	**Al$_2$O$_3$**	0.08
Cr	0.10	**TiO**	0.15
Fe	0.29	**Si$_3$N$_4$**	0.20
Ni	0.14	**TiN**	0.15
Cu	0.25	**Fe$_2$O$_3$**	0.25
Mo	0.12	**GaAs**	0.61
Ta	0.32	**Pt**	0.23
W	0.12	**PMMA**	0.40

Note:
PMMA - PolyMethylMetaAcrylat

Application Files Examples

The **non-gas** assisted milling: the **Si new** application file:

- Beam Type: Ion
- Dwell Time: $1.0\ e^{-6}$ s
  (The time the beam spends on a single pixel per pass.)
- Overlap: 50% (Sets the beam diameter overlap.)
- Volume per Dose: $0.27\ e^{-9}\ m^3/s$
  (Describes the amount of material volume removed per charge. This is called sputter rate in previous dual beam tools.)

The **gas-assisted** application file: the **Tungsten** application file:

- Beam Type: Ion
- Dwell Time: $250\ e^{-9}$ s
  (The time the beam spends on a single pixel per pass.)
- Overlap: - 50% (Sets the beam diameter overlap.)
- Volume per Dose: $0.025\ e^{-6} m^3/nC$
  (Describes the amount of material volume removed per charge. This is called sputter rate in previous dual beam tools.)
- Refresh Time: 0 (Adds the waiting time between each pattern pass.)
- Blur: 0 (Defocus the beam to increase deposition for large areas.)

If the overlap is positive the mill time can be calculated based on the volume per dose parameter and the beam current:

$$Volume\ per\ dose = \frac{volume}{charge} = \frac{cubic microns}{nanocoulomb} = \frac{cubic microns}{beam\ current \times time}$$

$$mill\ time = \frac{cubic microns}{beam\ current \times Volume\ per\ dose}$$

For example, create a filled box pattern (5 × 5 × 2) μm (X × Y × Z, the desired material volume to be milled: 50 μm^3) and choose 0.5 nA, which is 0.5 nC/s. Therefore:

$$mill\ time = \frac{50\ cubic microns}{0.5\ nanocloumbs\ per\ second \times 0.15} = 666.6\ sec. = 11\ min.\ 6\ sec.$$

Doubling the Z size , the desired volume would be twice larger and the milling time twice longer, doubling the beam current cuts milling time in half.

Plasma Cleaner
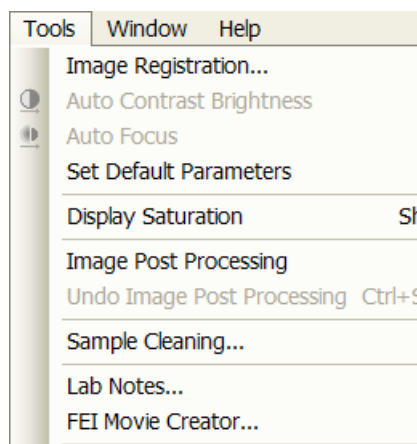
The **Tools** menu / **Sample Cleaning…** item starts the Sample Cleaning procedure, which is an efficient process for removing very thin contamination layers, which are typically formed by hydrocarbons residues remaining on vacuum parts after conventional cleaning or could be transferred into the microscope 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 5-24 PLASMA CLEANER
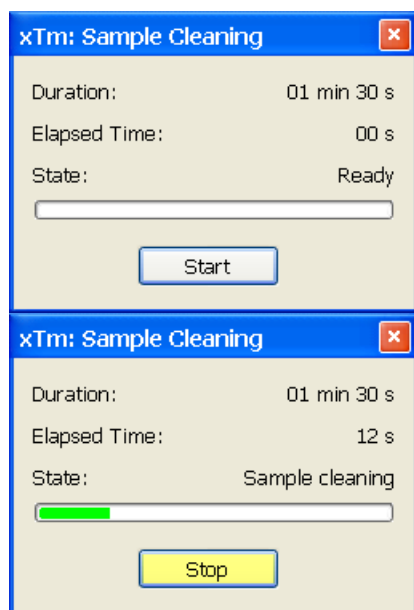
The Sample Cleaning procedure uses cleaning times up to 5 min, which is possible to set in the **104 - Plasma Cleaning** Alignment (see below).

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.
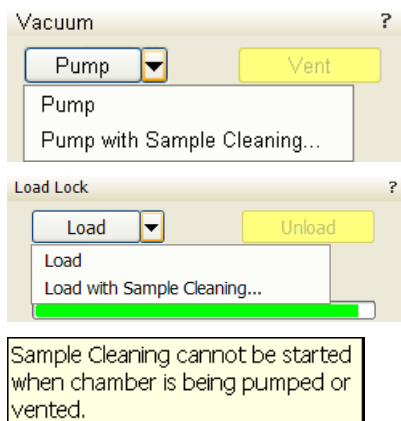
SAMPLE CLEANING PROCEDURE

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** or **Load Lock** module also. When the procedure is finished or aborted by an user, the system remains evacuated.

During the procedure run, stage moves are disabled temporarily.

3. Move stage back to the observation position.

When starting the procedure and some conditions are not allowed, the dialog or tooltip appears onscreen.

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!

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 (Au-C resolution tests samples could be left inside the chamber during the Sample Cleaning procedure).

FEI Limited Rights Data

6 | MAINTENANCE

This section describes necessary microscope maintenance procedures that can be carried out by the **FEI Supervisor User** / **FEI Microscope User**. The user maintenance is at a minimum due to gun and column design providing the long uptime. Therefore a complicated maintenance is normally a part of 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
• Stage Maintenance

Caution!

- 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** (option) **is very fragile** and **must be protected from large pressure oscillations**. It is also recommended to remove the detector before major cleaning activities.
- Be aware of removing the chamber door locking screw(s), used during an instrument transportation (labeled REMOVE)! If these are installed, an overpressure over 20 kPa (150 Torr, 0.2 bar) can arise inside the chamber during the vent procedure (N_2), which is harmfull to the EDX window, if installed.

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 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 aluminous 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

W A R N I N G !

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 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.

C a u t i o n !

Gold plated parts should not be polished with abrasive.

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.

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.

Stage maintenance

STAGE MECHANICS

Checking the condition of the stage should be a weekly exercise as many different 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

Abrasive and solvents must not be used on the moving stage parts. Cleaning by a suction 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. Spillage on the stage should be wiped up using a lint-free cloth, followed by suction 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 above).
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.

C a u t i o n !
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!

Scroll Pump

The pre-vacuum pump is used in the vacuum system which pumps the microscope, back-ups the TMP and controls the pressure in the specimen chamber.

It is very important that the pipes to and from the pump are not restricted in any way. If the pump exhaust pipe is fitted to an internal company exhaust system it is important that the gas flow is unrestricted by the system capability, otherwise back pressure can occur which will overheat the dry pump and deteriorate the pumping speed.

PERIODIC CHECK

Periodic check of scroll pump should be performed every 3 months, or every month if sample loading is at a high frequency.

Compressor and Pneumatics System (option)

To ensure proper and long-lasting functionality of the Compressor it is necessary to:

- Check monthly the compressor oil level. During the standstill the correct level should be between min and max indicators.

FIGURE 6-1   COMPRESSOR OIL LEVEL CHECK

Follow the preventive maintenance schedule (see the separate compressor manual, page 6).

- Check monthly the condensate amount presence and follow the Condensate Draining procedure if necessary.

Condensate Draining procedure

1. Vent the the microscope chamber and wait until it is fully vented.
2. Switch off the compressor.
3. Close the compressor Main valve and disconnect the hose from the compressor outlet.

FIGURE 6-2   COMPRESSOR CONDENSATE DRAINING

4. Fix a piece of a hose no.8 to the small draining valve on the air receiver.
5. Let the water with oil residue out into the empty bottle.
6. Dispose the oil contaminated material of properly according to the local regulations.

Note:
Drain the compressor carefully to prevent spillage.

7 | SYSTEM OPTIONS

This chapter covers hardware and software that is an option either integrated in, or accessory to the system.

The items covered here are:

- Optional Detectors
- External Current Measurement (Keithley Picoamper Meter)
- Charge Neutralizer
- Multistub Holder
- Nav-Cam
- Quick Loader
- CryoCleanerEC

Contact your FEI sales representative for more up-to-date information on system options.

Optional Detectors

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) or in combination with the Flipstage. It works best at a slow scan conditions.

FIGURE 7-1   STEM II DETECTOR
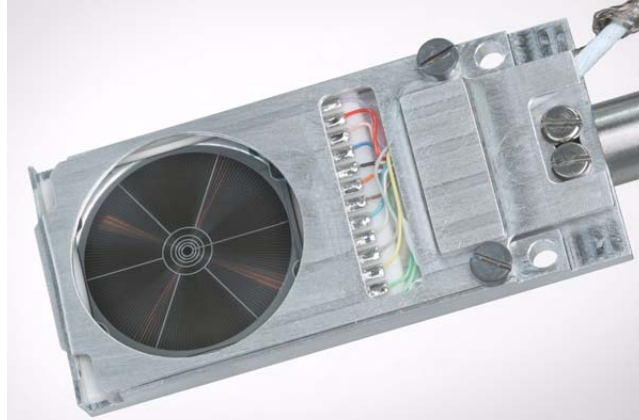
Note:
When the STEM II detector is inserted to the chamber, the stage rotation and the tilt are locked automatically for the safety.

Holder Arm Installation

Model difference:
Helios NanoLab 450 S / Helios NanoLab 450 ML uses the Flip stage.
Helios NanoLab 450 loads the Holder Arm automatically via the LoadLock.
For Helios NanoLab 650 / Helios NanoLab 600i use following procedure:

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 7-2   HOLDER ARM
Helios NanoLab 450 / Helios NanoLab 600i (650)

FEI

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 7-3   ROW HOLDER ON LOAD BASE /
ROW HOLDER ATTACHMENT INTO ARM (4XX / 6XX)
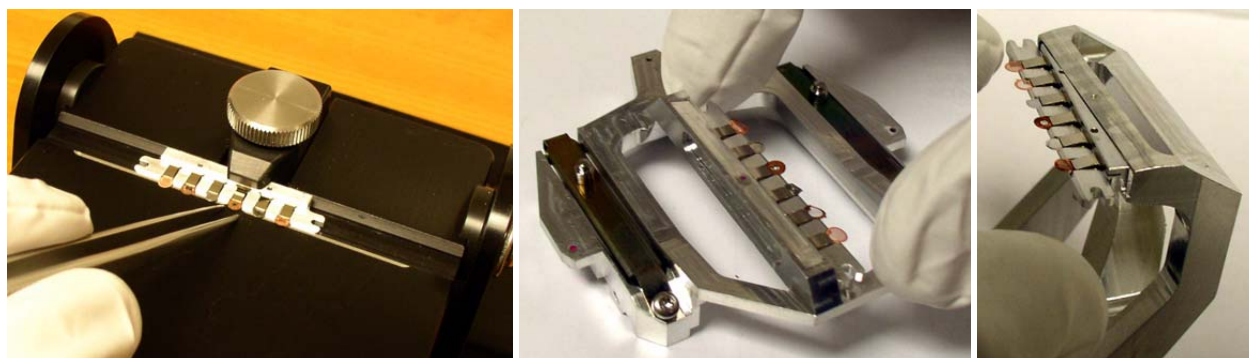
Inserting and Retracting STEM II Detector

Caution!
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.
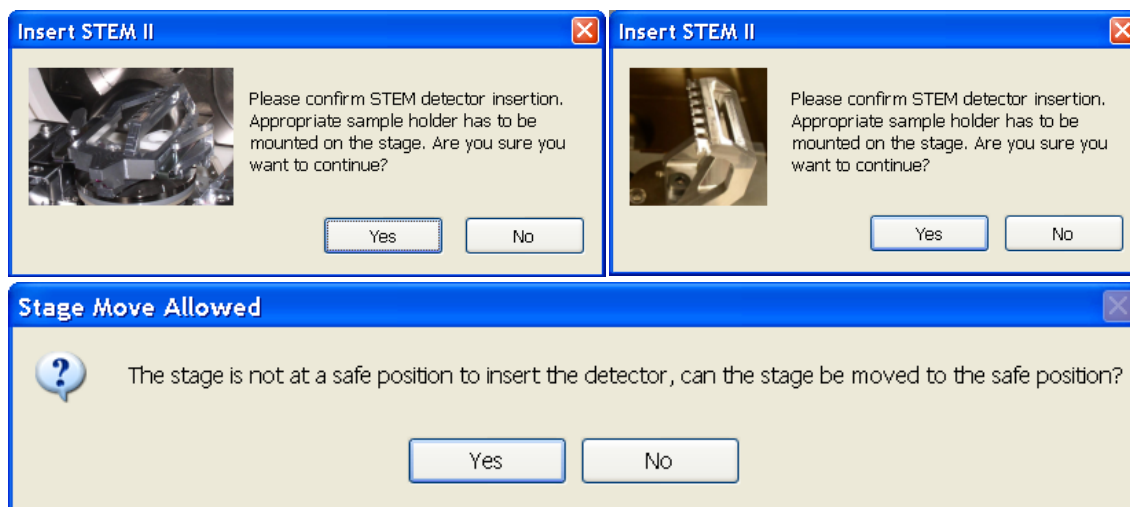
Retracting the STEM II is automaticall with the Stopping / Starting the server or venting the chamber. Otherwise the user can use the **Retract** button. When the detector is retracted, the information text is displayed in each quad which uses it.

Sets up STEM II imaging conditions:
View 1 - Bright Field
View 2 - Dark Field
View 3 - HAADF
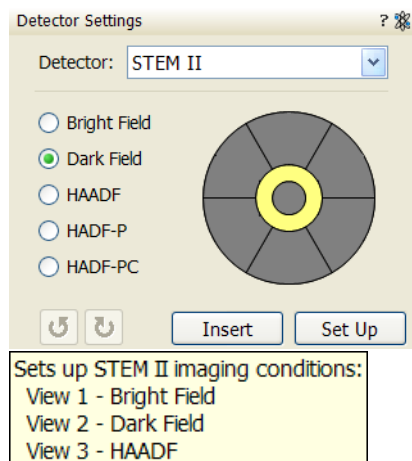
Settings for STEM II Detector

1. the desired sample in the field of view using the ETD or ICE. Focus and link Z coordinate to FWD.
2. Select the **Detector Settings** module / **Detector** list box / **STEM II** detector.
3. Clicking the **Insert** button causes a dialogue to appear (see above).
- Clicking the **Set Up** button sets the **Bright Field** / **Dark Field** / **HAADF** imaging mode (see below) to the quad 1, quad 2 and quad 3 automatically (see the tooltip).

Bright Field imaging

1. Tick the **Bright Field** 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. Tick the **Dark Field** 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 Brightfield is a good guide level.

1. Obtain a Bright Field image first.
2. Tick the **HAADF** radio button.

HADF Partial imaging

1. Tick 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 arrow buttons (on the left and right side of the detector diagram) to view orientation contrast changes etc.

HADF Partial Complementary imaging

1. Tick the **HADF-PC** radio button.

   It gives the signal from complementary segments to those selected in HADF Partial.

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.

It is mounted on a retractable arm which can be inserted between the lens and the sample and it is parked to the pole piece to reduce vibration.

FIGURE 7-4   DIRECTIONAL BACKSCATTERED DETECTOR
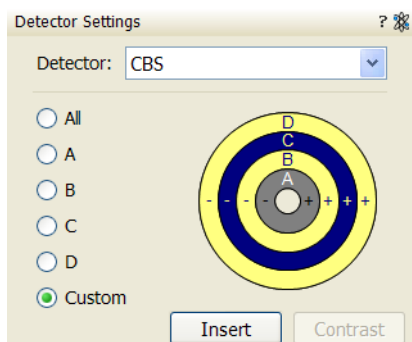
Detector Settings

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) / substract (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 azimuthal 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).

When the detector is retracted, the information text is displayed in each quad which uses it.

Inserting and Retracting CBS Detector

Before insertion the retractable detector, the user needs to check the following conditions:

- Chamber is pumped.
- The stage must be moved to a safe position for inserting the detector. The Link Z to FWD feature must be done and the WD must be more than 2.5 mm.

- The loadlock cycle must not be in progres (Helios NanoLab 450).
- The GIS's (if present) must not be inserted.

If the above conditions are not fulfilled, the **Insert** button is disabled, a ToolTip occurs when the mouse cursor is over a disabled Insert button.

The detector will be inserted after the insertion is confirmed and the tilt is locked. The stage X, Y and R movements have no limitations, Z-axis movement is limited to 2.5 mm.

Retracting the detector is automaticall with the Stopping / Starting the server, when venting the specimen chambre and when the Loadlock cycle starts. Otherwise the user can use the **Retract** button.
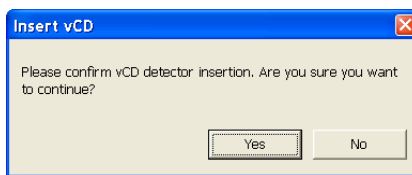
OBTAINING AN IMAGE IN BSE MODE

1. Select the corresponding Detector in a live Quad.

   The vCD limits the minimum achievable working distance so it is disadvantageous for a high resolution imaging.

2. Close the chamber door and pump down the chamber.

3. When the Vacuum is ready, switch on HV and slowly increase the contrast and brightness to obtain an image.

Note:
Whenever the Quad BSED 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).

RETRACTABLE DETECTORS CONTROL

When any retractable optional detector is installed on the system, the **Insert** / **Retract** button is added also to the **Detector Settings** module / **Detector: CCD** to enable the equipment control while working in the optical quad.
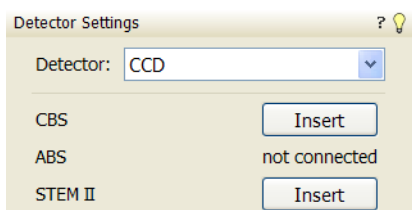
External Current Measurement (Keithley Picoamper Meter)

Stage | Tools | Window | Help
xT Align Feature...
Scan Rotation Align Feature...
Compucentric Rotation   F12
Define User Units...
User Units
Beam Shift Reset
Zero Beam Shift
Auto Beam Shift Zero
Home Stage   Shift+F3
Home Stage Without Rotation
Center Position   Ctrl+0
✓ Touch Alarm Enabled
External Current Measurement
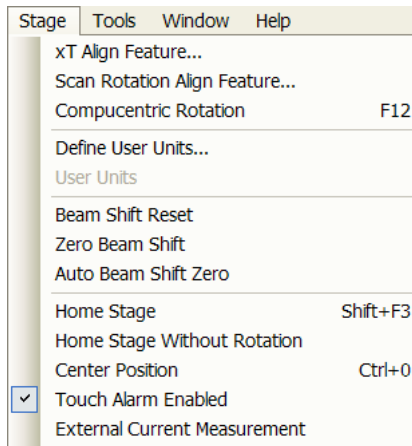
When the **Stage** menu / **External Current Measurement** is ticked, it is expected to have Keithley picoamper meter connected to the **External Connectors** panel / **Specimen Current** connector, which is located at the back side of the microscope console.

FIGURE 7-5   EXTERNAL CONNECTORS PANEL

Status   ?
Specimen Current: N/A
Ion Beam Current: 0.02   pA
Chamber Pressure: 3.77e-4   Pa
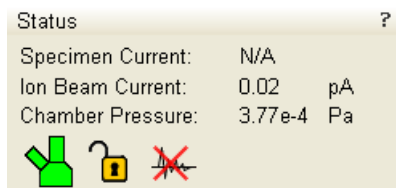
In this case the **Status** module / **Speciment current** value is **N/A** and the meter readout shows actual speciment current.

Note:
When the **Stage** menu / **External Current Measurement** is not ticked, switch the picoamper meter off or disconnect it!

Fast Beam Blanker

This equipment is used to protect sensitive samples from electron beam. During moving of the beam to the starting point of a new line / frame / pattern, the beam is blanked.

Note:
When the Fast Beam Blanker is used, electron current measurement may be lower than actual value. This inaccuracy is higher at fast scanning times. To obtain an exact electron current value use the Spot mode at a sample area, which is not sensitive or importatnt. (see Chapter 3).

Multi Stub Holder

Helios NanoLab 450

The Multi-stub Holder with 7-stub holding disc is provided with the microscope as an option.

FIGURE 7-6   MULTI-STUB SAMPLE HOLDER

It has a spring clip fitting and the threaded shaft which screws into the stage rotation head center and can be securely attached to the stage by means of the conical locking piece.

TORX DRIVERS

Within the kit are two Torx drivers to complete the fitting of the interfacing parts. All screws for interfacing connections are Torx. All screws for clamping sample stubs are of the Hex-key type. The appropriate Hex-key tool is standard with the system and not found in this kit.

I-Beam Charge Neutralizer
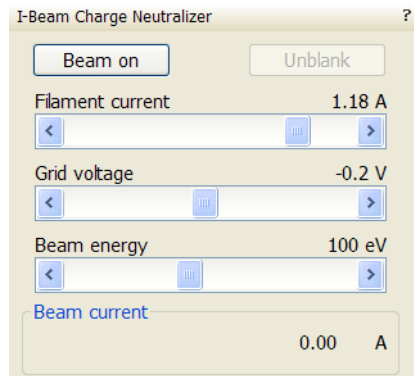
The FEI I-Beam Charge Neutralizer uses a low energy electron beam to control charging induced by the ion beam. This allows imaging and patterning of nonconductive materials and reduces electrostatic discharge-related sample damage (by spreading electrons on the sample).

All controls are placed within the **Detector** page / **I-Beam Charge Neutralizer** module. Values could be adjusted even while the beam is off in the ranges:

- **Filament current**: from 0 to 1.43 [A]
- **Grid voltage**: from -5 to +5 [V]
- **Beam energy**: from 28 to 200 [eV]

1. Verify whether the correct detector / detector mode is used to enable the Charge Neutralizer usage (see Chapters 5 and 7):
- The **ETD** can be used with negative Grid Voltage values (Custom mode),
- The **TLD** can be used with with negative Suction Tube Voltage values (Custom mode),
- The **ICE** can be used with negative Grid Voltage values (SI / Custom mode).
2. Click the **Beam On** button to switch the **Filament current** on (the filament starts to generate electrons and is heated).
3. Start the charge neutralizer by clicking the **Unblank** button. The **Grid voltage** (as indicated on the slider) is now applied to the grid and (in case of a positive voltage), electrons will be spread via the grid on to the sample.
4. Optimize imaging by adjusting the values.
5. Click the **Beam off** button to turn the Charge Neutralizer off.

    The software waits for the filament to cool before venting the chamber is possible (the progress bar shows the cooling progress, which takes about 7 minutes).

Finding the Optimal Operation Range

- Before adjusting the filament current or beam energy settings, adjust the grid voltage until the sample is no longer charging (no drift or flash):

    Start with the grid voltage at -5 V, then slowly increase the value until the image stabilizes.
- The Initial value of beam energy should be about -100 eV.
- The Initial value of filament current should be about 1.15 A.

    Note:
    Filament adjustment should be kept to a minimum as this will decrease the lifetime of the electron gun.

If neutralization cannot be reached at these values, first increase the beam energy, then adjust the filament current if necessary.

It is advisable to adjust settings after changing:

- Samples,
- System magnification,
- Scan conditions,
- Ion beam current.

Otherwise, if conditions and sample types remain constant, you should only have to fine-tune your initial successful settings.

The last settings are stored and can be recalled when switching the Charge Neutralization off / on and also after exiting UI software.

Balancing Electron and Ion Beam Currents

If your image is still too white and lacking details after you have started the charge neutralizer and slightly reduced the contrast, you probably have too much electron beam current compared to ion beam current. The electron beam is desorbing ions from the surface, which masks the gallium ion-induced signal (the electron-stimulated desorption). To rectify the problem try following suggestions:

- Reduce the grid voltage to reduce the beam current. The details should become visible as you achieve the balance between ion and electron currents.

- Fine-tune the grid voltage settings to a level appropriate for your application; the exact value is sample-dependent.

- If you continue to reduce the grid voltage you will reach a switch point where there are just not enough electrons to compensate the charging anymore. If you have gone below this point slightly increase the grid voltage again until the charging disappears. Now you have reached the optimum working condition with the best possible contrast of your charge compensated secondary ion imaging.

If you are still unsatisfied with the image, adjust the beam energy (50 V, for example) and check the results.

In case the filament does not start slowly increase the filament current.

Remarks

- Checking that the Charge Neutralizer is functioning can be made using a glass sample (FEI company part nr 22805 Rev A).
- When patterning is paused the ChargeNeutralizer stays on.
- When a snapshot / photo is performed with the ion-beam while patterning with the ion-beam is active the ChargeNeutralizer should stay unblanked.
- When a snapshot / photo is performed with the E-beam while the ion-beam patterning and ChargeNeutralizer are active, the ChargeNeutralizer is automatically blanked and unblanked.This will enable the use of E-beam grabframe during patterning.
- When an E-beam grabframe is performed during ion beam imaging, the ChargeNeutralizer will blank but not automatically unblank when switching back to ion beam imaging.
- In iSPI mode the ChargeNeutralizer can not be used. When working in iSPI mode the detector interlock is not OK because the electron beam is imaging.

Nav-Cam (chamber door mounted)

Helios NanoLab 650 / Helios NanoLab 600i

This functionality represents a possibility to navigate across the range of the stage movement area. This 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 4 mm (top sample surface) with the use of the **CCD 4 mm Marker**. Do not pump the system!
    At this position only the Nav-Cam functionality is correct!
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.
    CAUTION!
    When the stage is moving to the Nav-Cam position, do not rotate the camera until the stage reaches the final position, the alignment setting (see below) could be lost!
    When the Stage movement stops wait about 5 seconds to let the camera to automatically adjust a brightness & contrast.
    DANGER!
    Be aware of a stage movement, do not put fingers to the trajectory!
5. Capture a navigation image (with the high resolution of 3072 × 2207 pixels) by pressing the silver camera button on the top of its body or by Snapshot or Photo function (see Chapter 4). 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 the navigation image is not sufficient, try to find a Z-coordinate (about ±1 mm from WD 4 mm) at which an image is sharp enough and repeat steps No. 3 and 4.
6. Rotate the navigation camera back to its home position (the stage moves to its last position before venting the chamber), close the chamber door and pump the system.

Besides a navigation image one can use also 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).

For a dark or shiny specimens a Nav-Cam image quality could be bad. In this case run the **401 - Nav-Cam AutoBrightness** alignment (see Chapter 4).

Quick Loader

Helios NanoLab 650 / Helios NanoLab 600i

The Quick Loader comprises of the following components:

- Gate valve unit with system safety interlocking
- Lead glass door and loading chamber
- Sample sledges and Stage Adapter
- sample stubs of diameters 12.5 mm, 25 mm and 32 mm
- A guided transfer rod with spring mounted bayonet fitting
- Integrated vacuum control (simple pump and vent control)

The Quick Loader was designed for:

- Easy Sample transfer
- Faster sample through-put
- Contamination free chamber environment
- Materials applications

GENERAL DESCRIPTION

The loader can manually load and unload small samples into the SDB / SEM. The loader is connected to the specimen chamber of the SDB / SEM and also integrated into the main vacuum system hardware and software.
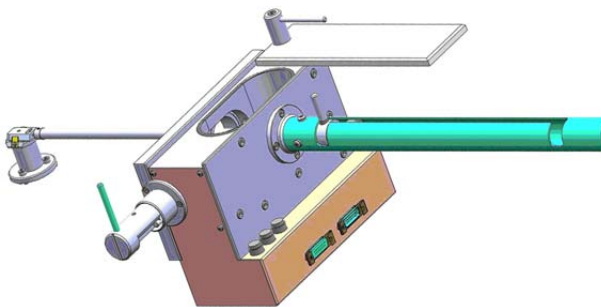
The loader consists of a loading rod with set slide and parking position, a vacuum chamber for loading and unloading the sample carrier (with sample) onto a bayonet fitting located at the end of the rod. A gate valve seals the vacuum of the SDB / SEM specimen chamber and can only be opened when the vacuum of the loader chamber is correct, this being indicated by a '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.
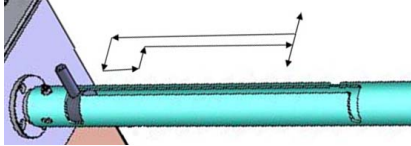
Loading rod

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).

CAUTION!

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
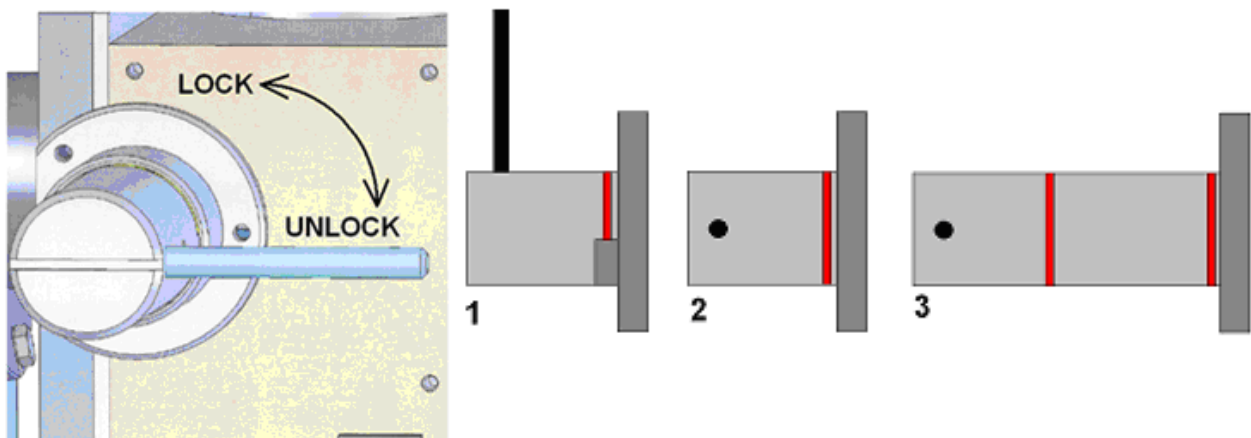
*   Position 1 - IN and LOCK
*   Position 2 - IN and UNLOCK
*   Position 3 - OUT

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 (the buttons are 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. If the microscope chamber as well as loader is vented then pressing the **V** button release lever interlock and gate valve can be opened.
- 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 system...). After finishing the state transition the control buttons will be in operation again.

Sample Carrier, Sample Gauge 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 decoupled at the bayonet coupling when the sample carrier is located in the adapter and withdrawn leaving the sample carrier ready for sample observation.
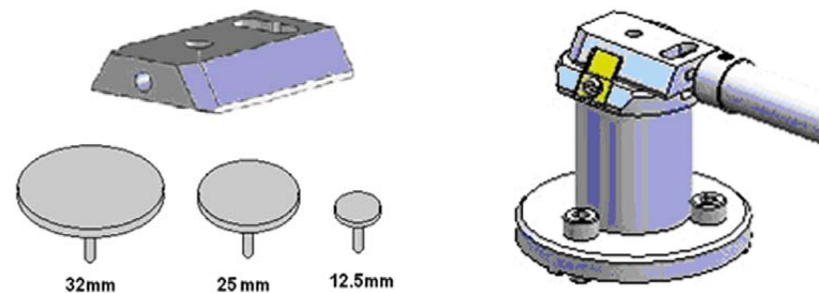
The Stage Adapter is connected to the rotation base of the FEI stage by 3 hexagonal headed screws. The base of the adapter has 3 highpoints for a firm 3-point contact to the rotation base to prevent vibration transmission.

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).

The sample transfer position Ztr is not 0, but in practice from 0.5 to 1.0 mm. The achievable Working Distance could be calculated:

- WDmax = 11.9 mm - H (sample height) + Ztr
- WDmin = 1.9 mm - H (sample height) + Ztr

Consequently the minimum working distance in case of a sample with minimum thickness could be as much as WDmin = 2.9mm. This is too much for proper HiRes imaging. However by simply mounting the stub into the shuttle in an elevated position, as in the drawing, the sample can be brought up to a minimum working distance of zero.
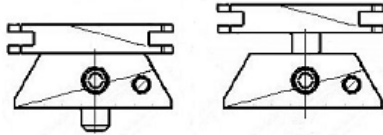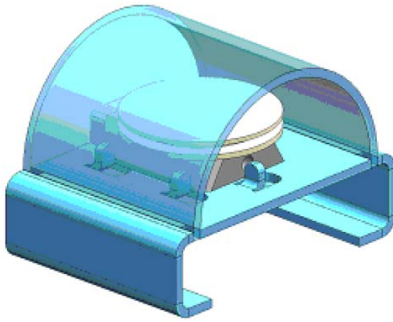
INSTALLATION

The Quick loader is pre-installed in FEI factory. No special adjustment is needed only the loading rod was uninstalled for transport.

1. Unpack the lead glass lid.
2. Remove four screws holding the cover of the loading rod feedthrough.
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 Alignment** at first.

Alignments	?
Quick Loader Alignments ▼	
QuickLoaderAlignments	
QuickLoaderAlignment	

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. 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.

3. Press quick loader 'Vent Button', open Gate Valve and insert the transfer rod with the shuttle.

4. Adjust X, Y, and Z to find the optimum exchange position

5. Retract the transfer rod and close Gate Valve.

6. Press the Finish button to save the exchange position or press Cancel to restore previous exchange position

X:	-1.9794 mm
Y:	-1.2412 mm
Z:	0.8858 mm
R:	40.4 °
T:	52.0 °

Cancel   Finish

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. The 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.

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, Omniprobe 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 (anticlockwise) 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 (anticlockwise) 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, Omniprobe 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 (anticlockwise) 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 (anticlockwise) 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.

Loading/Unloading - vented microscope chamber

If the microscope chamber is vented and Loader chamber is evacuated, press **V** to vent the loader chamber. After the chamber is vented, you can:

- press **P** button to pump the chamber again if needed (store sample under vacuum condition)
- press **V** button to release the mechanical interlock of the gate valve lever. Then you can open gate valve.

Close the gate valve before microscope chamber pumping.

CryoMAT Loader

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 7-7 CRYOMAT LOADER BLOCK DIAGRAM
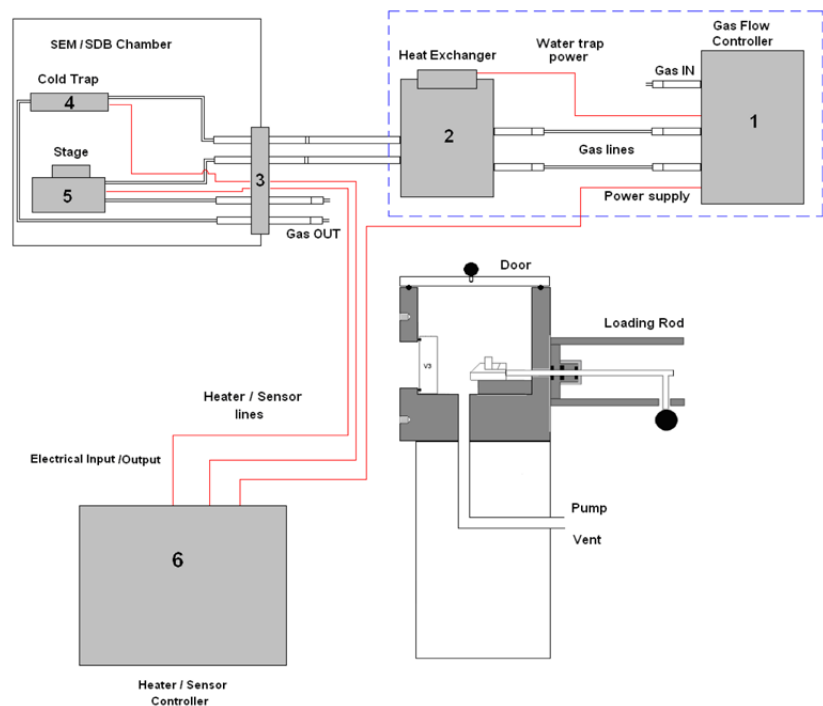
- 1. The **Gas flow controller** (on a trolley mount) controls the N2 pressure and flow through the cryo components.
- 2. The **Heat exchanger** cools down the flowing N2 to cryogenic temperatures. A **water trap** captures water from the N2.
- 3. The **Gas and electrical interface flange** introduces 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 7-8 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 nonclosing action
- 7× gas connections with interconnective 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).
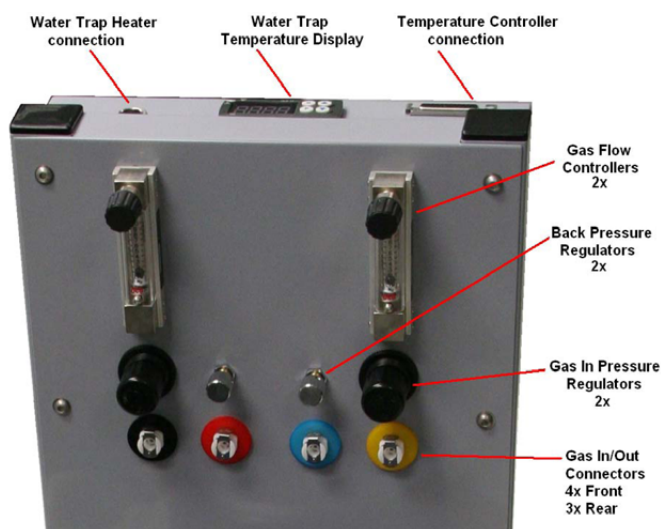
2. HEAT EXCHANGER AND LN2 DEWAR

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 7-9 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
- Non-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 above the GIS needle input level.

Cold Trap components
- Cold trap plate
- Mounting rod and insulator
- Sensor element
- Ground connector
- Swivel bracket
- Extension Plate

FIGURE 7-10 COLD TRAP
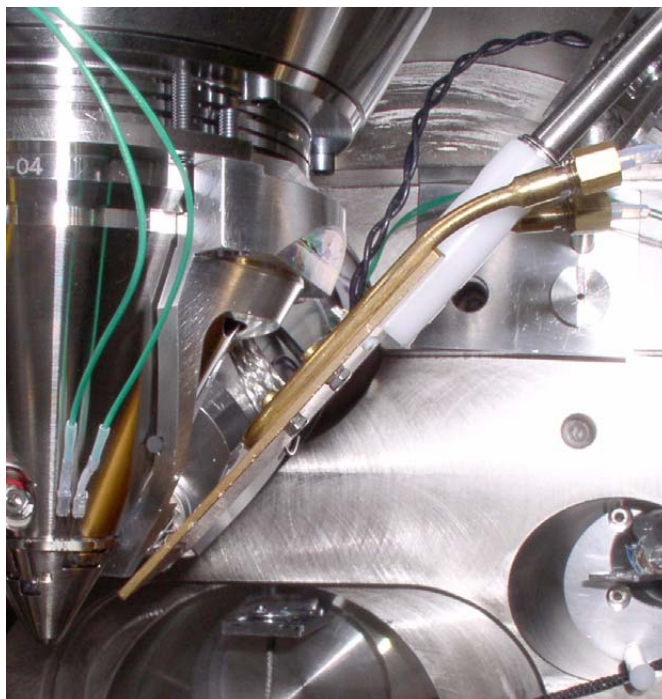
5. CRYO STAGE

Caution!
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 multi 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 (above 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 7-11 CRYO STAGE CONSTRUCTION
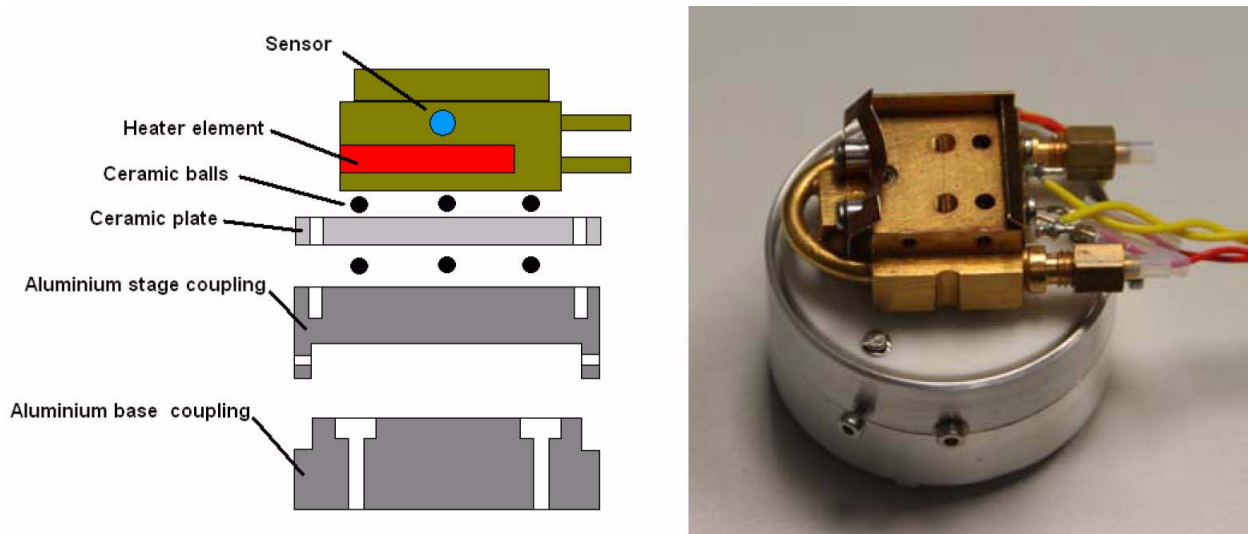
Cryo stage components
- Mounting base plate
- Thermally insulated stage mount
- Heater element to 100°C
- Sensor element
- Ground connector

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 reconnection 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 7-12 CRYO SAMPLE CARRIER WITH STANDARD STUB
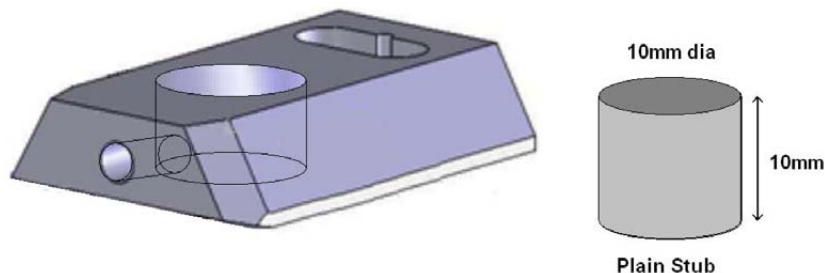
6. CRYO HEATER & SENSOR CONTROLLER

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 7-13 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 non-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 nontilt 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.

CryoCleanerEC

These equipments allow to decrease the contamination level in the system. The CryoCleanerEC can be efficient to approximately 24 hours (CryoCleaner – older version – has silver plated Dewar vessel and can be efficient about 10 hours).

The kit consists of:

*   Vacuum vessel, including o-rings, screws
*   Vacuum vessel lid
*   Nitrogen vessel (Dewar) with cap, including proper warning labels
*   Nitrogen vessel stand
*   Nitrogen vessel safety Pliers
*   Manual

WARNING!

This option uses liquid Nitrogen (LN2), which may cause serious cold burns.

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 7-14 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.

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 7-15 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 visior 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 7-16 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. Unclip 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.
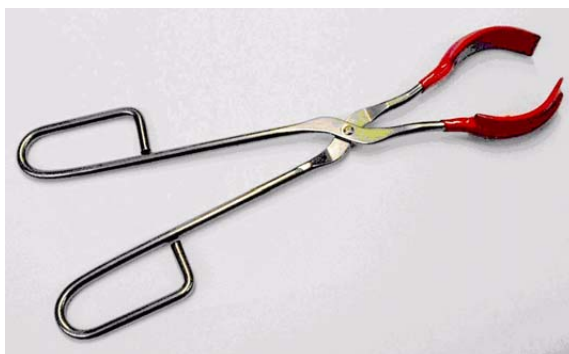
3. Place the Lid over the Vacuum vessel to seal it from the atmosphere (fix the clips). Pump the specimen chamber again, however the microscope vacuum remains cleaner than before and sample contamination is still reduced.
4. Remove the cap from the Nitrogen vessel and pour out the excess LN2 into a suitable 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 harmfull 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