The Nova NanoSEM
User Operation Manual

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1 ■ PREFACE

User Manuals

THE USER SAFETY MANUAL

provides important information required during an operation and a maintenance for a product and personal safety. Be sure to read this document (which is delivered as the PDF file and in the printed form also) at least.

THE USER OPERATION MANUAL

for your Scanning Electron Microscope is divided into the following chapters:

1. **PREFACE**
    provides information about the manual structure.
2. **SYSTEM OVERVIEW**
    gives the basics about your system capabilities.
3. **SYSTEM OPERATION**
    gives the basics about the vacuum system and procedures for several system on/off modes, including Log On/Off, Standby Mode, Overnight Mode, Complete Shutdown, and Emergency Shutdown, emmision modes, SEM resolution modes.
4. **SOFTWARE CONTROL**
    describes the interface that controls system operation, giving the function of each tool, menu item and control page.
5. **OPERATIONS**
    gives procedures for how to use the system.
6. **ALIGNMENTS**
    explains how to align the column and stage to achieve optimal performance.
7. **STAGES**
    gives a full description of the stage functionality and its software control.
8. **MAINTENANCE**
    gives step by step cleaning and maintenance procedures.
9. **SYSTEM OPTIONS**
    explains relevant options that are integrated into or accessory to the system.

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How to Use this Manual

This manual is available in two forms, the electronic PDF file and the printed form (option).

It is recommended to read this manual 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.

In the electronic PDF file you can take advantage of the searching and navigation possibilities offered by this file format. In the printout the following conventions are observed to be of help:

- You can search for the information in the main table of contents at the beginning of the User's manual, where tables and figures (excluding explanatory ones) are also listed.

- Major headings have been hung in the left column to help you scan for the basics within a chapter. That column provides space for some explanatory figures and for your own notes as well.

- Some software functions use shortcuts, which are given beside the heading in the brackets (for instance: **Save (Ctrl + S)**) and in the summary table available from the Help menu.

- Pages are numbered by this way:
  [Chapter No.]-[Page No.] within the Chapter. Instead of **[Chapter No.]** you can find an abbreviation **C**, which means content pages.

- Tables and figures (excluding explanatory ones) are numbered within each chapter in this way:
  FIGURE [Chapter No.]-[Figure No. within the Chapter]
  TABLE [Chapter No.]-[Table No. within the Chapter]

- References to specific knobs, buttons, labelled functions are highlighted in bold to aid association of items. A sentence such as: "Click the **Measurement** button to start this function" refers to the software button itself.

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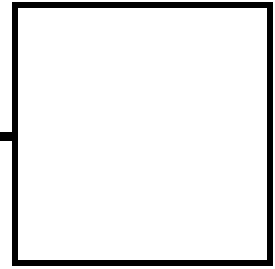
The Nova NanoSEM Scanning Electron Microscope (SEM) produces enlarged images of a variety of specimens, achieving magnifications of over 500 000x providing ultra high resolution imaging in a digital format. This important and widely used analytical tool provides exceptional depth of field, minimal specimen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

The Nova NanoSEM has 2 operating vacuum modes to deal with different types of sample. **High Vacuum (HiVac)** is the conventional operating mode associated with all scanning electron microscopes. The other application mode is **Low Vacuum (LoVac)**. In this mode the column is under high vacuum, and the specimen chamber is at a high pressure ranging from 0.075 to 1,5 Torr (10 to 200 Pa). This mode can use water vapour from a built-in water reservoir, or auxiliary gas which is supplied by the user, and connected to a gas inlet provided for this purpose. Using the Low Vacuum mode Observation of outgassing or highly charging materials can be made without the need to metal coat the sample, which would be necessary for conventional High Vacuum mode.

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How Nova NanoSEM Works

Four main components combine to produce images of a specimen:

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

FIGURE 2-1   SEM SCHEMATIC OVERVIEW
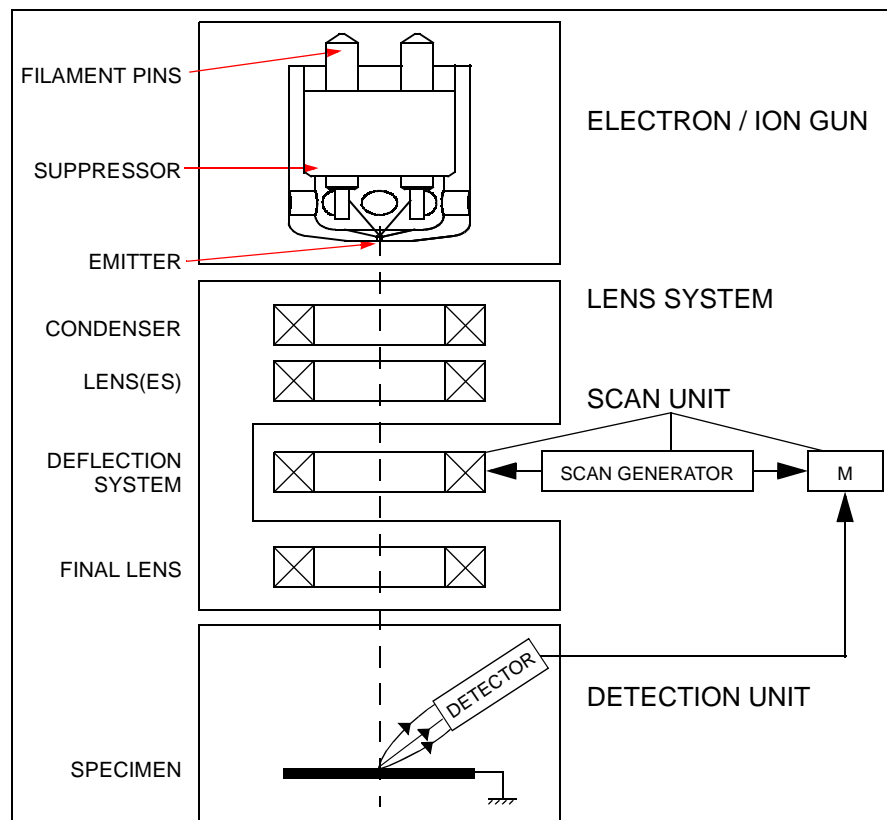
IMAGE VIEWING AND CAPTURE

Because the amplified detector signal is displayed synchronously with the beam scanning, there is a correspondence between the brightness of an image point on the monitor screen and the signal detected at 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. Increased magnification is achieved by reducing the size of the area scanned on the specimen.

SYSTEM VACUUM

The entire electron path from gun to specimen must be under vacuum so that the electrons do not collide with air molecules. Various levels of vacuum are necessary, so a Turbo Molecular Pump (TMP) backed by a rotary pre-vacuum pump (PVP), obtains the necessary specimen chamber vacuum. The exception to this rule is the LoVac mode where water vapor or an auxiliary gas is introduced to the specimen chamber.

Specimen exchanges take place through a chamber door which, when opened, exposes the specimen stage. Exchange time takes a few minutes. Vacuum software and interlocks ensure that the system is protected against operating failures.

POSITIONING OF THE STAGE

A choice of computer-controlled high-accuracy multi-axis stages offers precision specimen manipulation and automation of all axes for overall spatial orientation on highly repetitive or extremely irregular samples.

FIGURE 2-2 NOVA NANOSEM 230

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System Layout of Nova NanoSEM

The standard layout of the Nova NanoSEM 230, 430 and 630 systems is based around a dedicated microscope controller along with an electrical console to power the microscope console (vacuum, gun, column, and stage).

The support computer contains various other items that are generally accepted as essentials or are dedicated to a particular application, such as forensics or failure analysis.

The user interface devices are peripherals to the microscope controller, either software or hardware. The Completion Packages differ in content depending on the demand of the application or the wishes of the customer. As a result it is not possible to specify all possible combinations here.

FIGURE 2-3 NOVA NANOSEM STANDARD LAYOUT SCHEME
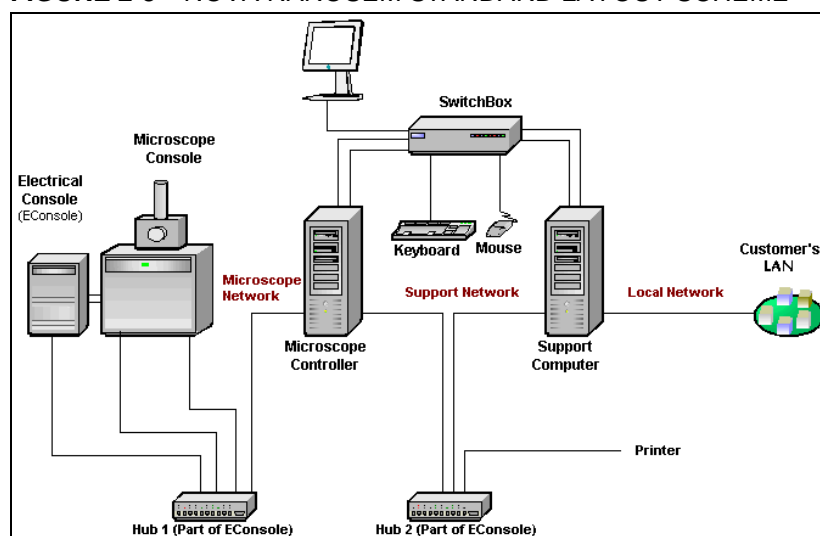
For more information on the types of completion packages and overall content, refer to Chapter 9 'Options'.

SOFTWARE INTERFACE ELEMENTS

The software control contains graphic applications within Windows xP™ operating environment. **xT microscope Server** starts and stops the basic microscope functions and makes it 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 detection and analysis, scanning, image gathering, manipulation and output, magnification and vacuum, 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

See Chapters 3 and 4 for more information on Logging on and Logging off, the start-up of the system and all the features of the user interface elements.

HARDWARE INTERFACE ELEMENTS

The system is computer controlled and as such has a **microscope PC** which must be turned on to operate the microscope by means of the software. The power button on the microscope PC must be used to turn it on. The **support PC** can hold some other software utilities. The **switch box** switches insertions of the keyboard, the mouse and the monitor 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. It is possible to connect a second LCD monitor (option) to the support PC. To control software utilities one can use **keyboard, mouse, joystick** (option) or **Manual User Interface** (option).

THE SYSTEM CONTROL PANEL

The console / system power is activated by pressing the front panel / green **power button** located on the microscope console. This switches the sub-systems on and allows the interface and communication with the microscope controller. All other functions (including the console Shutdown) are activated via the software control.

FIGURE 2-4   SYSTEM CONTROL PANEL POWER BUTTON

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STAGE CONTROLS

The stage is software / manually controlled and can be oriented with reference to five axes: **X**, **Y**, **Z**, **Rotation** and **Tilt** axis. Some stage types have only manually controlled Tilt, some ones have only software control (see Chapter 7 for a detailed description).

FIGURE 2-5   NOVA NANOSEM 230 / 630 CHAMBER
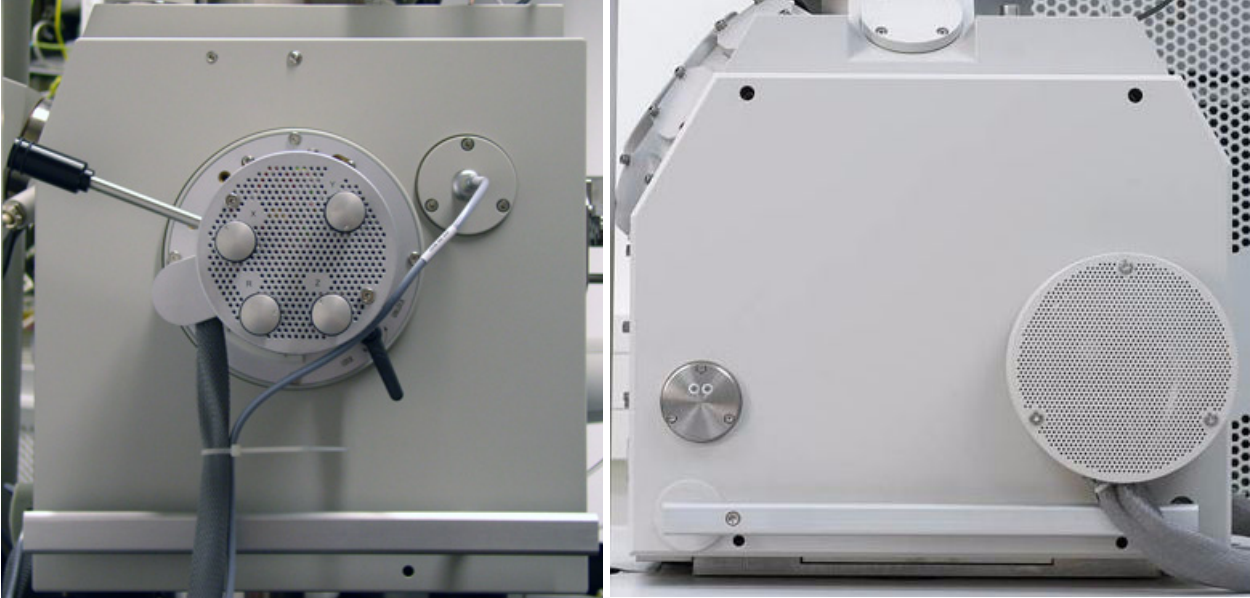
INFRARED CCD CAMERA

An optical image obtained with this CCD camera assists in overall sample orientation. It also aids in positioning non-uniform samples. IR LEDs are used to light the specimen chamber interior.

FINAL LENS APERTURE STRIP

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

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

FIGURE 2-6 FINAL LENS APERTURE STRIP CONTROL KNOB

⚠️ *WARNING!*

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

TABLE 2-1 APERTURE SIZES AND THEIR USE

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

Nova NanoSEM Options

A range of hardware and software are available as options for Nova NanoSEM systems. This range will be extended when new items become available. Some of the options are:

- The **Solid-State Back-Scattered Electron Detector (BSED)** is the low-kV detector preferred for phase distribution data collection.
- The **Gaseous Analytical Solid-State, Back-Scattered Electron Detector (GAD)** is similar to the standard low-kV, SSBSED, but features an additional X-ray cone with a 500 micron Pressure Limiting Aperture which seals to the objective polepiece.
- The **Low-voltage High-contrast Detector (vCD)**
- The **Solid-state STEM I Detector** allows detection of electrons transmitted through the sample. Regular voltage range is from 30 kV down to around 5 kV, which is of course dependent on the sample thickness.
- The **Retractable Annular STEM II Detector**
- The **SIS Scandium Image Software,** the **SIS webRacer,** the **SIS Scandium Desktop Licence**
- The **Pattern Generation Software**
- The **e-Beam Depositoin Kit**
- The **Deposition Gasses**
- The **Specimen Current Monitor Kit** allows to combine the touch alarm with specimen current measurements in an automated way.
- The **19" LCD monitor**
- The **Joystick**
- The **Thermal Printer Kit**
- The **Manual User Interface USB**: optional, supplementary control console providing direct manual control of microscope parameters such as focus, magnification, contrast, brightness, beam shift and stigmator.
- The **UMB Specimen Holder Kit**, **Set of 20 Specimen Stubs** for SEM's
- The **Mains Matching and Isolation Transformer SEM** provides a galvanic isolated, AC-regulated output voltage of 115 or 230 V, 50 or 60 Hz from the local grid.
- The **High-resolution SEM Course** (Acht)
- The **Nova NanoSEM Course** (Hillsboro)
- The **Advanced SEM Course** (Acht)
- The **On-site Training/Support** (1day)
- The **Set of 3 Apertures** 400 µm, 3 mm Diameter
- The **Mo Strip Apertures & Holder**: 2x 30, 40, 50, 100 µm (Additional)
- The **Mo Strip Apertures & Holder**: 10, 15, 20, 2x 30 µm
- The **Mo Strip Apertures & Holder**: 2x 30, 50, 2x 30 µm

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

3 SYSTEM OPERATION
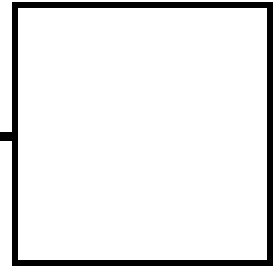
This chapter describes:

- The Nova NanoSEM vacuum system
- Vacuum statuses and relevant actions (Pump, Vent)
- Vacuum modes (HiVac / LoVac)
- Emission Modes
- SEM Resolution Modes
- Nova NanoSEM System States
    - Start up procedure generally
    - Shut down procedure generally
    - Emergency off (EMO)
    - Power off

Nova NanoSEM Vacuum System

There are three main vacuum sections:

- Gun
- Column
- Specimen Chamber.

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

All valve and pumps operations are fully automatic.

FIGURE 3-1 THE Nova NanoSEM VACUUM SYSTEM

Legend:

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

Vacuum Statuses

The vacuum status controls are in the **Vacuum** module, located at the top of the **Beam Control, Detectors** and **Navigation** pages. The **Pump** button starts pumping for the chamber vacuum and the **Vent** button starts venting for a sample or detector exchange.

In the **Status** module at the bottom of any page the actual vacuum status is displayed with the coloured icon. This icon represents two vacuum sections schematically, each of which may have three possible colours with the following meaning:

- **Green: PUMPED**
  to the desired vacuum mode (HiVac or LoVac)
- **Yellow: TRANSITION**
  between two vacuum statuses (pumping, venting or purging)
- **Grey: VENTED**

PUMP BUTTON

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

For High Vacuum the system will achieve the best vacuum (lowest pressure) possible. For Low Vacuum it will go to the pressure specified in the **Chamber Pressure** adjuster at the bottom of the **Mode** area. For the LoVac the purge function can be defined in **Preferences / Low Vacuum.**

If the **Pump** button is selected when **venting**, the venting procedure stops and the system immediately starts to pump to the currently selected vacuum mode.

VENT BUTTON

When the **Vent** button is selected and the system is in any **Vacuum** status, the confirmation dialogue appears. After confirmation, the system switches off the detectors, high voltage supplies and vacuum pumps, and uses the appropriate valves to vent the system, with the use of an air or a gas (the dry Nitrogen typically) brought to the **Nitrogen Inlet**. The Nitrogen is recommended to obtain the better vacuum for high resolution imaging in HiVac mode.

Caution!
Maximum overpressure for the Nitrogen Inlet is 0,1 bar.

The Vent button is highlighted in and not accessible. After a specified venting time (10 minutes by default, could be changed by the FEI service engineer) the venting valve will close and the vacuum status should indicate **Vented**. The button will be enabled again.

If the **Vent** button is selected when **pumping**, the dialogue appears. After confirmation, the pumping procedure stops and the venting procedure starts.

When the **Vent** button is selected when **Vented** status has already been reached, the dialogue appears. After confirmation, the venting valves re-open. After the specified venting time, the valves will close.

3-3

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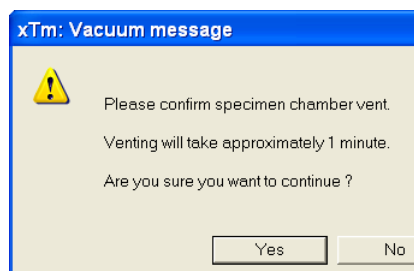
> **Note:**
> If you vent the system in order to change a detector, wait until the icon with a greyed specimen chamber appears in the **Status** module. Otherwise there is a risk of a detector assessment malfunction, and as a result the PLA (see below) will not be known by the system.

Vacuum Modes
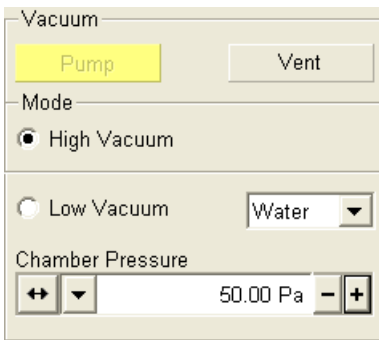
The vacuum mode radio buttons are in the **Mode** area of the **Vacuum** module. The vacuum system recognizes **High Vacuum** and **Low Vacuum** modes.

HIGH VACUUM (HiVac) MODE

This is the conventional operating mode associated with all scanning electron microscopes. The high vacuum condition is common throughout the column and specimen chamber. The **ETD**, **TLD** or any optional HiVac detectors can be used.

LOW VACUUM (LoVac) MODE

The **LoVac** mode is used most often in viewing images with the microscope. The gun and column sections are under lower pressure than the specimen chamber where pressure ranges from 0.1 to 1.5 Torr (10 to 200 Pa). This mode uses water vapour from a built-in water reservoir or a gas from an auxiliary gass inlet.

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

When pumping to LoVac mode, either from HiVac or from Vented status, the system prompts the user with the **Pole Piece Configuration** (**PPC**) as a graphical dialogue. This happens only for the first time after a particular Vent procedure.

The imaging gas can be selected in the **Mode** drop-down list (see below).

Pressure

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

When the system is in LoVac mode and the pressure value is changed in the Pressure adjuster, the pressure will automatically start changing to the new value. When the system is in any other status and the Pressure adjuster is changed, the new value will be used as the target pressure when the system pumps to the LoVac mode.

The actual specimen chamber pressure is displayed in the **Chamber Pressure:** field of the Status module at the bottom of all pages.

Pressure Limiting Apperture (PLA)

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

The **PPC** dialogue prompts to inform the system about the used PLA (in case it is not a part of a dedicated LoVac detector – Helix for
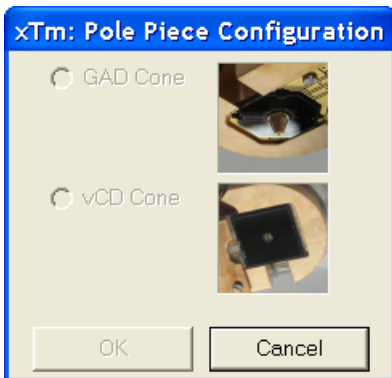
instance) when pumping or switching to LoVac mode. Along with a gas type, this information sets pressure limits and rates for vacuum level changes.

The PPC dialogue enables to select only a PLA of any currently mounted detector – the other ones are greyed out. Selecting a detector informs the system that the respective PLA is mounted on the objective pole piece and after **OK** is clicked the PLA size is known and the system starts pumping to the LoVac mode. From that point on, this information is automatically used until the system is vented again. In this case the vacuum system sets the PLA to unknown because the PLA can only be changed when the system is in Vented status. Clicking on **Cancel** leaves the system in it's current status mode (HiVac or Vent).

Pressure and Working Distance (WD) in LoVac mode

FIGURE 3-2 BRIGHTNESS VS PRESSURE
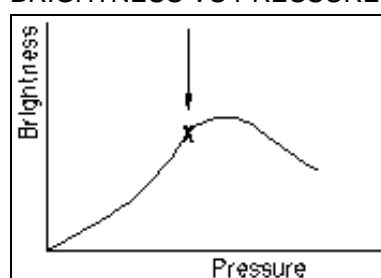
High resolution imaging is achieved by moving the sample closer to the pole piece; the objective lens performs the better the the smaller is the WD. Using the LVD detector, the chamber pressure needs to be higher at smaller WD.

Some experimentation may be necessary, as the relationship between working distance and chamber pressure is largely sample-dependent.

Note:
Always use the CCD image when adjusting the height of a sample. It is advisable to do this using the middle (Z-tracking) mouse button control in the CCD Quad.

Using Gas

The Low Vacuum mode allows the user to image samples in a gaseous atmosphere, which can be selected in the **Mode** drop down box:

- **water vapour** from a built-in water reservoir
  On occasion the water reservoir needs to be filled (see Chapter 8).
- **auxiliary gas** which is supplied by the user, and connected to a gas inlet provided for this purpose.

Caution!
Maximum overpressure for Auxiliary gas inlets is 0.1 atm (bar). However for better functionality it is recommended to use a regulator on the gas cylinder to provide an output pressure of about 10 kPa (0.1 atm).

Caution!
When using auxiliary gasses there are pressure limits, given in the following table. The system doesn't watch the limits and higher overpressure (especially for gasses not listed) set by a user could switch off the emitter! In some cases the system needs to be started up by a service engineer.

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TABLE 3-1   MAXIMAL CHAMBER PRESSURE [PA (TORR)]
UNDER DIFFERENT GASEOUS ENVIRONMENT

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

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

PURGE

The microscope provides an automatic sequencing for purging the specimen chamber according to the settings of **Purge Mode** in the **Preferences… / Low Vacuum** tab (see Chapter 4). This sequence purges any remaining room air out of the chamber during **Pump** or replaces the current chamber gas with the new one selected in the **Mode** list box. This is applied when the system is:

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

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

There may be certain applications (e.g., working with a sensitive sample) where the operator needs to change the purging parameters.

- Select **No Purge** when purging the specimen chamber is not desired. The chamber goes to the set pressure directly and the gas mixture in the chamber slowly changes to the selected gas type.
- Select **Automatic** to use pre-defined values for **Minimum / Maximum Pressure** and **Number of cycles**. The **Purge Settings** displays the current default values.
- Select **Custom** to change the **Minimum / Maximum Pressure** and the **Number of cycles** manually using the **Custom** Edit boxes. The maximum allowed pressure is 200 Pa (1.5 Torr) for all currently available PLA Cones.

SEM Resolution Modes
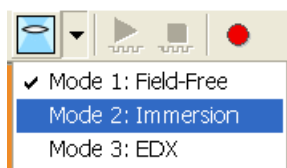
There are three imaging modes, which are electron column condition dependent.

MODE 1

(also referred as: Field-Free, High Resolution – HR)

This mode utilizes Final lens for imaging. High voltage, working distance and magnification values are not restricted. It is used mostly for finding the area of interest or when working with magnetic samples. For the secondary electron detection the ETD, TLD (HiVac) or LVD (LoVac) detectors are used.

MODE 2

(also referred as: Immersion, Ultra-High Resolution – UHR, Snor)

This mode utilizes Immersion lens for imaging. It is allowed only for higher magnifications (>1000x). For the secondary electron detection the TLD (HiVac) or Helix (LoVac) detectors are used.

Observing in this mode requires strong magnetic field around the sample. Maximum applicable High Voltage and the field of view are strongly depends on the working distance.

TABLE 3-2 APPROXIMATE HV, HFW AND MAGNIFICATION VALUES IN RELATION TO WD IN MODE 2

Working Distance [mm]	Maximum High Voltage [kV]	Maximum Horizontal Field of View [µm]	Minimum Quad Magnification
7	30.0	100	1000
5	18.0	90	300
4	12.0	70	1600
3	7.0	50	2100
2	3.5	40	3000
1	1.2	20	6000

MODE 3

(also referred as: EDX)

This mode is very similar to Mode 1. The only difference is the UHR lens use as the magnetic trap because of the EDX analysis.

Nova NanoSEM System States

There are several system states listed in the following table and the tree. The transitions among them depend on their initial and final conditions and are accessible from a particular user account.

TABLE 3-3   DESCRIPTION OF NOVA NANOSEM STATES

State	When to Use	Switched off components	Steps to Return to Full Operation
1) Complete Shutdown	During transportation, service actions or after a long power failure	System Vacuum (including IGPs), Emitter, Electronics and Computer	PC on, Supervisor: Log On, IGP start[1], Emitter On, Vacuum Pump, High Voltage On
2) Emergency Shutdown	During power failure or a hardware accident	System Vacuum, Emitter, Electronics and Computer	Up to 2 hours from emergency shutdown PC on (same as for 3)
3) Shutdown	When not using the system for more than 10 days.	System vacuum (except IGPs), Emitter, Electronics	Console on, xT Server start, Supervisor Log On, Emitter On, Vacuum Pump, High Voltage On
4) Full Operation	Working	-	-
5) Overnight	When not using the system overnight.	High Voltage	User Log On High Voltage On
6) Standby	When not using the system for more than 1 day.	High Voltage, PC + monitor	PC On, xT Server start, Log On, High Voltage On

FIGURE 3-3   Nova NanoSEM STATES TREE
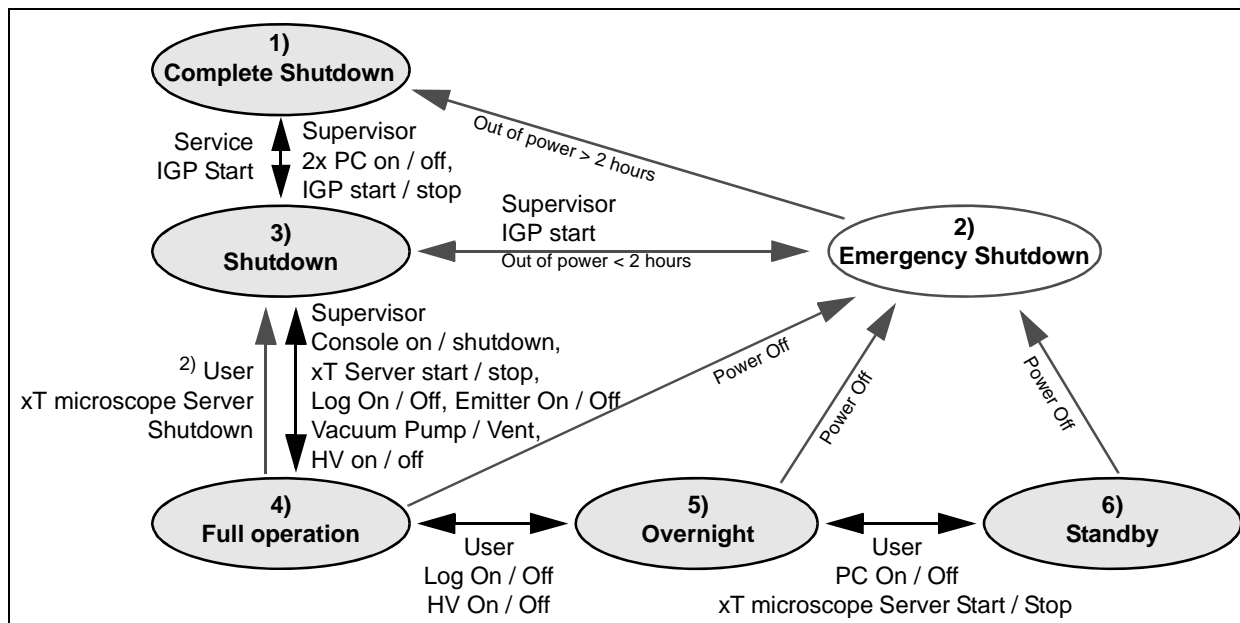
Note:
[1] Supervisor is able to switch IGPs on only a few hours after the Complete Shutdown (depending on microscope conditions). If IGPs fail to start, call an authorized FEI service engineer.
[2] xT microscope Server **shutdown** when **Emitter is On** is not optimal and sparing way for it. User should not shutdown xT microscope Server, only in case of emergency need.

STARTUP PROCEDURE GENERALLY

TABLE 3-4   STARTUP PROCEDURES GENERALLY
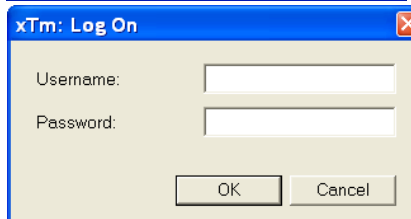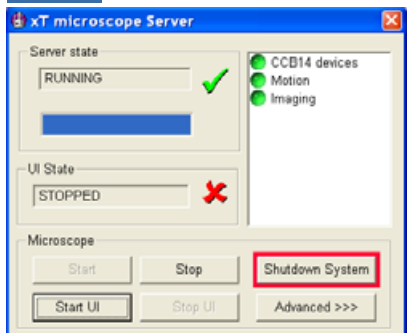
System State	Action
0. Emergency Shutdown	Before starting the system, check for the presence of electrical power, compressed air and nitrogen for venting. With the exception of nitrogen, interlocks prevent the vacuum system from operating if any of these are not present. For the following steps we assume the powered microscope.
1. Shutdown	Push the **power** button found on the front control panel of the microscope.
2. Standby	Switch on the PC. The operating system a) Windows xP loads and displays the Log On dialogue to log on the windows.
3.	Double-click the **xT microscope Server** icon to start the software. Wait until its dialogue is fully functional (All LEDs needs to be green). Click on the **Start** button.
4. Overnight	Click on the **Start UI** button to start the **xT microscope Control** software. The main window appears behind the **XTUI Log On** dialogue. Enter your **Username** and **Password**.
5.	When the xT microscope Control software is available the Beam Control Page will display on screen. Press the **Pump** Button in the **Vacuum** module at the top of the page. When the chamber icon in the Status module becomes green click the **HV** button in the **Column** module.
6. Full Operation	Select a quad, a detector and beam parameters and unpause the quad.

Note:

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

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SHUTDOWN PROCEDURE GENERALLY

TABLE 3-5   SHUT DOWN PROCEDURES GENERALLY
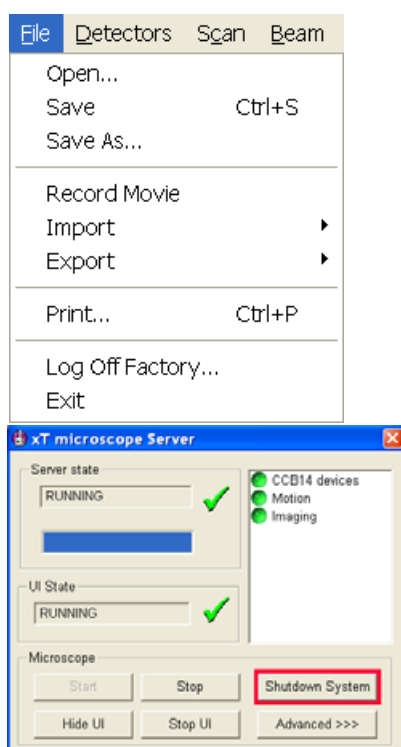
System State	Action
1. Full Operation	Switch off the High Voltage (HV button in the Column module must be grey).
2.	If needed, vent the chamber and remove your sample.
3.	**Pump** [c] the chamber to High Vacuum.
4. Overnight	Select [a] **Log Off** in the **File** menu to log off the present user and provide the **Log On** dialogue for entering another user. Switch off the monitors.
5. Standby [b]	Click the **Stop** button to stop the **xT microscope Server** software. Switch Off the both PCs and the monitors.
5. Shutdown[b]	Click the **Shutdown** button to shutdown the **xT microscope Server** software and to switch off the microscope console.
6. Complete Shutdown[d]	Go to the Shutdown state, disconnect all power supplies, inputs and outputs. Switch off the nitrogen inlet if used.

Note:

[a] 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 the user does not require Loggin off / Logging on at Windows xP level, but just restarting the UI level.

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

[c] It is strongly suggested to always leave the chamber in HiVac mode when not being used. When the sample chamber is left in the LoVac mode when the microscope is not being used, water vapour is likely to accumulate in it and the PVP lifetime decreases.

[d] 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. Normally, you would only perform a complete shutdown for transportation of the system or for service actions, like repair to essential systems.
The shutdown procedure brings the system to the non-powered state, where the vacuum in the column area is no longer supported by running pumps. All valves are closed, and the electron column and specimen chamber areas are vented.
This procedure should only be carried out by a FEI service engineer.

EMERGENCY OFF (EMO)

An emergency off is similar to that which would happen after a MAINS power off while the instrument is completely operational.

In case of emergency it can be handled by the system. Strike one of the large yellow and red EMERGENCY (EMO) buttons (if available) to switch off the electrical power completely. If there is no one present, proceed to press the breaker switch in the hole at the back of the Electronics Cabinet. This breaker switch is inside the top-back cabinet cover opening. If this is not easily accessible turn off the mains wall switch (if present), and disconnect the mains plug from the mains socket.

Note:
The EMO buttons are latching. Once pushed in, they must be rotated in the direction of the arrows to reset.

FIGURE 3-4   EMERGENCY SWITCH

Because the Emitter IGPs are supported by a UPS, which can hold it´s operation for approximatelly another 2 hours, some parts of the microscope are still under power.

Power Off

Take sufficient measures to avoid power failures as much as possible. If a power failure occurs during normal operation of the system, it comes down to a safe state and the following happens:

• The HV and Emitter are switched off abruptly.

• The specimen chamber vents gently, automatically.

• The momentary adjustments of all the system parameters (high voltage, magnification, stage positions) are lost if they were not saved.

:

4 ■ SOFTWARE CONTROL
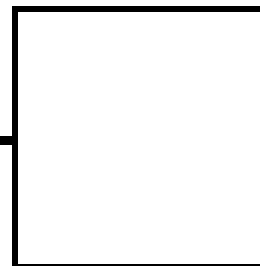
This chapter gives an overview of the **xT microscope Control** (referred to as **UI** or sometimes **xTUI** in dialogue boxes), **xT microscope Server** and **FEI User management** software, and describes the functionality of each part of the user interface. It takes you from the first main window and menu bar through each item on the pull-down menus. Graphics illustrating most of the choices help you locate specific features.

The software interface controls most system functions, including imaging, image and movie gathering / manipulation / output, detection and analysis, stage and vacuum.

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
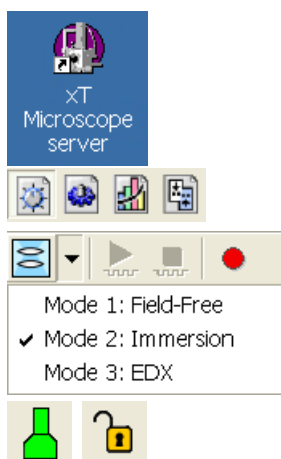
ICONS

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 any of these will cause them to press in, and when deactivated by clicking it again they spring out.

Some functional icons has 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

are activated when the cursor is left over an item on the user interface for more than two seconds. A short explanation of the item will appear 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.

Pull-down menu selections followed by 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.
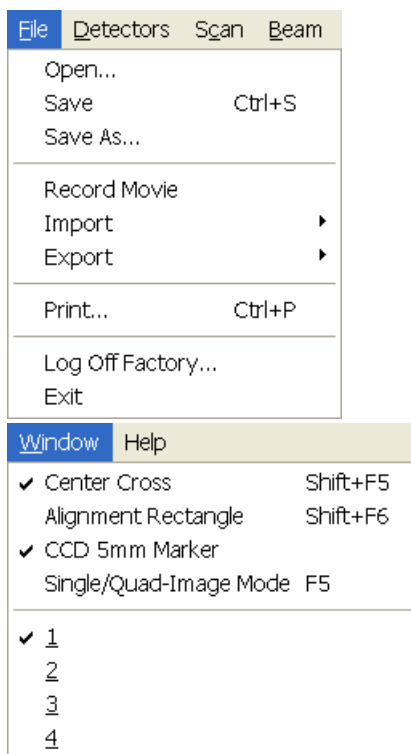
Using the Mouse

Click on the menu item in the Menu bar, then drag the cursor down to the desired selection and release the left mouse button.

Using the Keyboard

Press ALT plus the underlined letter (for example, **ALT + F** for the File menu), and then select from the choices with the left mouse button or with the up / down (left / right for submenus) arrow keys.

Some often-used commands can be quickly activated by hot 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
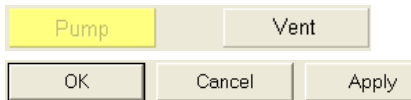
carry out or cancel functions. They press in when clicked and some change colour to show the corresponding function activity.

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

- **OK** button applies all changes made in the dialogue and closes it.
- **Cancel** button discards all changes and closes the dialogue.
- **Apply** button introduces all changes without closing the dialogue.
- **Reset** (or **Default**) button restores previous (or default) settings and leaves the dialogue opened.

LIST / LIST BOX
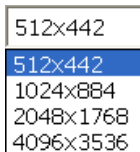
contain available choices, such as screen resolution, magnification settings, etc. Click the **List Box** to roll down all available values **List**, than click a desired value to select it and to display it as the actual one in the List Box.

PROPERTY EDITORS

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

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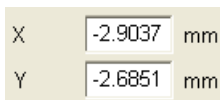
let you input text information (such as passwords, labels or precise numbers) using the keyboard. Some edit boxes, which are not part of a dialogue, require to confirm the input by pressing **Enter**. If you press **Esc** before leaving the edit box, its previous value is restored.

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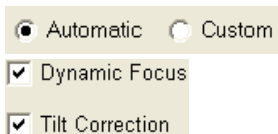
Within a group of related round **Radio buttons**, only one selection can be made active at any time by clicking in the individual box.

A single one or a group of square **Check boxes** can be switched on (checked) / Off (empty) by clicking in the individual boxes.

ADJUSTERS

allow to change parameters, such as contrast, brightness, gamma etc. in a continuous way by clicking 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.

Continuous Adjuster

- The **large adjuster** – for relative adjustments
  It has exponential response – the further from the center the adjuster button is pulled, the larger is the relative change.
  The adjuster button always snaps back to the center of the slider.
- The **slider** (grey bar) – for larger adjustments.
- The **end arrows** – for finer adjustments, single step increments.
- The **small adjuster** – for linear adjustment, continuous response
  The adjuster button position always corresponds to the actual parameter value within an available range.

Linear Continuous Adjuster

This is a linear response adjuster. Behaviour is the same, as for the Small adjuster (see above).

Preset / Continuous Adjuster

is used for values that have both a continuous range and a list of presets to achieve total control over one function. Items on the slider / drop-down change according to the function chosen. The button on the left side of the adjuster toggles between modes:
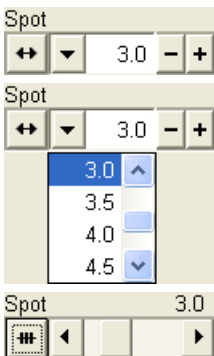
- **Drop-down list:**
  clicking on the -/+ buttons on the right of the drop-down menu steps through the values Up / Down in the list (given in the Preferences for that particular parameter), but only shows one value at any time in the text area. Clicking on the down-arrow next to the toggle button causes the drop-down list to appear. If the list extends further than is visible, a scroll adjuster appears on the right side of the list. Clicking on a value in the list highlights that value and enters it as current value in the text area displayed at the top.
- **Adjuster mechanism:**
  The adjuster has fine control of the values, see above.

Spinner

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

The arrows direction (left-right or up-down) can be changed in General Prefferences.

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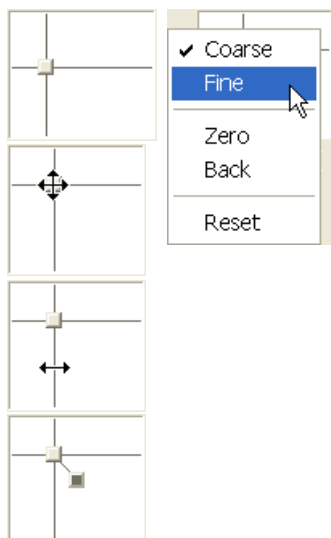
are represented by an X-Y box. The position of the crosshair corresponds to the actual parameter value with respect to its full range being represented by the perimeter of the box.

Click and hold down the crosshair with the left mouse button to display a 4-axis arrow cursor in the imaging area, which can be moved in four directions that correspond to the X / Y screen values. Clicking the X / Y axis in the same way displays a 2-axis arrow cursor, which can be moved in the corresponding direction. To fix the values, release the mouse button and the position of the crosshair is updated.

Clicking inside the 2D box with the right mouse button opens a dialogue showing the choices:

- **Coarse** / **Fine** switches the 2D control sensitivity.
- **Zero** – brings the 2D control to the center of the box.
- **Back** – brings the 2D control one step back (only one step is remembered).

The menu may contain also other functions that are actually available for the particular parameter. Select the corresponding menu item to activate the function.

- **Reset** – brings the 2D control to the preset value (only available for the Beam Shift)

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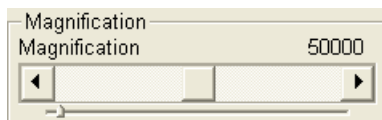
visually combines various software elements, which are related into a labeled group. Complex software elements like UI pages or dialogues are typically composed of modules.
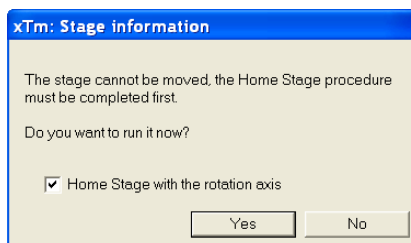
DIALOGUES

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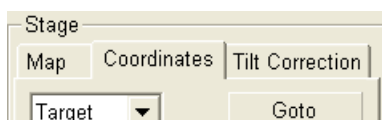
In modules or dialogues containing more interface elements than would fit into the limited area the **Tabs** are used. These related elements are splitted into the groups (sections) and each one is supplemented with the labeled Tab. Clicking the Tab brings it to the foreground displaying the corresponding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

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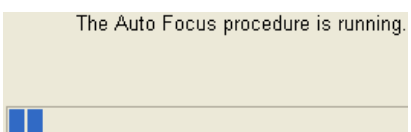
indicate progress of a long ongoing procedure over time. It is often displayed in a dedicated dialogue.

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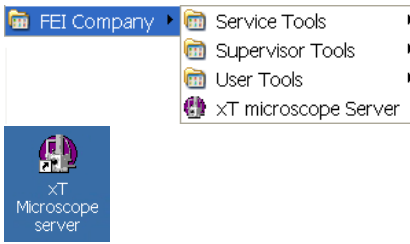
The **xT microscope Server** application starts and stops the software service controlling basic microscope functions and also the user interface (UI) software **xT microscope Control**.

Double-click on the icon found on the Windows desktop. The main **xT microscope Server** window appears. Once it is established, clicking with the right mouse button on the title bar opens a dialog that offers the option to minimize the server to the top bar of the UI.

FIGURE 4-1   XT MICROSCOPE SERVER WINDOW
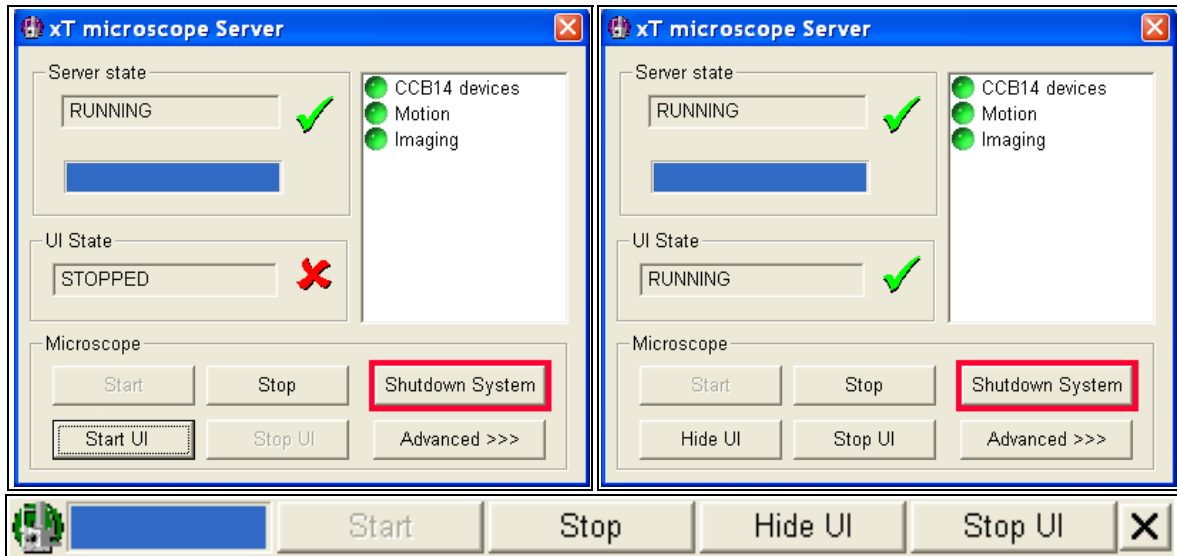
Server State / UI State modules

display the **RUNNING** or **STOPPED** state of the xT microscope Server services (**Server State**) and of the xT microscope Control software (**UI State**). During a transition between these states **STARTING** or **STOPPING** is displayed.

Microscope module

Here you can find commands:

- **Start / Stop** buttons starts / stops xT microscope Server services. If the xT microscope Control is running, Stop button closes it first.
- **Start UI / Stop UI** buttons opens / closes xT microscope Control UI.
- **Shutdown** button (available only for the Supervisor users) shuts down the microscope console. If the xT microscope Server and/or Control is running, it is stopped first. The console power supply is switched off, only the IGPs continue running. (Pushing the power button found on the front microscope console control panel switches it on again.)
- **Advanced** button displays **Administration** module containing detailed settings and operational conditions used for accurately specifying the software operation / hardware function state when calling the service.
  When the **Autorun UI** checkbox is checked, the Start button in Microscope module automatically starts xT microscope Control after starting the Server.
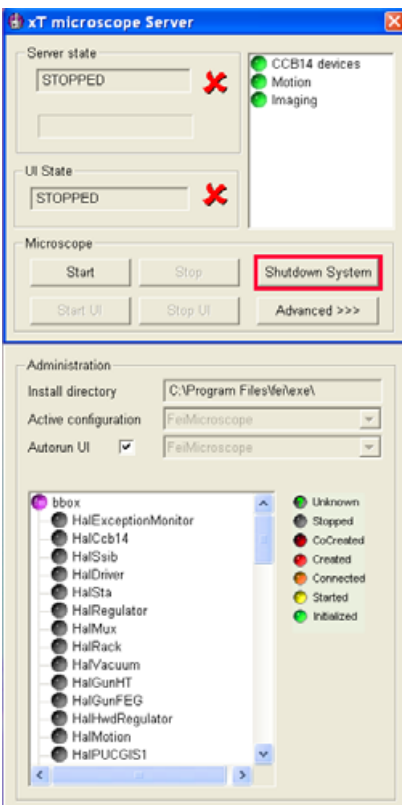
xT microscope Control Software

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

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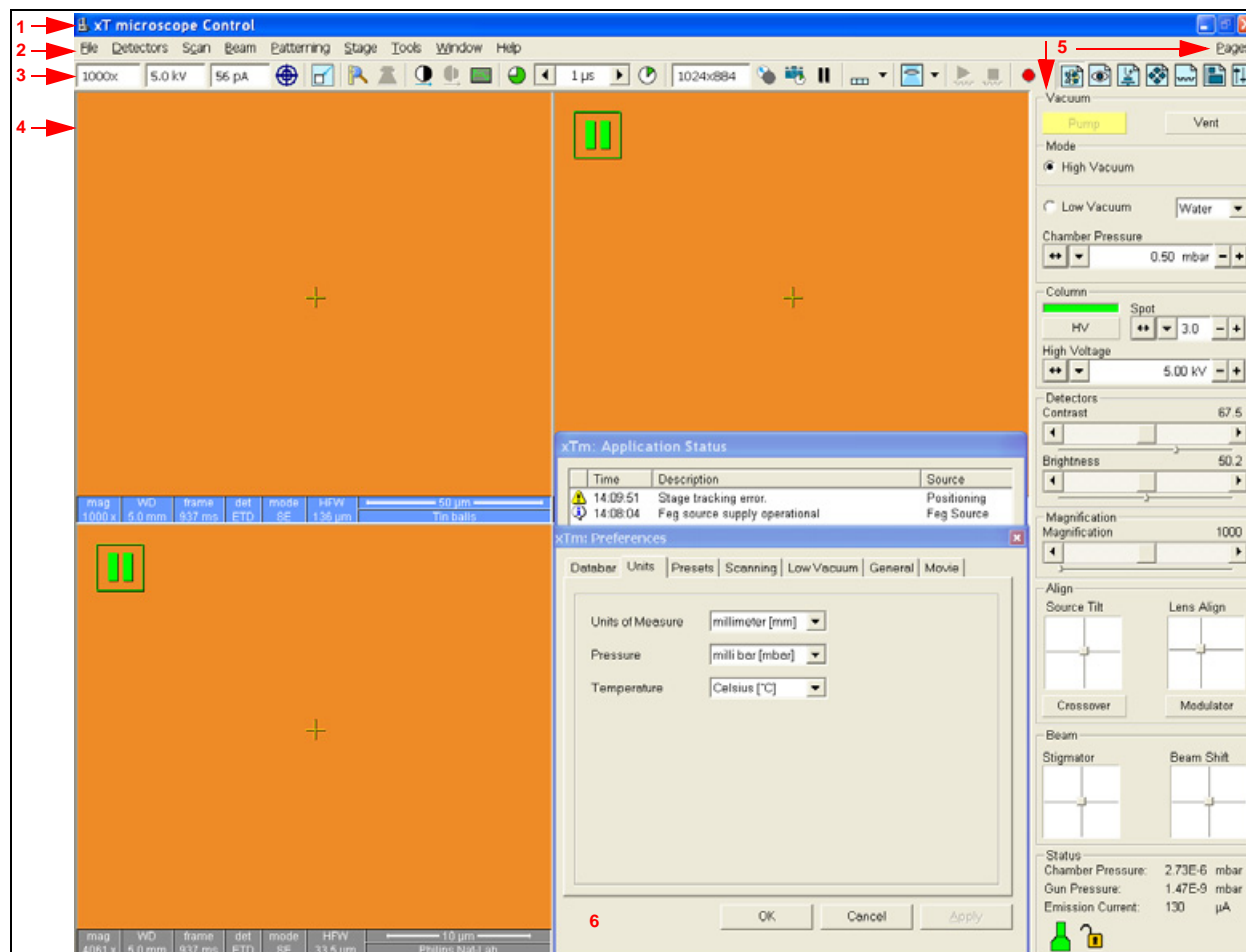
1. The **Title Bar** – labels the application
2. The **Menu Bar** – contains all operation menus and submenus
3. The **Toolbar** – contains functional icons for the most frequently used microscope controls and for the fast acces to the Pages
4. **Image Windows** – image windows with adjustable Databar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

:

THE TITLE BAR

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

FIGURE 4-3   THE TITLE BAR

The Maximize button is disabled because the UI already covers the whole screen. The Close button quits the xT microscope Control software (accelerating voltage and Immersion lens voltage are switched off for the security reasons).

THE MENU BAR

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

FIGURE 4-4   THE MENU BAR
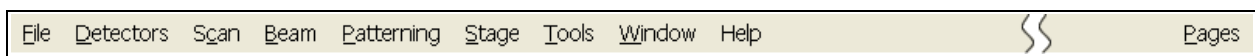
The following menus are available:

TABLE 4-1   PULL-DOWN MENU LIST

Menu Item	Use
File	Administrative files functions
Detectors	Selection of the installed detectors
Scan	Scanning control
Beam	Beam conditions settings
Patterning	Patterning process control (optional)
Stage	Stage navigation and corrective functions
Tools	Auto functions and other useful tools
Window	Switching of windows / modes and image markers
Help	Displaying and system information

Select pull-down menus from the menu bar by pressing:

- the left mouse button on the Menu title
- ALT + underscored keyboard letters
- ALT and then use 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.
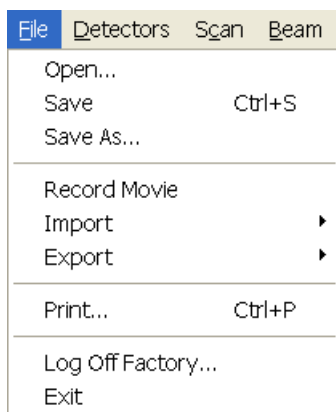
The File Menu (Alt + F)

opens File menu administrative functions:

Open

displays a standard dialogue for opening images previously stored to a media. Supported file formats are TIF, BMP and JPG, but only file saved from xTUI in **TIF** format contains the Databar information.

The dialogue displays, by default, the location (path) last used to open or save files from 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 (by default, but not limited to 3 digits) ensures that every image is saved as a new file (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 **TIF**, **JPG** or **BMP** format.

FIGURE 4-5 SAVE AS… DIALOG
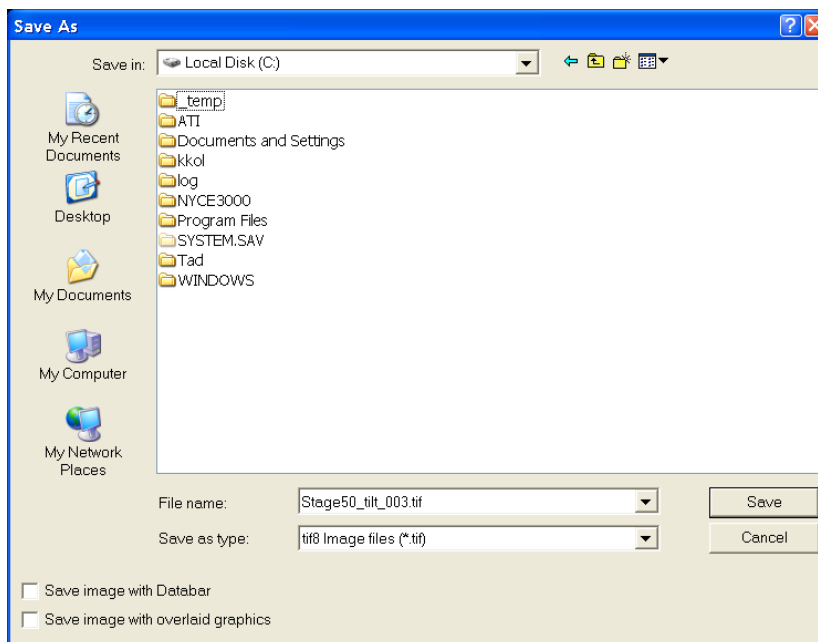
The dialogue displays, by default, the location last used to save or open files from xTUI and the name last used in the current Quad. The user can change a location, base name, incremental suffix format, image type format (**Save as type**), and also choose whether to **Save** the **image with** / without **Databar** and **with** / without **overlayed graphics** by checking / unchecking appropriate check box. The settings is remebered per Quad and used for the subsequent Save actions.

Record Movie

allows the 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 indicate that the movie recording is active. See Chapter 5 for a detailed description.

Import / Export

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

- **Stage Positions** stored with the use of the Stage module (.**stg** files)
- **Patterns** created with the use of the **Pattern** module (.**ptf** files)
- Current operation **Parameters** / microscope settings (.**par** files)

FIGURE 4-6 FILE IMPORT / EXPORT MENU
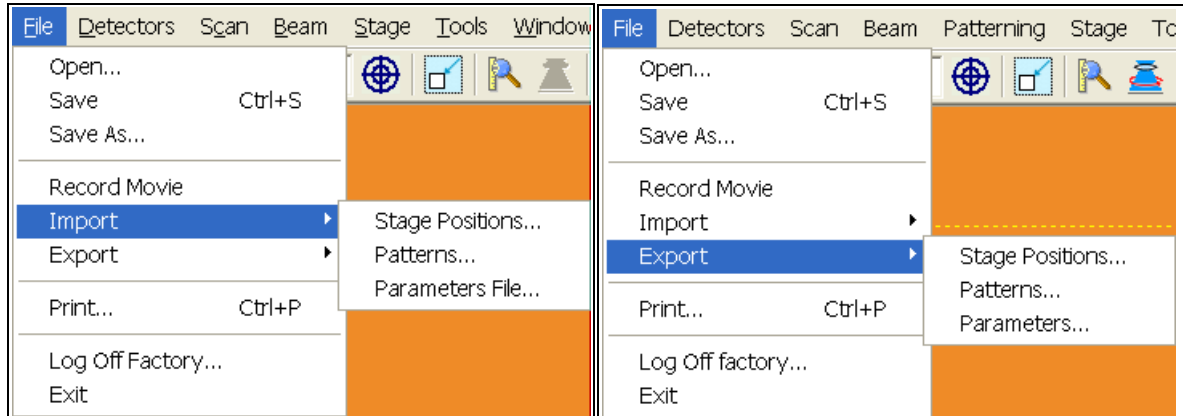
Print (Ctrl + P)

opens the Print dialogue so that the choice of printer and conditions
can be established to print an image or any other printable product
from the microscope. Pressing **OK** in the printer dialogue starts the
printing the job.

Log Off *User*

logs off the present User and provides Log On dialogue for the next
user of the microscope. When the User logs off the system goes to a
safe state: the HV and Immersion lens are switched off automatically.

Exit (Alt + X)

closes the xT microscope Control software (the current user is
automatically logged off first) and leaves the user in the operating
system environment. xT microscope Server is still running and
controls the microscope in operation.

The Detectors Menu (Alt + D)

opens the selection of all installed Detectors.

Detectors not mounted or not serviceable under the current
microscope conditions are disabled (greyed out). The selected
detector for the active Quad shows a tick next to its label.

The selected detector settings (mode, grid voltage, used segments,
etc) can be dynamically changed in the **Detector Settings** module.

The Scan Menu (Alt + S)

opens the Scan menu functions:

Pause (F6)

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

Select Pause / press F6 / click the Pause icon once / twice (double-click) to stop scanning at the end of the current frame / immediatelly.

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 Pause / press F6 / click the Pause icon once to release the pause function (the icon button pops out) and to return the scanning to the previous state.

Clicking the Pause icon while holding the Shift key pauses / unpauses all Quads with a SEM image at once.

Snapshot (F4)
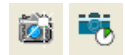
activates a single preset scan which pauses at the end of the frame. The result can be automatically stored with the File / Save or Save As function. Conditions for this function are defined in the **Preferences… / Scanning** tab.

Photo (F2)

activates a single preset high resolution slow scan which pauses at the end of the frame. The resulting image can be stored with the File / Save or Save As function. Conditions for this function are defined in the **Preferences… / Scanning** tab.

Videoscope (F3)

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

Reduced area (F7)

This mode is useful when focusing and stigmating as the scan speed is faster in the smaller area. When Reduced area is chosen, the small green area frame appears at the last known place on the screen, its area and position are adjustable by mouse. 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 four-ended arrow. Click and hold the left mouse button, drag the selected area to the desired position and release the mouse button.
- **Changing the size:**
  Place the mouse cursor over the edge of the selected area. The cursor changes to a two-ended arrow, either horizontal or vertical. A corner can also be used to move two sides at one time. Now drag the side out or in to obtain the desired size and release the mouse button.
- **Making a new one:**
  Place the cursor outside of the selected area. The cursor should be the normal arrow symbol. Move the cursor to where you want the left upper corner of the selected area to be. Click the left

mouse button and drag the cursor until the rectangle on screen includes the area you want to select. Release the left mouse button.

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

Full Frame (Ctrl + M)

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

Spot

brings you to Spot mode. The image pauses and the scaning is switched off. The current beam position is represented by a green cross in all paused SEM images. You can drag the beam around the screen with the left mouse button.

Line

brings you to Line mode. The green horizontal line is displaed in all paused SEM images. The beam scans along this line, using the line time defined for the selected scan speed. You can drag the line up / down with the left mouse button.

External

switches the scanning control from the internal scan generator to an external one or to any external beam position control, using the specific hardware input. In this mode, it is not possible to obtain a live image, except of the optical image. A 3rd party application (such as an EDX system) can build up the microscope image using the active detector signal, available from the specific video output. By default, the detector selected in the quad 1 is active.

Beam Blank (Ctrl + B)

deflects the beam off axis high in the column and protects the specimen from unnecessary exposure to the beam. This is useful at the end of scanning when ready to save the image so that the specimen is not continuously scanned before the next image.

When the beam is blanked the toolbar icon button is pressed. Clicking again on the button will release the blanker and return 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, held in the **Preferences… / Scanning** tab.

Slower / Faster Scan (Ctrl + , / .)

set the dwell time to the next Slower (left / up arrow) / Faster (right / down arrow) value. The spinner box shows the current dwell time, but does not enable to change or select directly its value - the values are changed one step up or down according to the set defined in **Preferences… / Scanning** dialogue.

Mains Lock

When ticked (default after the xT microscope Server start), the scanning (line or frame sawtooth signal) is synchronized with the mains AC oscillation. This greatly diminishes blurring and jittering of the SEM image resulting in smooth image edges at higher magnifications and slow scan conditions. It has no influence on fast scan images.

Live

leaves the image unfiltered for collecting raw direct images
- one frame follows another.

Average

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

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

Integrate

allows accumulative noise reduction by true integration over a
specified number (two or more) of frames. This process will continue
until the selected number of frames is reached and then pauses the
Quad automatically.

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

Note:
Clicking on 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 currently active
Filter Mode indicated by the icon image for the active Quad). Clicking
on 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 images
can be observed at the same time. The Filter Mode and Number of
Frames can be pre-set also for the Snapshot and Photo functions in
Preferences… / Scanning.

The Filter is set independently also for the CCD images. The Integrate
function is not available for them, and using averaging with more than
4 frames is not recommended, especially when moving the stage.

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 image relative to a specimen feature and/or detector direction.
See Chapter 7 - Stage Related functions for details.

A non-zero scan rotation is indicated by an icon in the **Status** module,
and its value can be also displayed in CCD Quads.
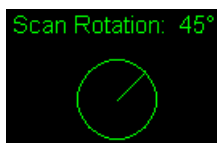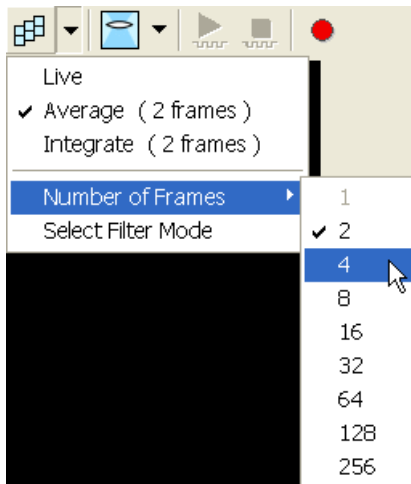
The Beam Menu (Alt + B)

opens the Beam menu functions:

SEM Aperture

opens sub-menu for selecting the final lens aperture. The selected
aperture size (marked by a tick) influences the Beam Current values
displayed in the Beam Current listbox and in the Databar.

If the microscope is equipped with the Automatic Aperture mechanism
(AVA), the selection causes the aperture strip to move to the
corresponding pre-defined position.

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:
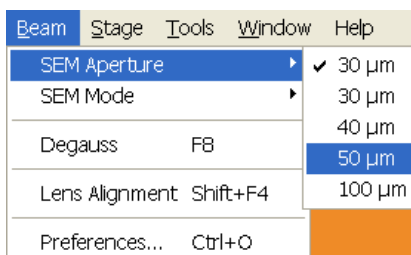
SEM Mode

opens sub-menu for selecting the electron
imaging mode (see Chapter 3). The current mode is marked by a tick
next to its name. If Mode 2 is currently unavailable (due to unsuitable
Magnification, High Voltage and/or Working Distance), the
corresponding menu item is greyed out.
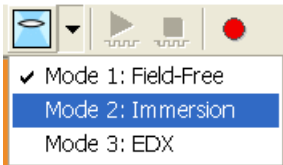
Clicking on the down-arrow next to the toolbar icon displays pull-down
menu items Mode 1 / Mode 2 / Mode 3 corresponding to the **Beam** /
SEM Mode sub-menu. Clicking on the icon itself switches the SEM
mode between Mode 2 (if allowed) and Mode 1 or 3 (the last used
one). The icon image changes to indicate the current SEM mode.

Degauss (F8)

triggers the degauss procedure appropriate for the current SEM
Mode. The procedure puts all currently used electron lenses in a
normalized state by removing their hysteresis efects. For a few
seconds while the procedure is running all live images disappear or
turn fuzzy, and than returns back.

Use this function with (almost) focused image to obtain the most
accurate Magnification, HFW and Working Distance readouts.

Lens Alignment (Shift + F4)

toggles lens alignment mode for the objective fine alignment. The
scanning condition changes to a fast scan, lens modulator turns on
and a green target cross appears in the center of all SEM image
Quads.

Pressing and holding the left mouse button activates a 4-arrow ended
cursor. The mouse motion starts the final lens alignment (see Chapter 6).

The Patterning Menu (Alt + P)

is for executing Patterning functions:

Start / Pause / Resume Patterning

begins patterning with the pattern selected on the Patterning Page.
When the patterning is active, the menu item and the corresponding
toolbar icon changes to **Pause Patterning**. When the patterning
process is paused, both the menu item and the icon changes to
Resume Patterning.

Reset Patterning

stops the patterning process and resets it to the beginning.

Next Pattern (Ctrl + Shift + N)

In serial patterning the current shape patternin is stoped and the
procedure continues with the next shape (if present).

Next Line (Ctrl + N)

When milling a Cleaning Cross Section shape, milling of current line is
cancelled and continues with the next one.

Note:
When a patterning is started and a necessary condition is not fulfilled,
a descriptive warning message appears in the Application Status…
dialog.
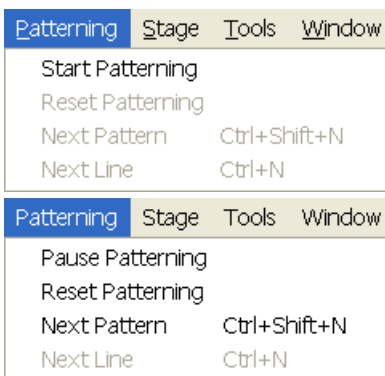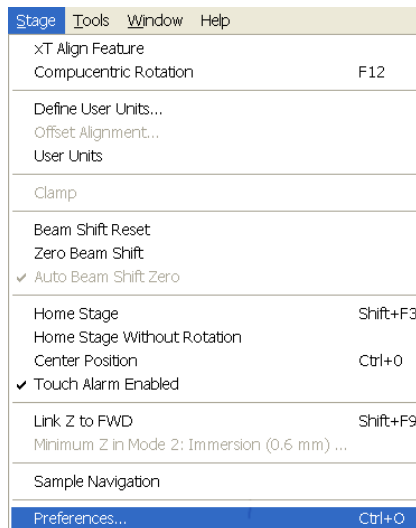
The Stage Menu (Alt + S)

opens the Stage menu functions:
(For a detailed description of the stage functions see Chapter 7 "Stages".)

xT Align Feature

opens a procedure that helps one to navigate along a feature that extends off the screen at the current magnification.

Compucentric Rotation (F12)

places a green circle in the active quad. By rotating the circle a different viewing orientation of the sample area can be achieved by 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 "7 - Stage Rotation Centre" alignment should be performed to locate the stage center and calibrate stage (see Chapter 6 "Alignments").

Define User Units…

activates a series of dialogues that guide the user to determine User Unit values for X and Y movements of the stage. These are used in relative movements associated with the stage mapping of regular features, in particular in IC applications.

Offset Alignment…

allows you to move to new points relative to the existing alignment but at a new location, for example, stepping between identical points on different dies quickly.

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 and are shown in the Location module by the UU symbol.

Clamp

toggles on / off a mechanical stage clamp in order to prevent stage vibrations during high resolution imaging.This menu item is greyed out on systems without a securing Clamp (50 x 50 mm stage).

Beam Shift Reset

zeroes the beam shift. A feature observed with a non-zero Beam Shift is automatically moved back to the image 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 sets beam shift to zero during each 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 stage homing the Stage Information dialogue displays its progress.
The stage axes are moved to their end-switches in the following order:

1. **Z**: to the lowest position
2. **T** (tilt): to maximum
3. **X / Y / R** (rotation): at the same time

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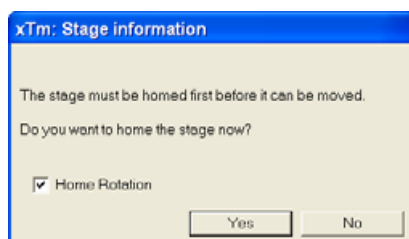
When the stage is homed correctly it will end up in the folowing position:

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 reference for Rotation is greyed out. This is useful when a large specimen is inserted and stage rotation could cause a collision with equipment inside the chamber.

By default the function is enabled and automatically reverts back to the enabled status after every venting / pumping cycle.

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 Immersion lens or any other equipment conductively connected to the chamber.

Link Z to FWD (Shift + F9)

sets the Z coordinate value to actual Free Working Distance (FWD) value. This allows accurate movement between the known height of the sample and the end of the Immersion lens.

Activating this procedure for the first time asks a user to focus the highest specimen point to define the FWD accurately.

The related toolbar icon image changes according to the Z-coordinate status:

- **Greyed icon** (not depicted): the function is disabled because either the stage has not been homed or the HV is switched off (so there could be no SEM image).
- **Red question mark**: the function is enabled and the link between Z and FWD is unknown. Use the function as soon as possible, after properly focusing the image.
- **Red circle**: Z is roughly linked to FWD, but it needs correction. The function is enabled. It happens e.g. after: changing the specimen, focusing and linking Z to FWD at a long Working Distance and then moving the stage to a short WD. Focus image carefully at a WD around 5 mm and use this function again.
- **Green double-ended arrow**: 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. The function is still enabled to allow further corrections of the Z-coordinate.

Minimum Z in Mode 2: Immersion

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

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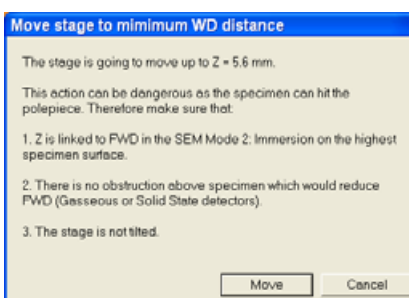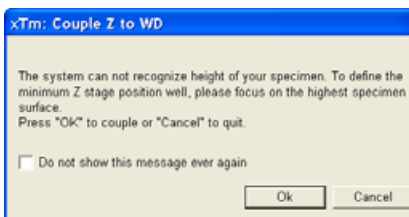
Sample Navigation

toggles on / off function that enables to navigate live SEM images (scan field) towards desired places on a specimen using either paused or loaded image of that specimen (usually taken at much lower magnification - see Navigation Montage below).
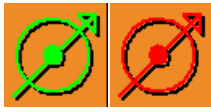
The Sample Navigation can be selected independently for any Quad, regardless of its current content and status. A tick next to the menu item indicates that the function is selected for the active Quad. As soon as this Quad is paused, the Sample Navigation indicator appears in the upper right corner of the Quad. The indicator is green as long as the paused image can be used to navigate the live images, otherwise turns read (e.g. when the stage rotation or tilt changes).

The Tools Menu (Alt + T)

opens the Tools menu functions:

Auto Contrast Brightness (ACB) (F9)

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

User Auto Contrast Brightness

examines graylevels of the active Quad image and stores their minimum and maximum. Next time the ACB function is used, it atempts to set the Contrast and Brightness so that the resulting image graylevels lies between this minimum and maximum instead of full black and white.

A tick next to this menu item indicates that the user grayleve limits are active. When selected again, the tick disappears and the ACB reverts to its default setting.

Auto Focus (F11)

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

Note:
When activated ACB / Auto Focus the dialogue appears to show the progress. The function can be interrupted by clicking the **Stop Now** button, which leaves the image / the focus (WD) at the current stage of progress. Clicking the **Cancel** button before the function ends returns the image back to its original status / the original WD value.
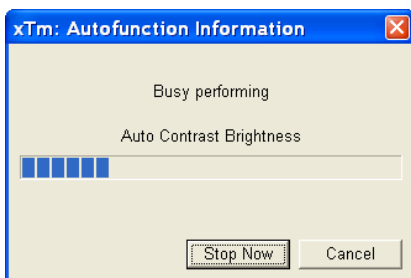
Set Default Parameters (Ctrl + D)

loads default settings for the current **Vacuum Mode**. The function 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 an usable image immediatelly.

Display Saturation (Shift + F11)

displays signal clipping in the active Quad by means of replacing the full black / white with dark blue / yellow colour. The function can be used both for live and paused SEM images, but cannot be applied to the CCD image.

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

Lab Notes…

opens the Windows NotePad application above Quad 4 for the 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 tabbed dialogue above Quad 4 for setting up a collection of sequenced TIF images, and sequencing them into an AVI movie. See Chapter 5 for a detailed description.

Navigation Montage...

This procedure takes an image of the sample to be used for the Sample Navigation (see Chapter 7).

Application status…

displays a dialogue above Quad 4 showing continuously updated system messages.

- **Pop-up on Message Severity**: None / Error / Warning / All specifies which kind of messages is going to be shown automatically on screen.
- **Clear** button clears all current 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 4-7   APPLICATION STATUS

The Window Menu (Alt + W)

opens the Window menu functions:

Center Cross (Shift + F5)

places a cross in the center of all SEM image 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.
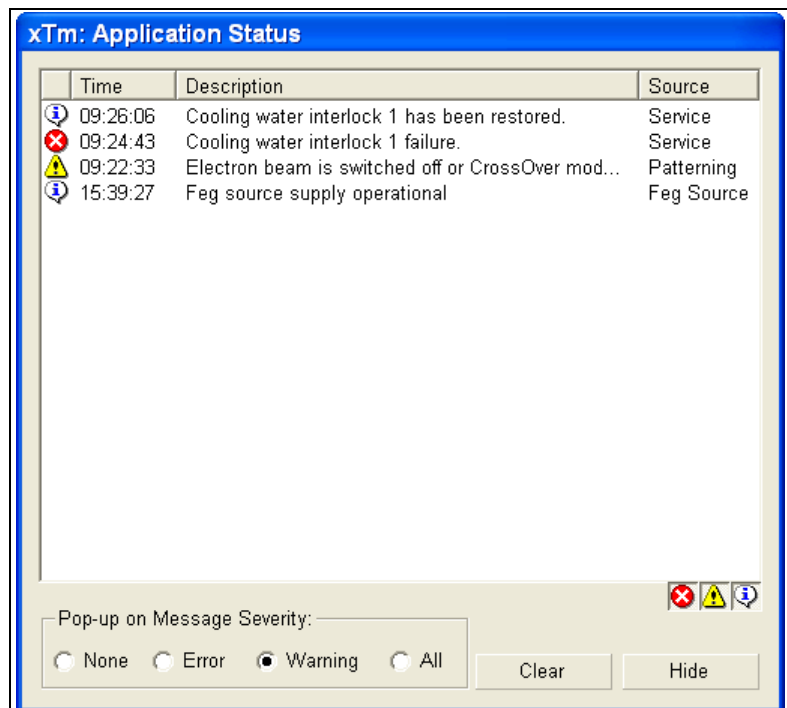
Alignment rectangle (Shift + F6)

places a dashed rectangle in the center of all SEM image Quads. This function is used in Alignment procedures to aid illumination control.

CCD 5 mm Marker

places a short horizontal line with 5 mm label in all CCD Quads (not in CCD II) 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 with the left mouse button and by confirming this action in the popped up dialogue.

Single / Quad-Image Mode (F5)

toggles the image display area between two posibilities:

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

1 / 2 / 3 / 4

selects the Active Quad (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. When in the Single Image mode, the selected Quad is displayed.

:

The Help Menu (Alt + H)

opens the Help menu functions:

Online Documentation… (F1)

The Help dialogue is displayed over Quad 4 at startup, but it can be moved or expanded using the icons in the upper right corner of the dialogue. The dialogue remembers its position and size for the next showing up.

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

FIGURE 4-8   ONLINE DOCUMENTATION .
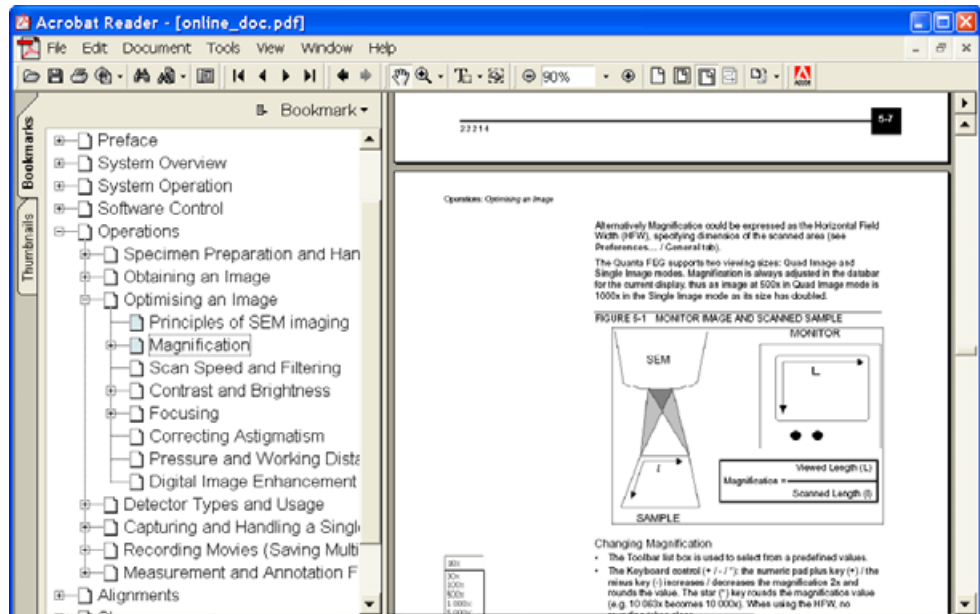
About xTUI…

displays a borderles window with a Nova NanoSEM picture containing information about the system configuration and the software version. The window automatically disappears after the first mouse click.

THE 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 depending on the system configuration or user preferences (see **Preferences… / General** tab in Chapter 5 "Operations").

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

FIGURE 4-9   THE TOOLBAR
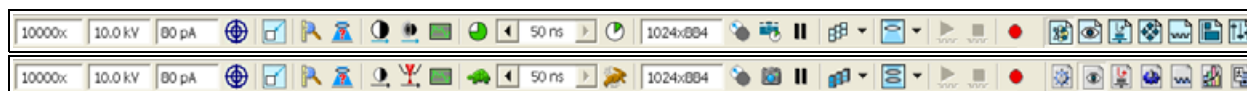
Rest the cursor on the icon for two seconds without clicking on it to see its explanatory tool-tip.

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

Magnification / HV / Beam Current List Box

Click the list box to open a selection of the pre-set and currently allowed values, choose one and it is applied immediatelly. The list of pre-set values can be modified in the **Preferences… / Presets** tab.

- The **Magnification** range differs for different Lens Modes, and in Immersion mode dynamically changes with the Working Distance and High Voltage.
- The **High Voltage** range changes in Immersion Lens mode, where the High Voltage values are upper-limited depending on the Working Distance.
- **Beam Current** range updates immediatelly when the SEM Aperture is changed. Beam current values corresponds to the pre-set Spotsizes (see Column module) and to the selected SEM Aperture (see the Beam menu). Changing the Beam Current from the drop-down list has the same effect as changing the Spotsize via the Spot adjuster.

Pixel Resolution List Box

contains list of the image sizes (pixel resolutions) available for viewing or recording a SEM image. Selecting a new resolution results in the immediate change of the scanning raster and since the current dwell time remains unchanged, the actual scanning frequency (both Line and Frame time) changes.

IMAGE WINDOWS

The xT microscope Control software displays images via 4 independent image windows called **Quads**. All Quads can contain live image from any detector (including External and CCD), paused images or images loaded from a file. Additionally, Quad 3 can display a mix of images from Quads 1 and 2, and Quad 4 can display a mix of images from Quad 1, 2 and 3.

The four Quads can be displayed either all at the same time in **Quad Image Mode** or one zoomed Quad at a time in **Single Image Mode**.

Each Quad consits of its image, adjustable Databar containing the image parameters, selectable overlay (user-defined colouring, annotations, measurement and patterning shapes) and some status symbols (Pause, Sample Navigation, etc).

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

Depending on the Quad content and status, some mouse functions are available over its area (see table 4-6 for details):

- **SEM image** (incl. External and Mix): focus, stigmate, Lens Align, Beam Shift, change magnification (coarse, fine)
  live: XY-move (get or tracking mode), (un)zoom
- **CCD image**: place 5 mm Marker; **live**: Z-move (tracking)

Note:
Due to a hardware limitations, some detectors cannot be displayed live simultaneously (e.g. ETD and TLD, or LVD and Helix). 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 Databar

displays Instrument, Image and labelling information. This can be a combination of Date, Time, HV, Detector, Stage coordinates, for instance. They can be placed in any order and will expand or contract to fit the Quad width as long there is enough room. The micron bar is always displayed above the user's label area.

Setttings in the Data Bar can be changed in the **Preferences… / Data Bar** tab (see Chapter 5 "Options").

FIGURE 4-10 THE DATA BAR EXAMPLES

Active SEM Quad		
Inactive SEM Quad		
Active Optical Quad		
Active Patterning Quad		
Inactive Patterning Quad		

Active SEM Quad

mag	WD	HV	det	mode	frame	500 µm
100 x	5.0 mm	10.00 kV	ETD	SE	747 ms	Quad1: Overview image

Inactive SEM Quad

mag	WD	HV	det	mode	frame	500 µm
100 x	5.0 mm	10.00 kV	ETD	SE	747 ms	Quad2: Averaged image

Active Optical Quad

10/23/2004	det	x: -367 µm	z	tilt	
2:41:48 PM	IR	y: 2 mm	5 mm	0 °	

Active Patterning Quad

mag	WD	HV	det	mode	frame	4 µm
10000 x	5.0 mm	10.00 kV	ETD	SE	5.62 s	Electron Patterning

Inactive Patterning Quad

mag	WD	HV	det	mode	frame	4 µm
10000 x	5.0 mm	10.00 kV	ETD	SE	5.62 s	Electron Patterning

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

PAGES AND MODULES

The software controls on the right side of the screen are organized into **Pages**. Pages are further divided into smaller **Modules** that hold specific functions. The frequently used controls appear as modules on more than one page. The required page can be selected either from the Pages menu or by pressing the corresponding icon button on the right side of the toolbar.

TABLE 4-2   PAGES LIST

Pages	Modules (Tabs)
Beam Control	1. Vacuum / Mode, 2. Column, 3. Detectors, 4. Magnification, 5. Align, 6. Beam, 7. Status
Detectors	1. Vacuum / Mode, 2. Column, 3. Detectors, 8. Detector Settings, 6. Beam, 7. Status
Beam Deceleration Control	2. Column, 9. Beam Deceleration, 3. Detectors, 8. Detector Settings, 6. Beam, 7. Status
Navigation	1. Vacuum / Mode, 2. Column, 3. Detectors, 10. Stage (Map / Coordinates / Tilt Correction), 7. Status
Patterning (option)	11. Pattern / Progress (Basic / Advanced), 12. Gas Injection (Overview / Details), 7. Status
Processing	13. Measurement / Annotation, 3. Detectors, 14. Enhanced Image (Lut / Mix 3 / Mix 4 / Color), 7. Status
Alignments	15. Alignments (Instructions / Individual steps), 7. Status

Note:
The number before the module name represents an order in which the modules are introduced in the following text.

1. Vacuum / Mode module

The module is used to control the pressure and the gas type in the specimen chamber (see Chapter 3).

The Pump Button starts the pumpdown procedure for the specimen chamber. The system allows high voltage to be switched on only when the chamber is sufficiently evacuated.

The Vent Button displays the confirmation dialogue and then proceeds to vent the chamber. The Column vacuum is not not affected.

The Mode Radio Buttons bring the system to either **High Vacuum** mode operation when observing conductive specimens or to the **Low Vacuum** mode for observing non-conductive or partially conductive specimens
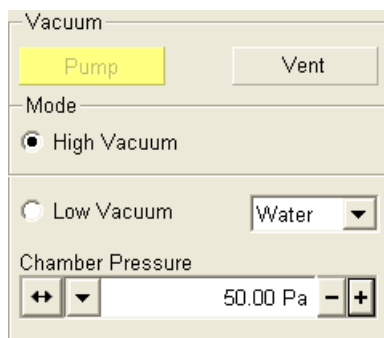
2. The Column Module

contains controls for setting the electron beam conditions:
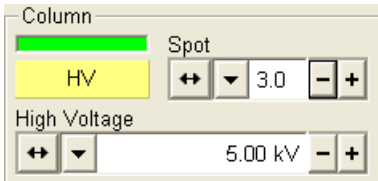
HV Button

This button switches on / off High Voltage and opens / closes the Column Isolation Valve (CIV). When activated / deactivated, the button changes from gray to yellow / yellow to grey.

High Voltage Preset / Continuous Adjuster

This adjuster enables to adjust the overall electron beam acceleration voltage either continuously or using the pre-set values. The current High Voltage value is displayed in text area of the adjuster and in the Databar (if selected). The pre-set list can be modified in **Preferences… / Presets** dialogue.

The High Voltage can be set in 100 V steps from 200 V to 30 kV in SEM Modes 1 and 3. In Mode 2, the upper limit dynamically changes (down to less then 1 kV) according to the current Working Distance.

Spot Preset / Continuous Adjuster

This adjuster enables to adjust the beam **Spot size** numbered from 1 to 7 in 0.1 steps. The current Spot size is displayed in the text area of the adjuster and in the Databar (if selected).

The Spot number influence both the size of the focused electron beam and the Beam Current displayed in the toolbar (and in the Databar, if selected). The lower the Spot number, the lower is the Beam Current. The Spot size change causes to happen the Beam Current change, and vice versa.

3. The Detectors Module

contains continuous adjusters (described in detail in the beginning of this chapter) to control the Contrast and Brightness of the active detector..
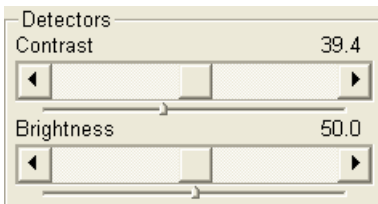
These adjusters are always linked to the detector selected in the active Quad. Since each Quad can display different detector with different Contrast and Brightness settings, the values and the small slider positions changes when changing the active Quad or selecting a different detector. The adjusters are disabled if the active Quad detector is not available or cannot be controlled (e.g. CCD camera or an External detector).

The Contrast / Brightness Continuous Adjuster

controls the contrast (gain) / brightness (offset) of the active detector. Regardless of the detector actual gain range, the Contrast range is always 0 - 100 (%) and the small / large step is 0.1 / 1. The Brightness range step size may differ from 0.1 / 1 for some (especially Low Vacuum) detectors in order to achieve sufficient sensitivity. A more precise number can be entered by double-clicking on the Contrast / Brightness value.

4. The Magnification Module

The Continuous Adjuster offers a variety of ways to control the current image magnification (see Continuous Adjuster description in the beginning of this chapter). The small linear adjuster position corresponds to the current magnification. The magnification range changes dynamically according to the current SEM Mode and Working Distance. The large relative adjuster sensitivity is set as follows:

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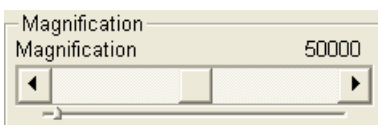
- Clicking **between** the **end arrow** and the **button** increases magnification by about **20%**.

The Magnification can also be controlled using the mouse wheel and using the numeric keyboard:

- **Ctrl + mouse wheel**: coarse control
- **Shift + mouse wheel**: fine control
- *** (star)** key rounds off the magnification value.
- **+ / -** key increases the magnification **2x** up / down and rounds it off.

5. The Align Module

displays controls for user beam alignments.
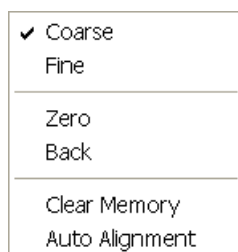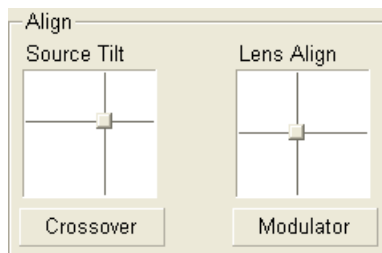
The Source Tilt 2D Control

enables to fine-tune FEG source apparent position with respect to the final lens aperture. Use it to manually centre the illumination in Cross Over mode (or maximize the image brightness in normal imaging mode), especially for Spots bigger than 4.

Pressing the right mouse button above the Source Tilt control displays a pop-up menu with the following functions:

- **Coarse** / **Fine** switches the 2D control sensitivity.
- **Zero** sets the user Source Tilt value to zero (Supervisor Source Tilt alignment is not affected).
- **Back** sets the previous Source Tilt value.
  Note that only one step is remembered (the last change can be undone if the illumination is lost).
- **Clear Memory**: a user setting of a few last used beam conditions (different Spot or HV) is recorded. When changing the beam conditions, the Source Tilt is set either to the last value used at these conditions (if recorded) or to a value estimated for the new conditions (based on the available record). The Clear Memory command clears this record, so there is no change in the Source Tilt when changing the beam conditions.
- **Auto Alignment** tries to optimize the user Source Tilt value using an automated procedure.

The Crossover button

switches on / off the Crossover mode. It is enabled only when the system is in operation. The electron source is imaged to help the user to properly adjust the Source Tilt, even when there is no illumination in a normal imaging mode.

When the Crossover mode is on (button highlighted), a slow scan is automatically selected and a green cross apears in the center of all SEM images, marking the correct position of the electron source image. After switching off the Crossover mode, previous scanning conditions are restored.

The Lens Align 2D Control

enables to center the beam with respect to the objective lens in order to remove beam shift during focusing and to minimize the objective aberrations. Use it together with the objective Modulator to center the image rotation. You can also use the Lens Alignment function by selecting the corresponding Beam menu item or pressing the toolbar icon.

The control behaviour and pop-up menu is exactly the same as described for the Source Tilt control.

Clicking Ctrl + right mouse button over a SEM image also triggers the

Lens Align function. The mouse cursor changes to quad arrow with a small target sign differentiating it from the Stigmator cursor.

The Modulator button

switches on / off the objective lens (focus) modulation. At the actual focus, it periodically under- and overfocus the image in a narrow range. Use this function at fast scanning rates to immediately view the system response to the modulation. The image rotation center should be identical with the Quad center. At higher magnifications (> 20 000), the correct Lens Alignment leads to a non-moving image.

6. The Beam Module

The Stigmator 2D Control

enables to correct image astigmatism. The crosshair indicates the actual setting of the stigmator.
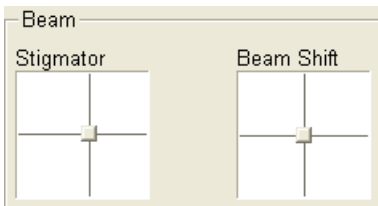
Clicking and holding the left mouse button anywhere inside the X-Y control changes the the cursor to four-ended arrow and moves it to the screen position corresponding to the actual astigmatism value (minimum in the middle of the screen and maximum at the edges). Moving the mouse over the screen changes the beam astigmatism.

Clicking **Shift + right mouse** button over a SEM image can be also used for correcting astigmatism. Unlike the Stigmator control, this function is magnification sensitive and therefore it suits for fine corrections of the image astigmatism at high magnifications.

Clicking the **right mouse** button above the Stigmator control displays a pop-up menu with the following functions:
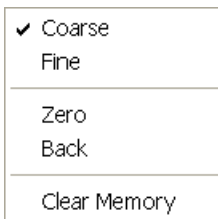
- **Coarse** / **Fine** switches the 2D control sensitivity.
- **Zero** sets the Stigmator value to zero (switches off stigmator).
- **Back** sets the previous Stigmator value.
  Note that only one step is remembered.
- **Clear Memory**: a user setting of a few last used beam conditions (different Spot, HV or SEM Mode) is recorded. When changing the beam conditions, the Stigmator is set either to the last value used at these conditions (if recorded) or to a value estimated for the new conditions (based on the available record). The Clear Memory command clears this record, so there is no change in the Stigmator when changing the beam conditions.

The Beam Shift 2D Control

indicates and controls the beam shift with respect to the objective lens axis. It is useful for fine imaging shifts without stage movement. The control behaviour is similar to the Stigmator control.
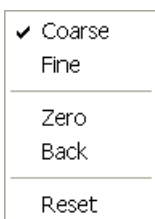
Clicking **Shift + left mouse** button over an electron or ion imaging area also triggers the Beam Shift function. The mouse cursor changes to a hand one that holds the imaging and drags it over the screen. Because of a limited Beam Shift range, this works well only for high magnifications.

- **Reset** set the Beam Shift value to zero and moves the stage to compensate the resulting image shift (same as menu function Stage / Beam Shift Reset).

7. The Status Module

Status
Chamber Pressure: 2.73E-6 mbar
Gun Pressure: 1.47E-9 mbar
Emission Current: 130 µA
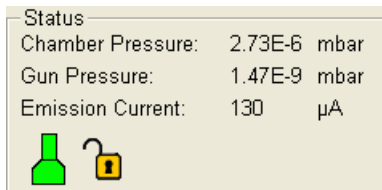
can be found at the base of all pages. It displays important system parameters and conditions.

- **Chamber Pressure:** shows the current pressure in the specimen chamber.
- **Gun Pressure:** shows the current pressure around the FEG source.
- **Emission Current:** shows the electron current emitted from the FEG source.

Complete set of currently measured pressures is displayed in a tooltip over the Gun or Chamber Pressure line. The system conditions are displayed by means of the animated icons:

TABLE 4-3 STATUS ICON MEANING

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

8. Detector Settings Module

Detector Settings
Detector: CCD
ETD
TLD
External
CCD

The module enables to select the active Quad's detector and adjust its parameters.

Detector List Box

The choice contains list of detectors currently available for the active Quad (the same as enabled items in the Detector menu). The list box always displays the detector currently selected in the active 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 for detailed description of individual detectors' settings.)

:
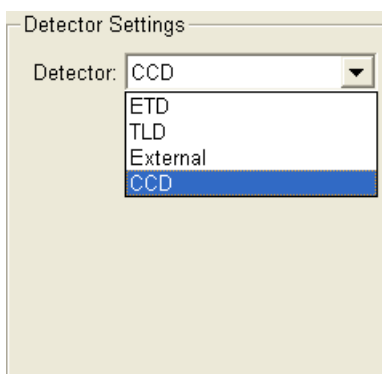
9. Beam Deceleration Module

This module controls the Beam Deceleration (see Chapter 5).
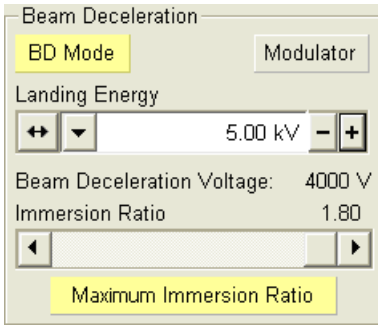
10. Stage Module

The module consist of three tabbed sections (see Chapter 7 for detailed description.)

- The **Map** tab displays the location of positions on the stage in a visual map form and in a list for selection. When clicked on, the stage is driven to the position selected. These positions can be stored in a file and contribute to a map of locations that can be reintroduced at a later date for reinvestigation of the same sample.
- The **Coordinates** tab displays numerical information about a particular position when selected from the location list. Position values can be entered to drive the stage to a set position. Any of the axes or all movements can be locked.
- The **Tilt correction** tab contains correction features for the tilted image. When the appropriate check box is ticked, the function becomes active.

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

FIGURE 4-11 THE STAGE MODULE
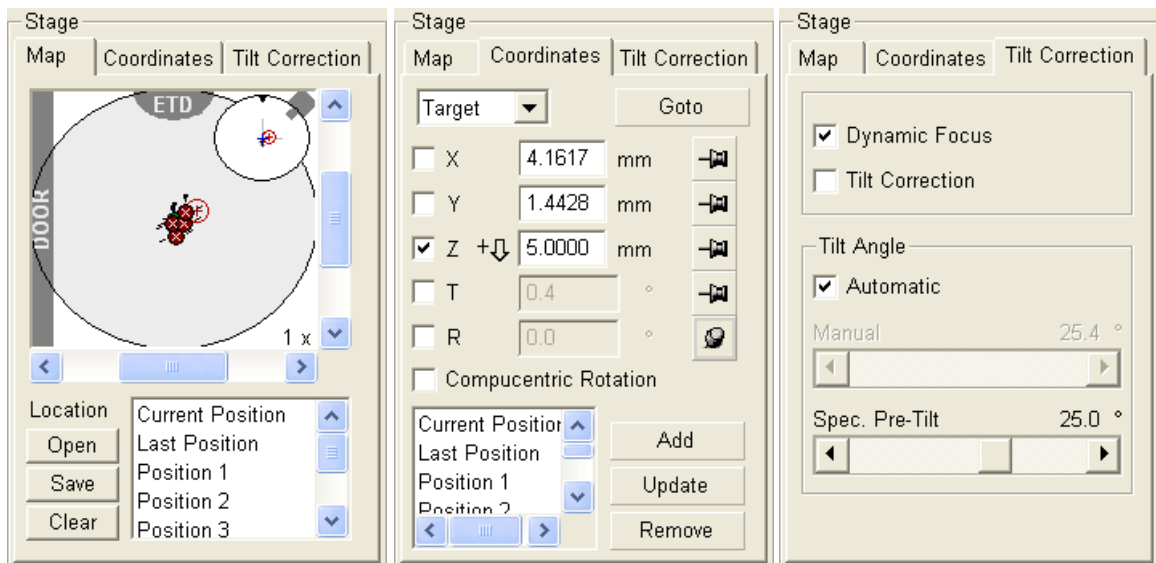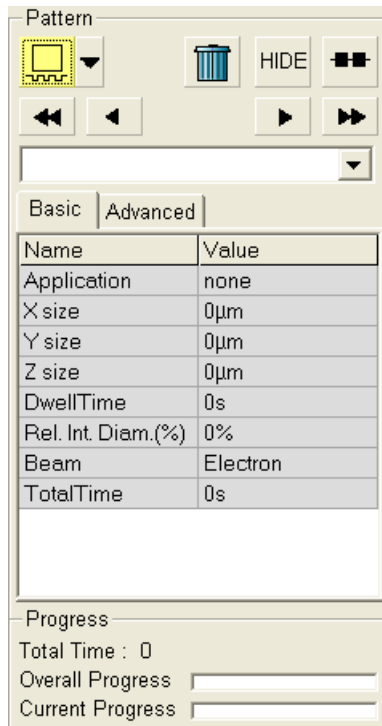
11. The Pattern Module (option)

is used to create patterns in a SEM image, set up the patterning proces and check its progress. A shape can be selected from the icon menu in the top left corner of the module, and then drawn in a SEM image Quad. The true pattern size corresponds to the image size in the selected Quad. The patterns are indexed and displayed in the pattern list box (see Chapter 9 for a detailed description).

The Pattern module icons have the following functions (left to right):

- **Select pattern type** – the selected shape is displayed on the highlighted (yellow) icon. Clicking on the icon switches the shape selection on / off. If no pattern is selected, the existing ones can be moved, resized or rotated using the mouse.
- **Delete** selected patterns
- **Hide all patterns** – the hidden patterns remain accessible from the list box.
- **Serial** / **Parallel** processing
- **Move** selected pattern to the **last** position
- **Move** selected pattern one position **forwards**
- **Move** selected pattern one position **backwards**
- **Move** selected pattern to the **first** position

The patterns list box enables to select an existing pattern. Parameters of the selected pattern are displayed in the below property editor. The **Basic** / **Advanced** tabs switches between two selections of parameters displayed in the pattern's property editor - basic / full set.

The **Progress** sub-module displays the running patterning process **Overall Progress** (total) and **Current Progress** (of the currently processed pattern).
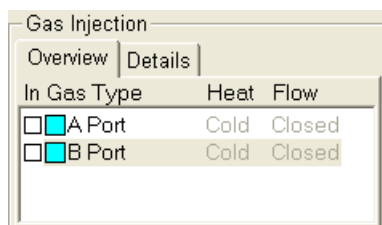
12. The Gas Injection Module (option)

controls the optional GIS units (see Chapter 9 for a detailed description).

Overview Tab

- **In** check box: In (checked) / Out (Unchecked)
- **Gas Type** check box: the gas assignment to the port
- **Heat** status: Cold / Hot
- **Flow** status: Closed / Open

The Details Tab

displays the characteristics of the active Gas Injector, which can be changed by entering the details to configure the injector.
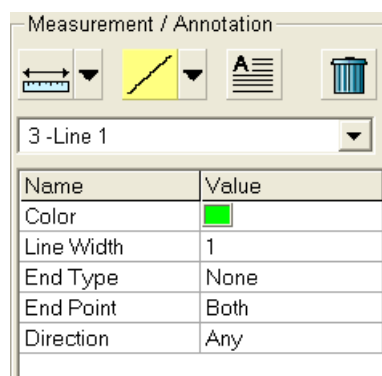
13. The Measurement / Annotation Module

combines tools for measuring and making annotations in SEM images. 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 a SEM image Quad. All objects are sequentially indexed and displayed in list box below the icons.

The measurement tools display their true dimensions directly in the image (inside or next to the tool). While drawing a measurement tool, its current dimensions are immediatelly displayed and continuously updated.

The Measurement / Annotation module icons have the following functions:

- **Select Measurement / Annotation type** – selects (highlighted) / deselects an measurement / annotation shape.

:

- **Text** – selects (highlighted) / deselects a text annotation.

If no measurement tool nor any shape or text label is selected, the existing objects can be moved, resized or rotated using the mouse.

- **Delete selected objects** (Trash can)

The **objects list box** enables to select an existing measurement tool or annotation. Parameters of the selected object are displayed and can be modified in the property editor below.

Note:
The Measurement tools have their physical dimensions which scale with the image - when changing magnification, the displayed tools change their size accordingly. On the contrary, the Annotation shapes and texts have their sizes fixed relatively to the Quad.

14. The Enhanced Image Module

consists of four tabbed sections for digital image enhancement, mixing and colouring.

The digital processing does not influence the original (raw) image stored in the image memory, and therfore can any time be modified or switched off ("undone") completely.

The digital image enhancement can be applied to any detector image, including CCD, and also to paused or loaded images. In contrary to Detector Contrast and Brightness functions, the image enhancement functions are applied only the the active Quad, independently from other Quads settings.

The Lut Tab

contains tools for monitoring and modifying greylevels distribution (histogram) of a greyscale image. The digital image processing defined in this section is the first one applied to the image (possibly after integration / averaging).

The Presets List Box

enables to select the Digital Contrast / Brightness / Gamma values at once using a pre-defined or Custom preset.

The Digital Contrast Continuous Adjuster

enables contrast to be set in range from -10 to +10 (negative values lead to an inverse imaging)

The Digital Brightness Continuous Adjuster

enables brightness to be set in range from -2.0 to 2.0

The Gamma Continuous Adjuster

corrects image brightness non-linearly in range from -10 to +10

The Graph Window

graphically displays the applied greylevels conversion (blue line - original grey values are on horizontal axis, resulting values on vertical axis) and the image histogram (if switched on).

The Histogram Button

switches on / off the greylevels historam corresponding to the active Quad image. Left / right side of the histogram corresponds to black / white pixels in the original image, and the height of each red line is proportional to the number of pixels with the corresponding gray value.
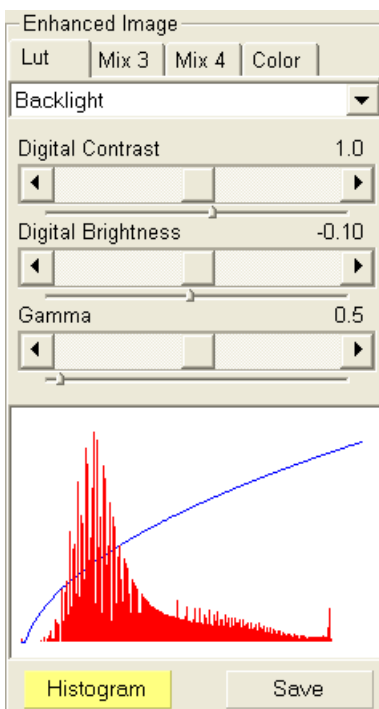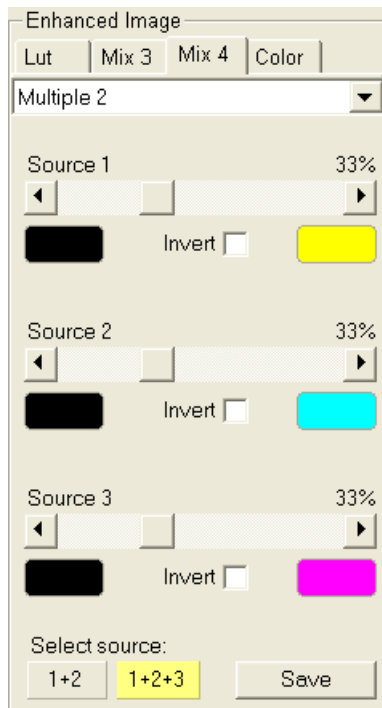
The Save Button

saves the current Digital Contrast, Brightness and Gamma setting as the Custom preset.

The Mix 3 / Mix 4 Tabs

enables to control the Mix "detectors". The Mix 3 / Mix 4 section is enabled only if **Detector / Mix** is selected in Quad 3 / Quad 4.

The Presets List Box

enables to select the mixing ratios and colours as a pre-defined or **Custom preset**.

The Source 1 - 3 Linear Continuous Adjusters

enables to tune the mixing ratio of Quad 1 - 3 images. The value of each adjuster (0 - 100 %) says how big part of the resulting image composes the corresponding source image. Changing one Source value results in automatic change of the other (two) values so that the sum of all Source values is always 100%.

The Color Selection Controls

on the left and right side below each Source Adjuster enables to select any colour that will replace the Source image black (left) and white (right) for the mixing purposes.

Double-click on the pained area to open the Color selection dialogue, select any colour, and press the OK button. The corresponding Source image grayscale will be linearly transformed to a new (colour) spectra (defined by the left and right colours) before it will be mixed with the other Source(s).

Note:

When mixing colour images (e.g. processed using the Color section), they are first internally converted to greyscale.

The Invert Check Boxes

inverts the corresponding Source image spectrum. It has the same effect as exchanging the left and right colours selection.

The 1 + 2 / 1 + 2 + 3 Buttons

are useful only in Mix 4 section. They switches between two mixing modes available in Quad 4: Quad 1 + Quad 2 or Quad 1 + Quad 2 + Quad 3. In Quad 3 (Mix 3), only the 1 + 2 mode is available. In this mode, the Source 3 controls are disabled.

The Save Button

saves the current mixing ratios and colour selections to the Custom preset.

The Color Tab

enables to introduce pseudo-colours into the originally grayscale image. The image colouring defined in this section is applied after the Lut processing. An already coloured image (e.g. Mix that uses a colour spectra) cannot be coloured again - in this case, the whole section is disabled.

The Presets List Box

enables to select a pre-defined or Custom colour profile.

The Colouring Control Area

displays the active Quad's image histogram and enables to create any colour profile:

:
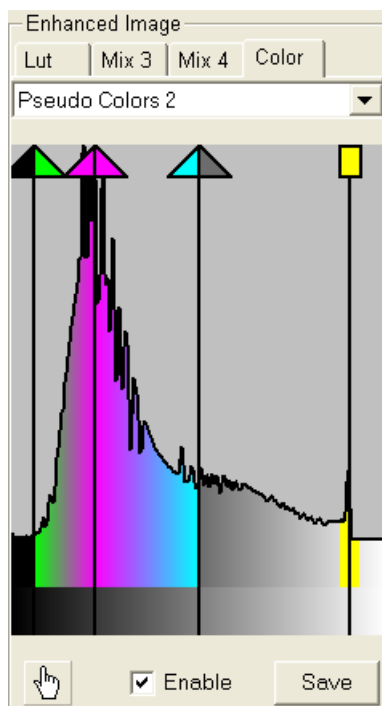
Right-click into the histogram image to add the borderline with up-arrow, or onto an existing borderline to remove it. **Left-click** onto a bordeline to drag it over the histogram. **Double-click** onto the left / right part of the arrow head to select the left / right border color.

The graylevels surrounded by two borderlines will be in the image replaced by a colour spectra continuously connecting the selected border colours.

The "Hand" Button

enables to select and colour a particular graylevel in the image. Click on the button to open the Color selection dialog, select a colour and press OK. The mouse cursor changes to the hand image. Now click in the image on a feature, which greylevel you want to highlight. This adds new borderline into the histogram picture, with a rectangular instead of the arrow-head. The selected pixel plus some close range of greylevels will be marked with the chosen colour. You can move this borderline within the histogram, change the highlighting colour by double-clicking on its head, or change the width of the highlighted greylevels range by dragging the left or right side of the borderline head.

The Enable Check Box

switches on / off colouring of the active Quad's image, but does not change any other settings in the Color section. It is useful for temporarily removing all colours from the image without the necessity to save or re-create the current colour profile.

The Save Button

saves the current colour profile to the Custom preset.

15. The Alignments Module

contains alignments which enables to optimize the system performance. Please read Chapter 6 "Alignments" fully before proceeding with adjustments.

The Alignments List Box

contains list of Alignment procedures available for the current user level (User, Supervisor or Service). Selecting an Alignment procedure will display its short description in the Instructions box.

The Start / Previous / Next / Finish Button

Press the Start button to start the selected Alignment procedure. The Step sub-module changes its label from No Step to Step 1 of N, and displays all controls necessary to perform the first step of this procedure. The Instructions box displays new instructions relevant to the current procedure step.

The Start button label changes to Next - press it only after properly finishing the current procedure step. After the last procedure step the button label changes to Finish. By finishing the procedure, all alignments done in the previous steps are saved and any previous alignments connected to this procedure are lost.

The Cancel Button

can be pressed any time to interrupt the current procedure and restore the beam conditions, which were set before the Alignment procedure Start.

Note:
Alignments should be performed only by an authorized personnel with an appropriate level of understanding. Improper alignments can make the system difficult to use.
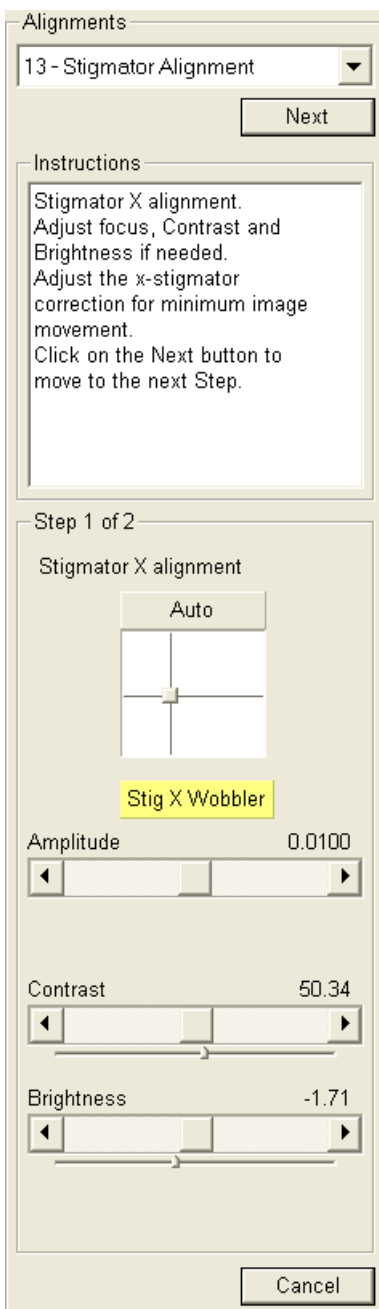
PREFERENCES… DIALOGUE

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

The Units Tab

allows the user to change the **Units of Measure** (for the Stage Coordinates) and **Pressure**. Selection can be made by clicking on the list arrow and consecutively clicking on the desired unit. The choices affects the Stage module input boxes, the databar display, the status module and so on. The chosen units are remembered separately for each user.

FIGURE 4-12 UNITS PREFERENCES
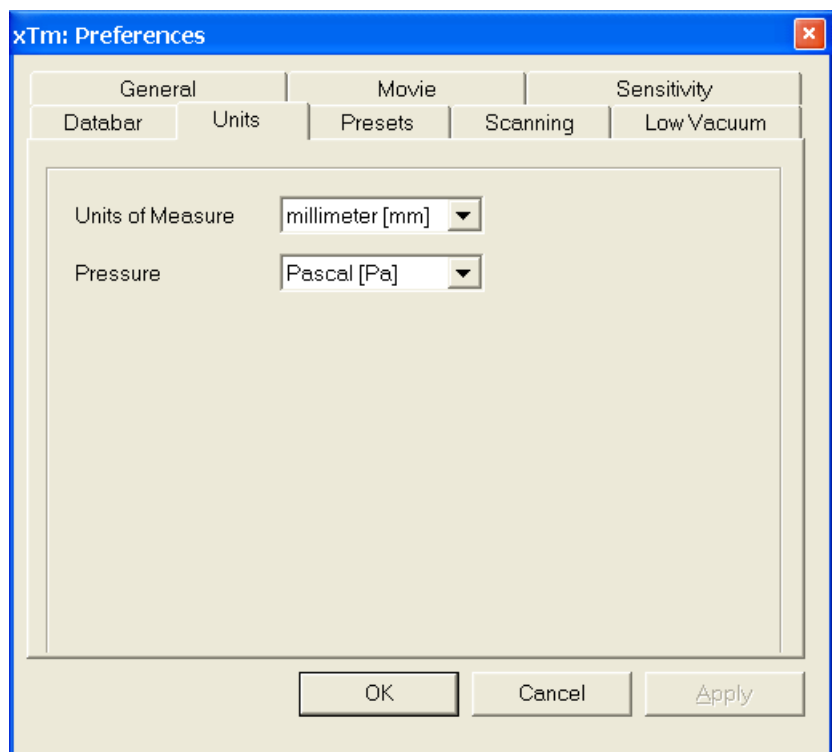
Selection possibilities are:

- **Units of Measure:** Millimeter / Micrometer
- **Pressure:** Pascal / Torr / Bar

:

The DataBar Tab

specifies content of the databar displayed at the base of all Quads. The Databar configuration and available items differ for SEM imaging and CCD Quads. Actual content of the Databar Preferences dialogue corresponds to the currently active Quad, and will change when the active Quad changes between the CCD and a SEM image. For all SEM imaging Quads (as well as for all CCD Quads) the Databar configuration is identical, except of the Label which can be set for each Quad independently.

FIGURE 4-13 DATABAR PREFERENCES
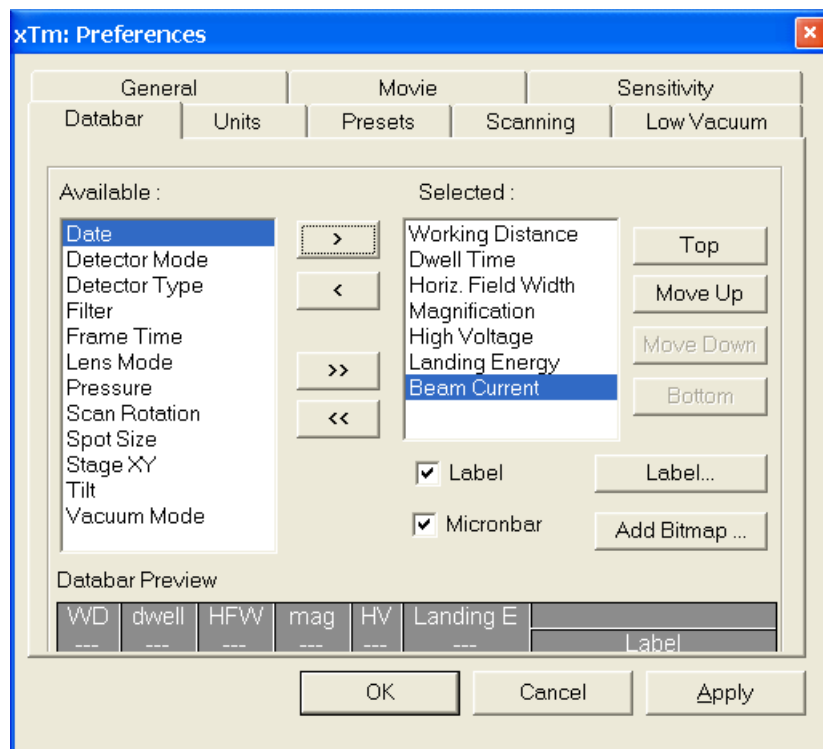
There are two lists in the dialogue, one labelled **Available** and the other **Selected**. Items in the Available list can be added / removed individually (**>** / **<**) or as a whole (**>>** / **<<**) to / from the Selected list. The Selected list contains items that will be displayed in the Databar. 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 Databar settings is remembered separately for each user.
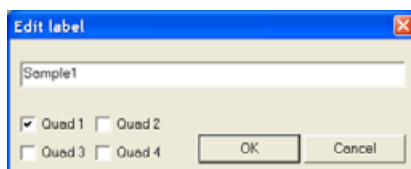
The **Label** and **Micronbar** can be chosen by checking the appropriate box. Their area expands or contracts as other items are added to or removed from the DataBar.

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

Clicking the **Add Bitmap…** button opens a dialog to load a bitmap into the databar.

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

The Presets Tab

allows the user to change the pre-set values in the **High Voltage**, **Magnification** and **Pressure** drop-down lists. Values can be changed by selecting a value in the list to edit and entering new values 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. The changed pre-set lists are remembered separately for each user.

FIGURE 4-14 PRESETS PREFERENCES
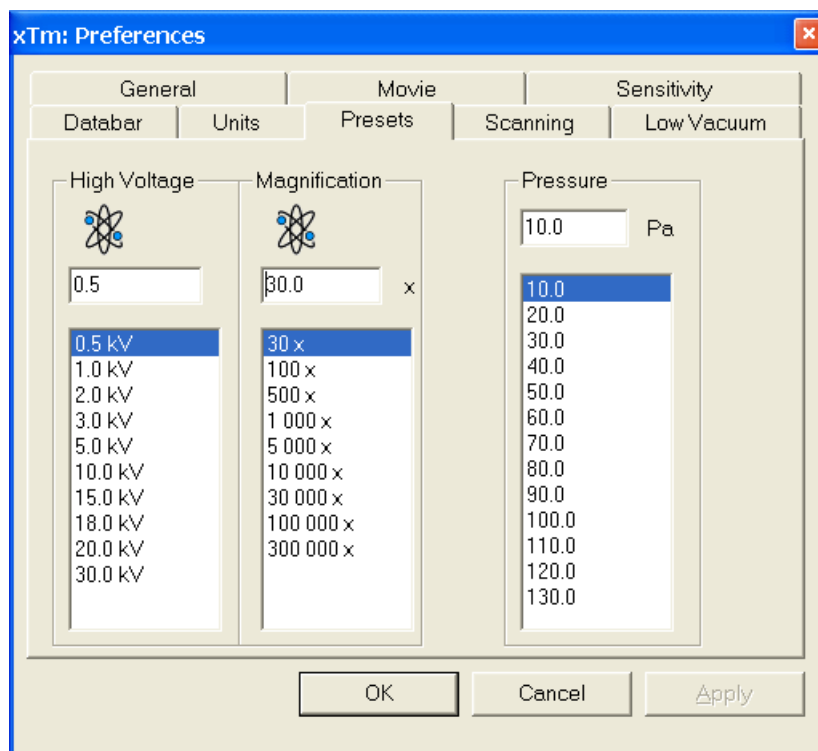
The **High Voltage** list can be changed to span any values from 200 V to 30 kV. The values must be entered in kilo Volts (0.2 means 200 V).

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 current SEM conditions are not shown in the toolbar / Magnification list box. Magnification range is from cca 30x to 1 000 000x.

The **Pressure** list can be changed to hold specific values frequently used in the Low Vacuum mode in the range from 10 to 200 Pa (from 0.075 to 1.5 Torr).

The Scanning Tab

allows the user to change the dwell-times (scanning speeds) table and set-up the Slow scan / Fast scan / Snapshot / Photo functions.

FIGURE 4-15 SCANNING PREFERENCES
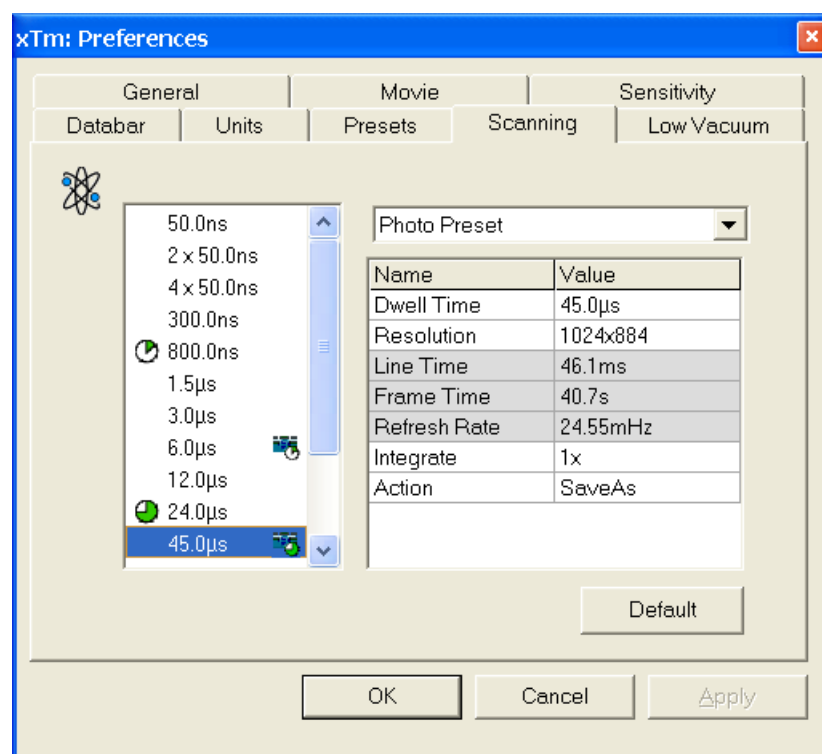
On the left side of the module there is a dwell-time preset list with a fixed number of entries (11). A selected entry can be changed in the **Dwell Time** line of the Property Editor on the right side of the module.

Slow (large green sector), **Fast** (small green sector), **Snapshot** (camera with small green sector) and **Photo** (camera with large green sector) preset buttons, which correspond to the scan menu items, indicate the dwell-time value for these functions. To change these values move any icon up or down just by clicking-and-dragging it. The **Default** button restores the default dwell-time list and scan functions settings.

Snapshot / Photo Presets

These presets are dedicated to capturing images at given scan conditions, which are adjustable for appropriate preset (selectable also from the dropdown menu). Following properties are editable:

- **Dwell Time:** one point beam duration time
- **Resolution:** no. of points, Width x Height (image resolution)
  This is editable only for the Snapshot and Photo functions.
- **Integrate:** no. of integrated frames (1, 2, 4, 8, 16, 32, 64, 128, 256)
- **Action** activated at the end of Snapshot / Photo functions**:**
  Save saves the taken image using automatic file name and format.
  Save As… opens the Save As dialogue to save the taken image.
  None just takes the image and pauses the active Quad.

Following properties are informative and non-editable:

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

The Low Vacuum Tab

enables to customize the specimen chamber purging, which is automatically initiated when the system pumps the vented chamber to the Low Vacuum mode.

FIGURE 4-16 LOW VACUUM PREFERENCES
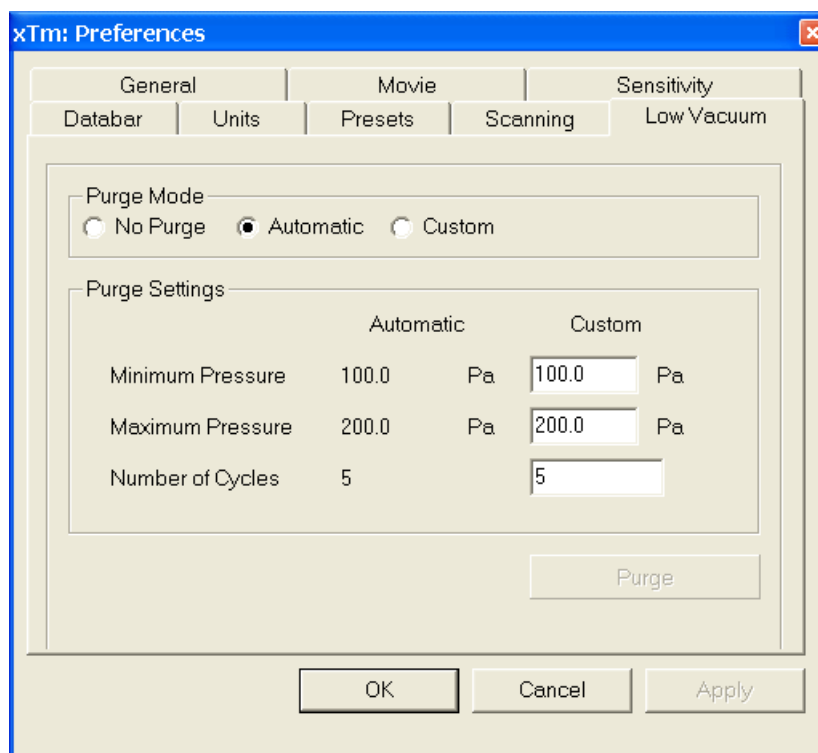
Purge Mode radio buttons:

- **No Purge** – The purging is switched off and the vacuum goes directly to the Low Vacuum mode
- **Automatic** – All purging parameters are set automatically, according to the mounted Low Vacuum detector (Cone).
- **Custom** – The Custom parameters defined in Purge Settings are used.

Purge Settings displays the current Automatic purging parameters and enables to set the Custom ones. The custom pressures should be in the range from 10 to 200 Pa (from 0.075 to 1.5 Torr).

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

Notes:
– The new Purge Mode or Settings is applied immediately after pressing the **OK** or **Apply** button, even if the purging cycle is already running.
– During the purging procedure, the vacuum is not ready for SEM operation (the vacuum status is Pumping). Therefore, pressing the Purge button will automatically switch off **HV** and closes the Column Isolation Valve.
– Unlike most of the other Preferences, the Purge Settings is not remembered separately for each user. If it is of any importance, please check these Preferences before starting the Low Vacuum operation.

:

The General Tab

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

FIGURE 4-17 GENERAL PREFERENCES
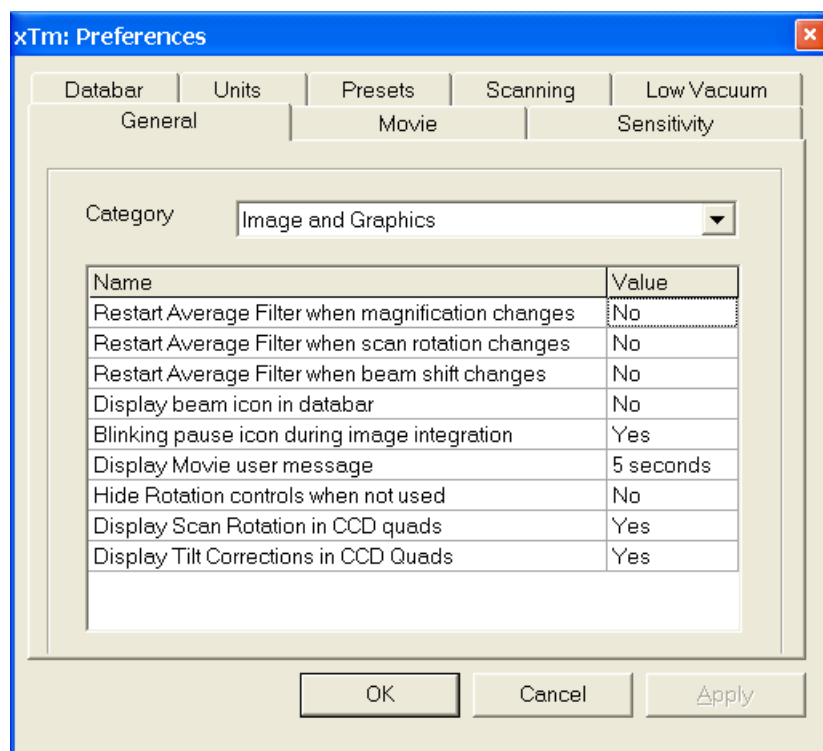
Each item of the General Preferences is represented by single line displayed in the property editor. Clicking on the corresponding **Value** will display a drop-down list with the settings available for that item.

Note:
Some changes from the UI appearance Category 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.
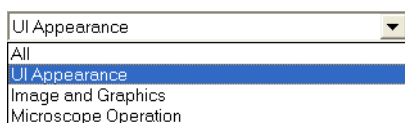
UI appearance
- **Icon style** (Nova / Quanta)
  Selects appearance of the Toolbar icons
- **Toolbar listbox style** (Reduced / Standard)
  Specifies appearance of the High Voltage, Magnification and Beam Current drop-downs lists
- **Toolbar spinner style** (Up-Down / Left-Right)
  Specifies appearance of the Dwell Time spinner
- **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 (un)zoom function linked to the left mouse button

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- **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

Image and graphics

Name
Restart Average Filter when magnification changes
Restart Average Filter when scan rotation changes
Restart Average Filter when beam shift changes
Display beam icon in databar
Blinking pause icon during image integration
Display Movie user message
Hide Rotation controls when not used
Display Scan Rotation in CCD quads
Display Tilt Corrections in CCD Quads

- **Restart Average Filter with magnification change** (Yes / No)
- **Restart Average Filter with scan rotation change** (Yes / No)
- **Restart Average Filter with beam shift change** (Yes / No)
  The above three items enable to choose whether the image averaging should be restarted when the indicated parameter changes. Restarting the Average Filter causes the image to blink and get noisier; on the other hand, the averaging slows down the image response to the changed parameter.
- **Display beam icon in databar** (Yes / No)
  Adds an "atom" picture to the first position in the Databar. This is likely to disappear in the future.
- **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 Movie user message**
  (No / 1 second / 2 seconds / 5 seconds / 30 seconds)
  During the Movie Recording, some information may be displayed in the recorded Quads. This selection controls if and how long such information shows up.
- **Hide Rotation controls when not used**
  (No / 10 seconds / 30 seconds / 60 seconds
  Specifies if and when the on-image Scan / Compucentric Rotation control should be automatically switched off
- **Display Scan Rotation in CCD quads** (Yes / No)
  Specifies if the Scan Rotation indicator and value should be permanently displayed in the CCD image(s); note that only non-zero Scan Rotation is displayed
- **Display Tilt Corrections in CCD Quads** (Yes / No)
  Specifies if the Dynamic Focus and Tilt Correction indicator and values should be displayed in the CCD image(s); only non-zero values are indicated

Microscope operation

Name
Lower stage when venting the chamber
Change magnification when pumping
Switch off CCD automatically
Pause E-Beam Quads when switching off HV
Allow Beam Shift in Get mode
Blank beam during long stage moves

- **Lower stage when venting the chamber** (Yes / No)
  Specifies if the stage should automatically go to a low Z values when user Vents the chamber. This is recommended settings, because it greatly diminishes the chance of hitting the polepiece when closing the chamber doors after mounting a higher specimen.
- **Change magnification when pumping**
  (No / Set to 100x / Set to 200x
  Specifies if the magnification should be automatically set to a low value when the chamber is being pumped (presumably after replacing the specimen)
- **Switch off CCD automatically**
  (No / 1 minute / 10 minutes / 30 minutes / 1 hour / 2 hours / 6 hours)
  Specifies if and when the CCD should be automatically switched off. The countdown starts when unpausing the CCD image and continues regardless of the operator activity
- **Pause E-Beam Quads when switching off HV** (Yes / No)
  Specifies if the SEM image Quads should be automatically paused when switching off the High Voltage

- **Allow Beam Shift in Get mode** (Yes / No)
  Enables / disables automatic using of BeamShift when the user requires very small point-to-point movements (double-click in the image at high magnifications). When enabled, the Stage menu item Auto Beam Shift Zero allows selecting if the BeamShift should be automatically reset each time the point-to-point stage movement is required.
- **Blank beam during long stage moves** (Yes / No)
  If Yes is selected, the electron beam is automatically blanked during long software controlled stage movements. This may protect extremely sensitive samples from exposure to the beam in undesired areas.

The Movie Tab

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

Sensitivity Tab

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

FIGURE 4-18 SENSITIVITY PREFERENCES
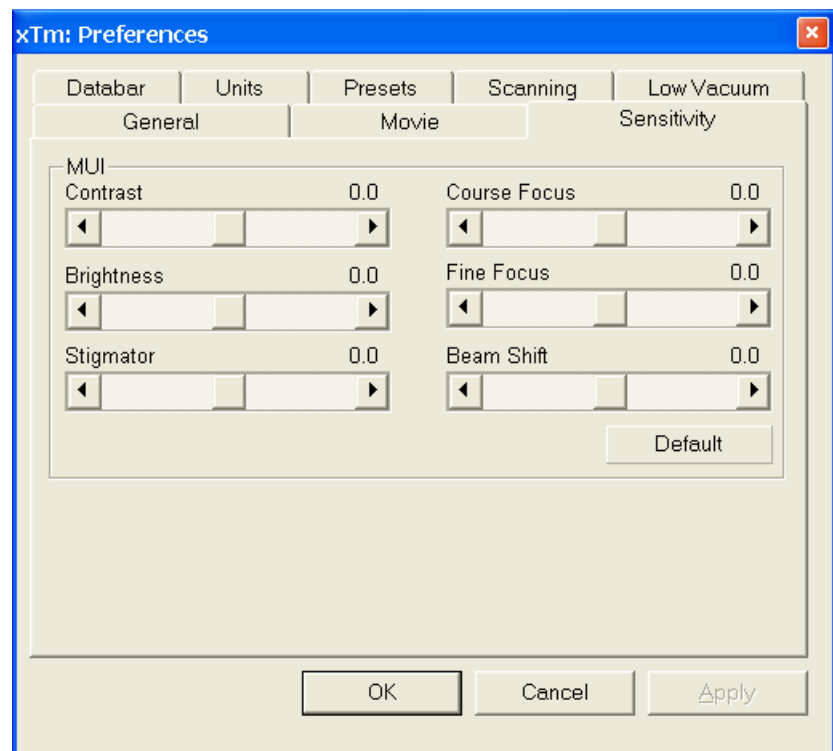
All MUI controls are represented except the Magnification. The **Default** button sets the original settings.

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 clicking the right mouse button (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 4-19 FEI ACCOUNT ADMINISTRATORS CONTROL OVERVIEW
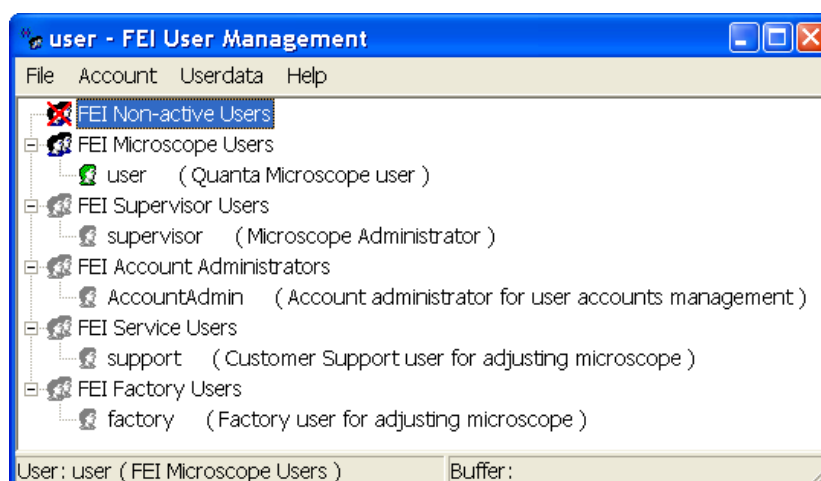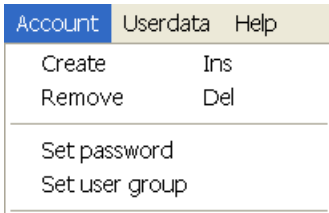
The File Menu

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.

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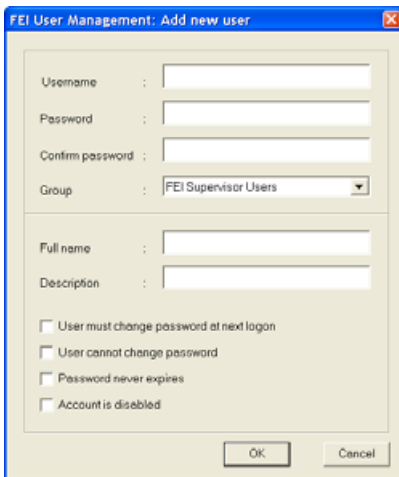
- **Remove (Del):** click to remove an existing user. The user must be highlighted first.

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.
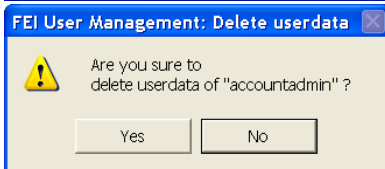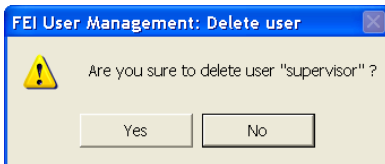
- **Set password:** click to make a password for the user. The user must first be highlighted in the tree.
  An FEI Account Administrator can change the password for any user from a lower level account.
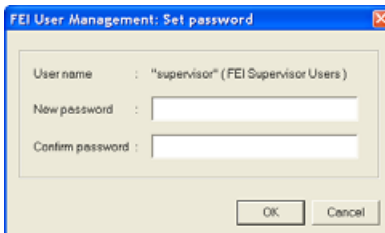
- **Set user group:** click to set the group for the user. The user must first be highlighted in the tree. When confirmed, the user is moved to selected group. When moving a user from the FEI Microscope Users group to the FEI Non-active Users group, his user data will be removed. A warning is displayed in this case.
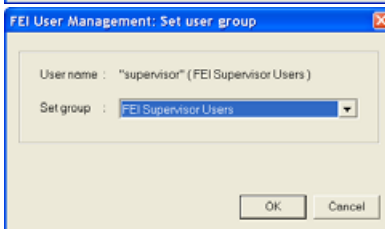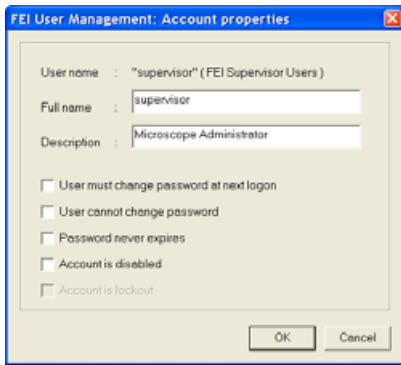
- **Properties (Alt + Enter):** click to see and change the properties for that user. The user must first be highlighted in the tree.
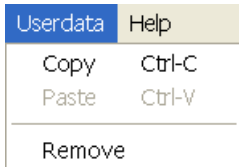
The Userdata menu

contains the following items.

- **Copy (Ctrl + C):** click to copy user data from a user of the same or a lower level group.
- **Paste (Ctrl + V):** click to paste user data into your own account or into the accounts of a lower group level. It is not possible to copy user data inside the FEI Supervisors User group.
- **Remove:** click to delete user data from a selected account of equal or lower group level.
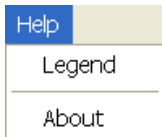
The Help Menu

contains the following items:

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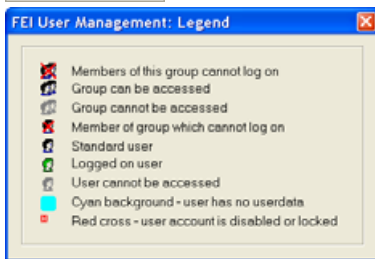
- **About:** displays the FEI User Management software version and copyright.

ACCOUNT LOGGING

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

- **accounting.tmp** is a temporary running file during use of the equipment at each user session, updated every 15 seconds so that any power down or operating system crash situation can be time logged.
- **accounting.log** is permanent file to which the previous data are sent when a new session is started. This file is only readable by the FEI Supervisor User or higher level.

These files can only be deleted at factory or service level, each one is a text - CSV file so it can be loaded into Microsoft Excel for processing.

Entering Commands in Summary

USING THE MOUSE

TABLE 4-4 MOUSE BUTTON FUNCTIONS

(Key +) Button	Function
Left	**Control Areas:** _makes selection_ in control areas (single arrow cursor). **On Screen:** click and drag a _selected area_ to _zoom in_ in magnification to fill the image area with the selection (selectable in Preferences). _**Double Click:**_ **Electron imaging:** _move the selected point_ to the middle of the quad. **Optical imaging:** _5 mm marker placement_.
Left + Shift	**On Screen:** click and drag a _selected area_ to _zoom out_ the image to fit the selected area.
Shift + Left	1. Activates _Beam Shift_ (hand cursor) 2. Pauses / Activates all quads when clicking the toolbar pause icon.
Right	To _focus_ with the mouse, press and move the mouse to the left or right (double ended arrow cursor).
Ctrl + Right	Activates _Lens Align_ (four-ended arrow cursor).
Shift + Right	To _correct imaging astigmatism_, press and move the mouse (four-ended arrow cursor) to the left / right (X stigmator), or up / down (Y stigmator).
Shift + Wheel Up / Down	**Fine Control:** moving the wheel _increases / decreases the magnification_.
Ctrl + Wheel Up / Down	**Coarse Control:** moving the wheel _increases / decreases the magnification_.
(Ctrl+) Wheel Press	**Electron imaging:** with the wheel pressed like a button the _TRACK mode_ for joystick-like movement over the sample surface is activated. **Optical imaging:** activates the _stage Z movement (stage Tilt)_. With the wheel pressed, moving the mouse up or down / left or right moves the stage up or down / tilts the stage left or right, which can be seen live.

Note:
the given sequence of key and button pressing is important for some functions.

USING THE KEYBOARD

TABLE 4-5 WINDOWS SYSTEM KEYS

Key (+ Key)	Function
Enter	Equivalent to _OK_ in a dialogue box.
Esc	1. Equivalent to the _cancel_ button. 2. _Cancels the click_ and drag function. 3. Stops the stage motion at that point.
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. Pressing the underlined character in the menu bar pulls-down the corresponing 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	_Exit active application_ or Windows operating system.
Del(ete)	_Deletes_ selected text or items.
Ctrl + C (Ctrl + Insert)	_Copy_ to clipboard
Ctrl + V (Shift + Insert)	_Paste_ from clipboard
Ctrl + X (Ctrl + Delete)	_Cut_ to clipboard

TABLE 4-6 FUNCTION AND SPECIFIC KEY SHORT-CUTS

Key (+ Key)	Function
F1	Displays On-Line Documentation
F2	Starts / Stops Photo
F3	Toggles Videoscope On / Off
Shift + F3	Starts Home Stage procedure
F4	Starts / Stops Snapshot
Shift + F4	Starts Lens Alignment procedure

:

TABLE 4-6   FUNCTION AND SPECIFIC KEY SHORT-CUTS

Key (+ Key)	Function
F5	Toggles Single / Quad Image mode
Shift + F5	Toggles Center Cross display
F6	Pauses / Activates scanning
Shift + F6	Toggles Alignment rectangle display
F7	Toggles Reduced area / Full Frame Mode
F8	Degauss
F9	Starts Auto Contrast and Brightness procedure
Shift + F9	Link Z to FWD
F11	Starts Auto Focus procedure
Shift + F11	Toggles Display Saturation function
F12	Toggles Compucentric Rotation tool
Shift + F12	Toggles Scan Rotation tool
Ctrl + 0 - number	Moves stage to X=0, Y=0
Ctrl + B	Toggles Beam Blank function
Ctrl + D	Set Default Parameters
Ctrl + F	Sets FWD to 5 mm
Ctrl + M	Sets Full Frame scanning conditions
Ctrl + N	Next line patterning
Ctrl + Shift + N	Next Pattern
Ctrl + O - letter	Opens Preferences dialogue
Ctrl + P	Opens Print dialogue
Ctrl + R	Restarts scan
Ctrl + S	Save image
Ctrl + Z	Moves stage to the Last position
Ctrl + (Shift +) ,	Set one step slower (slowest) scanning
Ctrl + (Shift +) .	Set one step faster (fastest) scanning
Ctrl + (Shift+) Tab	(Backward) Steps between quads
Ctrl + Page Up / Down	Left / Right Steps between pages
Ctrl + 1 / 2 / 3 … - letter keypad	Selection of the particular page (the number corresponds to the toolbar page icon sequence)
+ / -	Increases / Decreas magnification 2x
*	Rounds off magnification to the nearest round value

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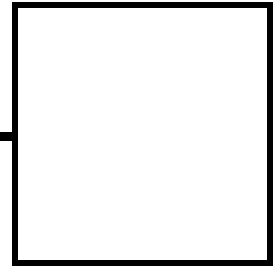
This chapter describes how to use the Microscope system from an application point of view. The following subjects are covered:

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

Caution!

These procedures assume you are familiar with the xT microscope server and xT microscope Control software described in Chapter 4 "Software Control", which are necessary to start and operate the Nova NanoSEM microscope.

Specimen Preparation and Handling

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

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

NEEDED ITEMS

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

NATURAL SPECIMEN

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

COATED SPECIMEN

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

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 image 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 THE SPECIMEN TO THE 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 paint. The specimen must be electrically grounded to the sample holder to minimize specimen charging. If you are using a vice mechanism or double-sided tape, 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 HV cable feed on the chamber door. This is to allow measurement of sample current.

C a u t i o n !
Store samples and sample holders in a dry and dust free environment. Dust on samples can get drawn into the electron column, degrading imaging and requiring an FEI Customer Service call to correct the problem.

INSERTING / EXCHANGING A SPECIMEN

It is assumed, that the microscope is in the Full operation state (see Chapter 3).

Inserting a specimen requires the specimen chamber to be at atmospheric pressure. If the high voltage is on when starting to vent the specimen chamber, the vent condition is interlocked to switch off various voltage supplies before actual venting occurs.

TABLE 5-1   INSERTING A SPECIMEN

Step	Action
1.	Click off the **HV** button in the **Column** module. Go to the **Stage / Coordinates** module and unlock the Z-axis so that the stage can be automatically lowered during the venting cycle. In the **Vacuum** module click the **Vent** button. The confirmation dialogue appears. After a High Voltage switch off cycle, the vacuum system will switch off the pumps and open the appropriate valves to vent the system. After a specified venting time the venting valve will close.
2.	When vented, open the specimen chamber and, using lint-free gloves or tweezers, place a specimen into the specimen holder. Secure the specimen stub with an appropriate hex-wrench unless a spring-clip holder has been used.
3.	Install any additional detector if it is not already done (follow the procedure described below in this chapter).
4.	Check stage position and Tilt before closing the chamber door! If the sample height is higher then it was for a previous sample, turn down the mechanical Z to suit the Adjuster Tool.
5.	Close the door.

Obtaining an Image

OPERATION PRE-CHECK

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

It is possible to use **Set Default Parameters** (**Ctrl + D**) function found on **Tools** menu.

TABLE 5-2   NOVA NANOSEM SETUP CONDITIONS

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

SELECTING VACUUM MODE

When a specimen and appropriate detector(s) are inserted correctly, close the specimen chamber door and follow the instructions:
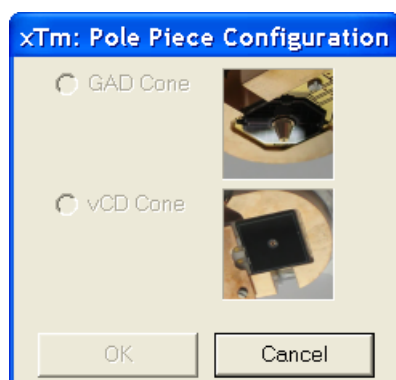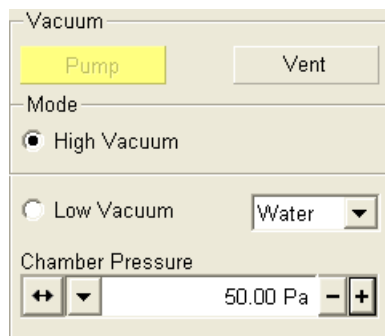
TABLE 5-3 SELECTING VACUUM MODE

Step	Action
6.	In **Vacuum / Mode** module, select the **High Vacuum / Low Vacuum** radio button (see Chapter 3).
7.	For Low Vacuum mode select the appropriate **gas** from the dropdown list and the target pressure that the system pumps to in the Chamber **Pressure** adjuster.
8.	In the **Vacuum** module click on the **Pump** button. While pumping, choose the highest specimen point and bring it to the 5 mm Working Distance (yellow line in CCD Quad).
9.	Under normal operation, the system will know the **PLA size** for the detector installed. This will allow the system to set automatic pressure range limits for the aperture installed, thus avoiding vacuum errors when setting chamber pressure. In some cases the user will be prompted for the PLA size by the Pole Piece Configuration dialogue.
10.	Wait for the vacuum status **Pumped**, represented in the **Status** module at the base of the page by green icon.

WARNING!

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

HIGH VOLTAGE AND BEAM CURRENT

The choice of High Voltages and Beam Currents is displayed in the editable dropdown list boxes on the toolbar. The High Voltage and Beam Current are related, any selected HV provides an individual set of beam current values. Changing HV will change the beam current values.
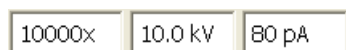
Changing High Voltage and Beam Current

Click the list box to open the drop-down list of available values, then click the desired one. The dropdown list automatically closes and displays the new value. If this is done while the HV is on, the change is immediate.
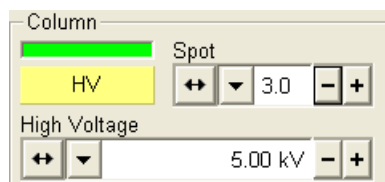
Any voltage in range from 200 V to 30 kV (in 100 V steps) can be set using the **Column** module **High Voltage** continuous adjuster. The default HV values displayed both in the toolbar list box and the High Voltage preset adjuster can be set in the **Preferences… / Presets** tab.

The electron **Beam Current** displayed in the toolbar list box (and optionally in the Databar) is approximate and valid only if the microscope is well aligned and the correct final lens aperture size is selected in the **Beam / SEM Aperture** menu.

:

An Alternative to the Beam Current selection is setting the **Spot** in the Column module. Using the Continuous Adjuster, any Spot size in the range from 1.0 to 7.0 with 0.1 steps can be set. For the given High Voltage and SEM Aperture values, the Spot size determines the Beam Current and vice versa.

OBTAINING AN IMAGE ON SCREEN

The following assumes that the FEG source (Emission) is ready.

TABLE 5-4   IMAGING PROCEDURE
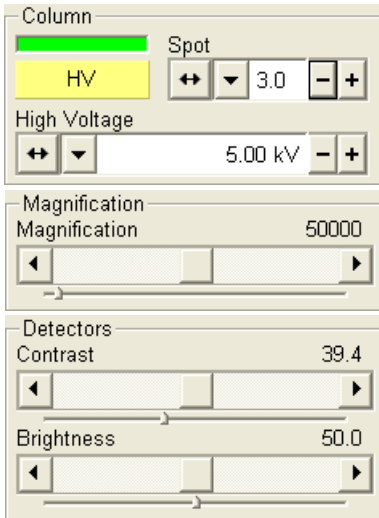
Step	Action
11.	Select an appropriate detector (see section Detector Types and Usage) and unpause the chosen quad.
12.	On the **Column** module, click the **HV** button to ramp up the High Voltage.
13.	Focus the image and **Link Z to FWD** (see Chapter 4).
14.	Adjust to a suitable magnification, optimize the image (**contrast and brightness, focus, astigmatism**) – fuller explanation later in this chapter.

Optimising an Image

PRINCIPLES OF SEM IMAGING

All scanning beam microscopes produce images 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. The result is a picture point (pixel) array. Low or high resolution images can be obtained by changing these factors. The larger the pixel array, the higher the resolution of the image. The image 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 image pixel. Because of this direct correspondence, the image displayed on the monitor is 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 image dimension (L) divided by the sample scanned dimension (l).

FIGURE 5-1   MONITOR IMAGE AND SCANNED SAMPLE
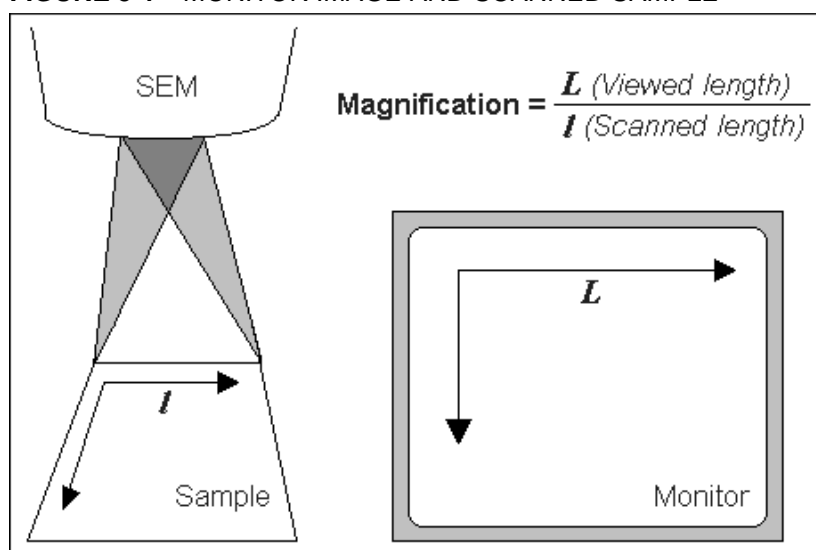
If the size of the raster on the sample is made smaller while the raster on the monitor remains constant in size, the magnification of the image increases. At low magnification, you see a large field of view. At medium magnification, you see a portion of the original scanned area. At high magnification, you are zoomed in on only a small portion of the original total scanned area.

The Nova NanoSEM supports two viewing sizes: **Quad Image** and **Single Image** modes. Magnification is always adjusted in the databar for the current display, thus an image at 500x in Quad Image mode is 1000x in the Single Image mode as its size has doubled.

Changing Magnification
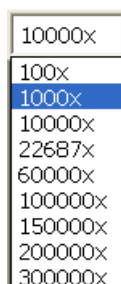
- The **Toolbar List Box** is used to select from a list of predefined values. Click the list box and the list of pre-set magnifications rolls down. Click the required magnification, the list box closes then and the selected magnification is set. During live imaging this results in immediate magnification change.
- **Keyboard control (+ / - / *):**
  The plus key (+) increases the magnification 2x.
  The minus key (-) decrease the magnification 2x.
  The star (*) key rounds off the magnification value
  (e.g. 10 063x becomes 10 000x).
- **Mouse wheel control:** Coarse / fine control can be operated by holding the Ctrl / Shift keyboard key and moving the mouse wheel up / down to increase / decrease the magnification.
- **Selected Area Zooming In / Out** is a quick way of zooming in or out on an area of interest. The function is activated by left mouse clicking on the image and dragging to make a dotted box over the area of interest. The cursor changes to a magnifying glass with + sign in the bottom right corner of the selected area. Once the left mouse button is released the selected area increases in magnification to fill the whole image. The longest side of the selected area determines the new magnification.
  Using Shift + the left mouse button reverses the zoom effect by

reducing the image area down to fit the selected area drawn. In this case the cursor changes to a magnifying glass with a - sign in the bottom right corner in the dragged area. The escape button cancels the operation at any time.

SCAN SPEED AND FILTERING

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

A noisy image 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 **Intergrate** filter (See Chapter 4).

CONTRAST AND BRIGHTNESS

The contrast and brightness settings can be set manually either by using the MUI or by adjusting the contrast and brightness controls in the **Detectors** module found on several pages (See Chapter 4).
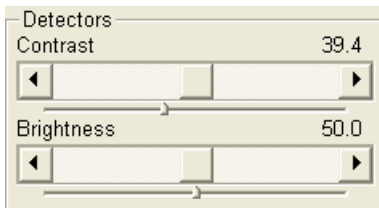
TABLE 5-5   CORRECTING C & B

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

These adjusters always have a label in the upper left and right corners displaying the current Contrast / Brightness level (in %). Double-click this label opens small edit box enabling to enter arbitrary precise value.

Using Videoscope (F3)

The contrast and brightness settings in **Videoscope** mode can be adjusted to optimise the image to obtain the full range of greyscale levels in the active Quad.

The function displays a yellow graph over the active Quad image. The graph consists of three horizontal lines indicating white (top line), middle grey and black (bottom line) levels, and the oscillogram depicting the signal intensity corresponding to the just displayed line. Magnitude and central position of the oscillogram reflect the current image line contrast and brightness, respectively.

If the oscillogram is cut by the bottom / top line of the graph, the signal level is clipped in black / white. This should be avoided in normal imaging because the image details are lost in the clipped areas. Tuning the oscillogram exactly between the top and bottom lines for the entire scanned image results in the crispest and full detailed image. The signal clipping may be used to obtain harder contrast conditions (for instance, in BSE images, when more black and white is sometimes needed). The shortening of the oscillogram amplitude between the top and bottom lines decreases the contrast accordingly, making the image look softer.

Enhanced Image

Lut | Mix 3 | Mix 4 | Color

Backlight ▼

Digital Contrast 1.0
◄ ►

Digital Brightness -0.10
◄ ►

Gamma 0.5
◄ ►

Histogram | Save
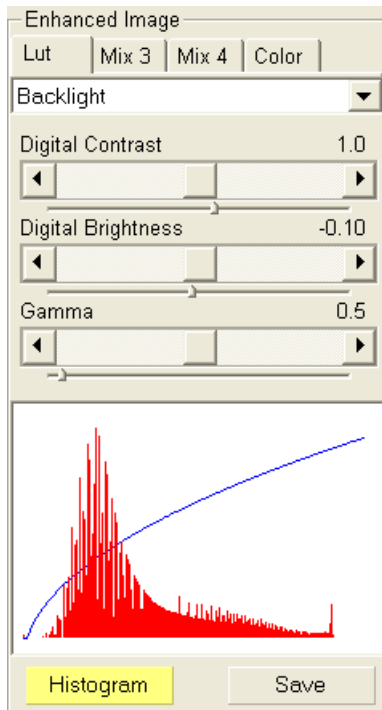
TABLE 5-6 CORRECTING C & B USING VIDEOSCOPE

Step	Action
1.	Select a slow scan in an active quad
2.	Click on the Videoscope button on the toolbar.
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 roughly in the middle.
6.	The high and low peaks should just clip the dashed lines.

Enhanced Image on the **Processing** page can be used to adjust the LUT, including Gamma control. This can be useful for low signal conditions or odd imaging requirements. Results affect the videoscope display.

Note:
Use also following functions to optimize
the Contrast / Brightness (see chapter 4 for detailed description):
Auto Contrast Brightness(F9), **User Auto Contrast Brightness**,
Display Saturation (Shift + F11)

:

FOCUSING

The easiest way to focus is to find a feature of interest with distinct edges on a specimen. Use a combination of contrast, brightness, magnification, and focus adjustments to maximize the image quality.

TABLE 5-7   CORRECTING FOCUS

Step	Action
1.	When the mouse cursor is over a SEM image, press and hold down the right mouse button. The mouse cursor changes to double-ended arrow indicating the focus function. Move to mouse from side to side until the image is sharp, then release the mouse button.
2.	When holding the right mouse button, the focus function (cursor) is active over the whole screen. If moving over the whole screen range is not sufficient to get the image in focus, release the mouse button at one side of the screen, move the mouse cursor to the oposite side, and press the right mouse button again to continue focusing.
3.	Move the specimen to a desired area with the X and Y stage controls or double-click with the right mouse button on the desired specimen feature and refocus until the image is sharp.
5.	If this is the first time focusing the new specimen, then click on the Z to FWD icon button on the toolbar to set the Z value on the **Stage** module equal to the actual free working distance.

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 at a higher magnification makes the result more precise. For example, for a high resolution output, set the magnification level at 2000x and focus at 4000x to 8000x.

Focusing with the MUI (option)

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

Note:
Use also following functions to focuse the image
(see chapter 4 for detailed description):
Reduced area (F7), **Auto Focus**

CORRECTING ASTIGMATISM

You need to correct astigmatism of the image when you change the final lens aperture, specimen or imaging conditions. Astigmatism in the image is usually better visible at higher magnifications (3000x or more). If astigmatism is present, a directional distortion change of 90° between the two out-of-focus conditions is observed.

TABLE 5-8 CORRECTING ASTIGMATISM

Step	Action
1.	Focus the image as well as possible
2.	Bring the image just slightly out of focus. The image appears to become sharper in one direction whereas in perpendicular direction image distortion increases (bluring or stretching of the image).
3.	Defocus in the other direction to observe the oposite astigmatic distortion.
4.	Focus to the midpoint between the two distortions.
5.	**Mouse:** press shift and hold the right mouse button down while in the active quad. This results in a 4 arrowed cross appearing on the screen with the cursor position at its center. Still holding the right mouse button down, move the cursor around the screen to achieve maximum sharpness). When you are satisfied with the image, release the right mouse button. **MUI:** adjust image sharpness with the stigmator **X** and **Y** knobs until the best image 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 right mouse button, 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 in a similar way as was described for focusing.

If stigmation cannot be corrected, there may be some other reason (usually the final lens apperture is dirty – see Chapter 8 "Maintenance" for cleaning instructions), the magnification may be too high for the beam spotsize (see below) or the sample is charging (apply conductive layer or use LoVac mode).

BEAM SPOTSIZE

The actual focused area of the electron beam on the specimen is referred to as spot size. **Spot** size has assigned numbers that range from 1 to 7. Both the focused beam area and the **Beam Current** increases with the increasing Spot size. The Beam Current depends also on the current High Voltage and the selected final lens aperture (**SEM Aperture** selected in the **Beam** menu). There are 11 pre-set Spot sizes with the corresponding Beam Current values selectable from the corresponding toolbar list box.
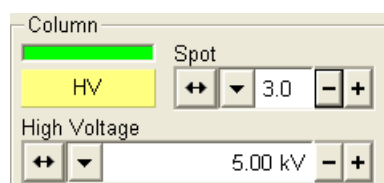
TABLE 5-9 SPOTSIZES AND RECOMMENDATION OF THEIR USE

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

Adjusting Spotsize for Imaging

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

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

Use the focus control with the right mouse button to correct the sharpness of the image. Focusing at a higher magnification makes the result more precise.

When you change spotsize, adjustment of the **Contrast** and / or **Brightness** in the **Detector** module may be necessary to optimize the image. An alternate approach is to press the **Auto Contrast Brightness** button found on the toolbar.

MIXING IMAGES

The XT-software gives you the possibility to mix up to 3 signals from different sources simultaneously in a single quad. See Chapter 4 for a detailed description.

Quad 4 serves to mix the signals from Quads 1, 2 and 3. Quad 3 can be used to mix the signals from Quad 1 and 2.

The Mix "detector" uses the images displayed in the imaging windows, not the raw detector signals. Any image processing (Average/Integrate Filter, contrast and brightness enhancement via the LUT, and application of the Color profile, if Enabled) selected for the source Quads occurs before the mixing operation. If the images being mixed are coloured, the colors are first converted to grayscale levels. The resulting Mix image can be again processed using the Enhanced Image / LUT and/or Color sections.

Any combination of Live, Averaged, Integrated, Paused or loaded (from a file) images can be mixed together, providing that the both (or all three) images being mixed have the same pixel resolution. However, there are some logical limitations applied to the resulting Mix image:

- The Average and Integrate filters are disabled
- Pause / Unpause influences only the mixed image, not its source images; the Mix Quad is always paused immadiately regardless of the current scanning status
- When a colour mixing is selected, any further colouring (using the Color section) is disabled
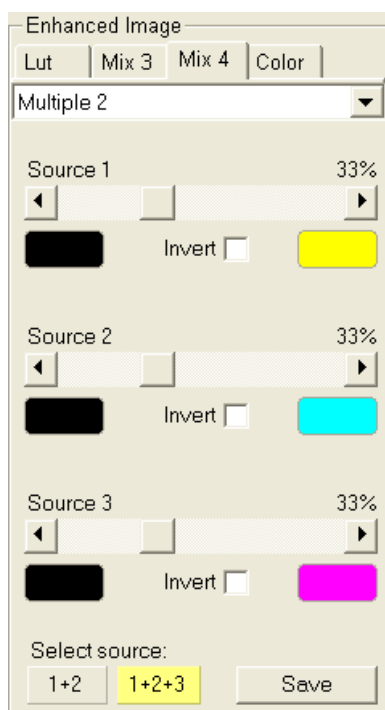
Detector Types and Usage
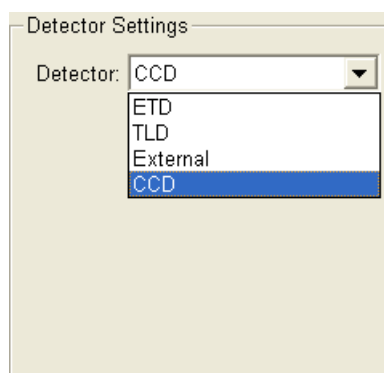
The **Detectors** pull-down menu shows the detectors installed on your system. Select the detector to be used for imaging. When you select a detector, the last set C & B values for the chosen detector and mode are set. Availability of detectors (full colour detector name in the menu) depends on vacuum state and chosen SEM mode. When changing the Vacuum or SEM mode, the system always reverts to the last detector used for that beam.

Note:
If any detector which is not compatible with the current mode is selected, the imaging quad cannot be unpaused.

TABLE 5-10 STANDARD AND OPTION DETECTORS

Standard	Detector Name	Tag	Vacuum Mode	Detected Signal	SEM Mode
Yes	Everhard-Thornley	ETD	HiVac	SE (tunable energy) BSE	**1** / **3**
Yes	Through-lens	TLD	HiVac	SE (tunable energy) BSE	1 / **2** / 3
Yes	Low Vacuum	LVD	LoVac	SE + BSE	**1** / 2 / **3**
Yes	Infra-red CCD camera	CCD	any	light, infra-red light	any
No	Helix	HLX	LoVac	SE	1 / **2** / 3
No	Solid-state backscattered electron	BSED	HiVac	BSE	**1** / 2 / **3**
No	Gaseous analytical	GAD	HiVac, LoVac	BSE	**1** / 2 / **3**
No	Low Voltage High Contrast Solid State	vCD	HiVac, LoVac	BSE	**1** / 2 / **3**
No	Special Low Vacuum (delivered with GAD and vCD)	LVD	LoVac	SE	**1** / 2 / **3**
No	Photo Multiplier Diode (Scintillation BSE or Cathodo-lumniiscence)	PMD	HiVac	BSE, photons	**1** / 2 / **3**
No	Solid State Scanning Transmitted Electron Microscopy Detector	STEM I	HiVac, LoVac	transmitted electrons	1 / 2 / 3
No	Retractable Annular STEM Detector	STEM II			
3rd party	Energy-dispersive X-ray	EDX	HiVac	X-ray photons	2 / 3
3rd party	Wavelength-dispersive X-ray	WDX	HiVac	X-ray photons	2 / 3
3rd party	External	EXT	detector-dependent	detector-dependent	1 / (2) / 3

Note:
- SE = secondary electrons
- BSE = back scattered electrons
- Preffered SEM modes are highlighted (boldface).

:

ON HOLD CHANGES WHEN PATTERNING

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

EVERHART THORNLEY DETECTOR (ETD)
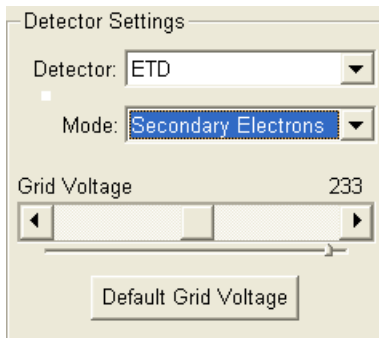
This is a scintillator photo-multiplier type detector monitoring electrons generated by the primary beam interaction with the specimen surface. It is permanently mounted in the chamber above and to one side of the sample. It works in two **Mode**s:

- Secondary Electrons (SE)
- Backscatter Electrons (BSE)

The **Detector Settings** module contains an adjuster to control **Grid Voltage**. The normal operating setting for **Secondary Electrons** imaging is +250 V . When the voltage is negative (use a range of -25 to -150 V), secondary electrons are repelled from the ETD detector and only **Backscatter Electrons** are detected.

The **Grid voltage** (a range of -200 V to +250 V) and scintilator voltage (10 kV) are switched off during venting of the specimen chamber, during vacuum mode change or in Low Vacuum mode.
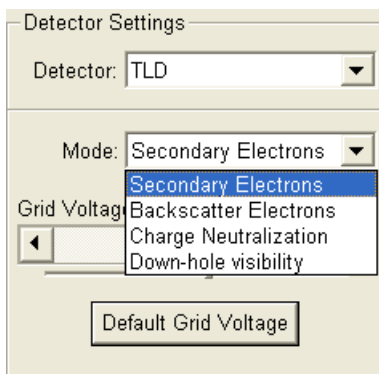
TROUGH THE LENS DETECTOR (TLD)

You can choose up to four modes for this detector from the Detector Settings module / Mode list box. The TLD works in all SEM modes, but it is primarily designated to high resolution imaging in Mode 2.

The TLD detector can have the grid voltage changed to give custom variations of electron collection. When grid voltage is negative, low energy secondary electrons are repelled from the TLD detector and only backscattered electrons are detected. When grid voltage is positive, low energy secondary electrons are collected by the TLD detector. The biasing capability is from -150V for only backscattered electrons to +150V for secondary collection.

LOW VACUUM DETECTOR (LVD)

is used as the standard detector for the Low Vacuum mode. Mounting this detector on the objective pole piece enables LoVac operation in the whole pressure range from 0.08 to 1.5 Torr (10 - 200 Pa). The LVD detector limits the field of view to about 1 mm at the working distance of 5 mm. The minimum working distance is limited to about 3 mm.

The LVD detector can be used in all SEM imaging Modes, but is primarily intended and gives better signal in modes 1 and 3. The signal from LVD contains both secondary and backscattered electron information. It is optimal for general imaging at Low Vacuum conditions.

FIGURE 5-2 LOW VACUUM DETECTOR (LVD)

Installing the LVD

The LVD plugs into the signal connector behind the objective pole piece on the left side , and is mounted onto the pole piece using the bayonet lock joint. The detector's PCB (Printed Circuit Board) must be plugged into the signal connector before the cone is mounted onto the pole piece. Hold the cone by its aluminium handle and put it gently on the bayonet base of the objective lens. Turn to the left to fix it on the base. Remove the detector the same way - first dismount the cone, then unplug the PCB connector. Always use gloves.

Obtaining the image

After pumpdown and purge process switch on the HV button, use mode 1 preferably. Detector Voltage slider is automaticaly adjusted to the value used the last time. Adjust **Detector Voltage** slider if necessary to increase signal or stop possible discharges. At the lowest possible magnification, increase the Contrast and adjust Brightness if necessary, until the bright circle of the LVD cone can be seen in the center of the image. Increase magnification and adjust Contrast and Brightness more precisely.
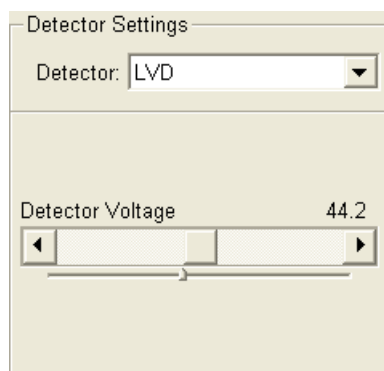
DISCHARGES BETWEEN THE LOVAC DETECTORS AND THE SAMPLE

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

• Detector voltage is set too high
• Sample is too close to the detector
• Gas pressure is too low
• Air in the chamber (water vapour purge cycle not complete)

5-15

Capturing and Handling a 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 xT DOCU database software image saving function (see separate manual). All permanent data should be stored on the support PC rather than the microscope controller to prevent filling the hard drive.

For a detailed description of the following functions see Chapter 4.

Setup the file name label and harddrive destination for the image to be saved or archived using the next available label / number prior to the capture session. Enter the correct information into the Data Bar (see Preferences… / DataBar tab), which is important if archiving.

The conditions for good image quality are:

• Slow scan speed (longer dwell time) of the beam.
• Select a pixel resolution from the dropdown list box to suit the detail in the image, i.e. no tearing pixelated edges.
• Increase the magnification at least 2x above the desired value, focus and stigmate (using the reduced area), then return the magnification back.
• Use the Videoscope to correct the Contrast and Brightness accurately, otherwise use the Auto C&B.

SNAPSHOT / PHOTO / PAUSE BUTTON

The **Scan** menu / **Snapshot** (**F4**; **Ctrl + F4**) / **Photo (F2)** function activates a preset scan (see Chapter 4) to capture an image. The toolbar icon corresponds to the Snapshot function.

The **Scan** menu / **Pause** (**F6**) function stops the scanning at the end of the current scan so that an image can be saved. To activate the scanning, activate the Pause function again.

FILTERING FUNCTIONS

The **Average** function improves an image by continuously averaging 2 or more frames. It is especially useful for fast scans to decrease the image noise level.

The **Integrate** function adds up frames into a single averaged image. This process continues until the predefined number of frames is reached, and then stops and pauses automatically.

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 colours 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 **Colour** 24 bit image offers 256 levels of each primary colour (red / green / blue).

  Digital colours coming from the Display Saturation feature, from the Image Enhancement module / Color tab, from the Mix quad with colour 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 colour enhancements, it is necessary to turn off the respective UI functions.

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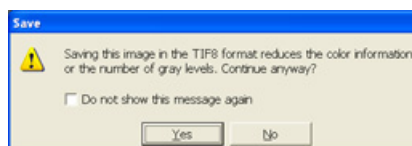
The image captured can be saved in various digital formats, depending on the resulting colour and bit depth needed. Generally there is no reason to save an image with a higher bit and colour depth than available in an original one. Over against saving an image with a lower bit and colour depth than available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

- The **TIF** 8 / 16 – greyscale image file
- The **TIF** 24 file – colour image type
- 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 / colour image file.
- The **BMP** file – the 8 / 24 bit depth is automatically selected when saving the greyscale / colour image file.

Note:
only files saved in **TIF** format (from the xTUI) contain the active processing information, which could be utilized later for a databar setting (see the **Preferences…** / **Databar** tab).

SAVING / OPENING / PRINTING
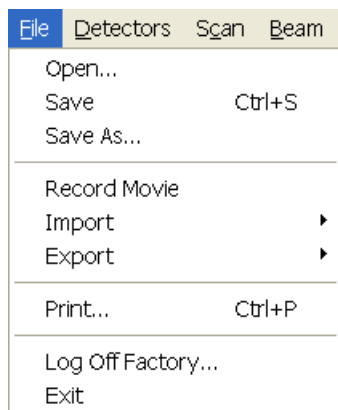
After pausing the scan, the following functions could be chosen:

- **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 and Photo functions in the **Preferences… / Scanning** tab.

TABLE 5-11 IMAGE CAPTURING PROCEDURE

Step	Action
1.	Select the area of interest and set the **Magnification**, the **Scan condition** and the **Pixel** resolution that are required in the captured image.
2.	Make the best image using any suitable method you are familiar with.
3.	Use the **Snapshot / Photo (F2) / Pause (F6)** 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 **Save (Ctrl + S) / Save As…** function in the **File** menu.
5.	The scan can be released by clicking on the **Pause (F6)** button on the toolbar.

- **Open…** opens a single image file in the active Quad. The dialogue displays, by default, the location used in the last Save As… dialogue.
- **Print… (Ctrl + P)** opens the printer setup dialogue so that the choice of printer and settings can be established to print the active image. Pressing OK in the printer setup dialogue activates the printer to print the job.

TABLE 5-12 IMAGE PRINTING PROCEDURE
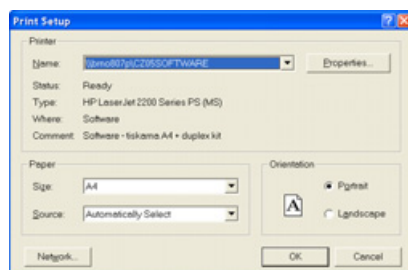
Step	Action
1.	Select a **Quad**. Optimize the image conditions in that quad.
2.	Capture the image or open an existing image from memory into the quad.
3.	Click on **Print… (Ctrl + P)** in the **File** menu, a print dialog appears.
4.	Complete the print setup and click on **OK**.
5.	The image set in the selected quad now goes to the printer.

Note:
Only printers on the Support Network are available. It is not possible to print to the network printers from the microscope controller as it is not on the LAN directly.
Some printers may not work with high resolution images because they do not have sufficient memory.

Recording Movies (Saving Multiple Images)

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

- Resolution 512 x 442 or 1024 x 884
- 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 coloured 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 (labelled **Timer)**, the other to set-up save conditions for the resultant movie (labelled **File)**.

FIGURE 5-3   MOVIE PREFERENCES

:
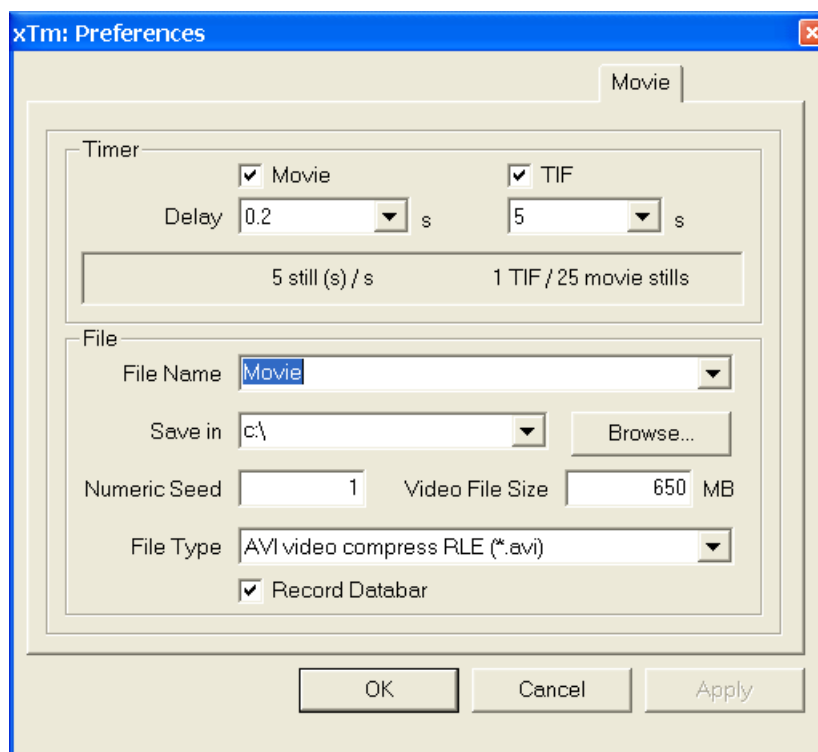
Timer module

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.
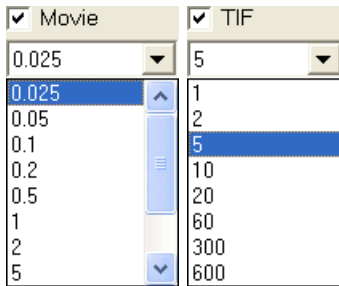
- The **Movie** check box – AVI (Digital Video) timer:
  After the **Delay** time, the image of each active quad is stored immediately (even in the middle of the frame) as a new frame in the video stream.
- The **TIF** check box:
  After the **Delay** time, images series of each active quad are stored 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).

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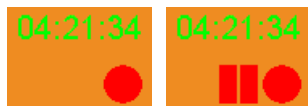
The **red dot** button starts the recording of all active quads at the same moment – no video / images are stored for paused quads. When a quad is paused during the video recording, the storing of the video frames is interrupted but the video streams keep synchronization for the next recording.

When the red dot representing 'Start' is 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.

TABLE 5-13   SET-UP AND RECORDING A MOVIE

Step	Action
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 x 884 the following dialogue appears: Choose either of the offered **Resolution** values at which the movie starts to record.
5.	Select the **File** menu / **Record Movie** again or click the toolbar / red square button to stop the movie recording.
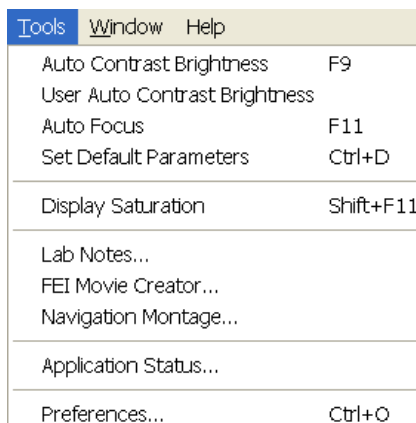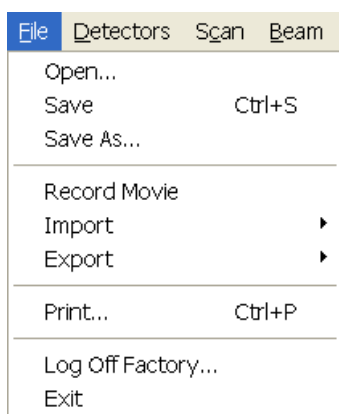
FEI MOVIE CREATOR

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 5-4   FEI MOVIE CREATOR TAB: FILE
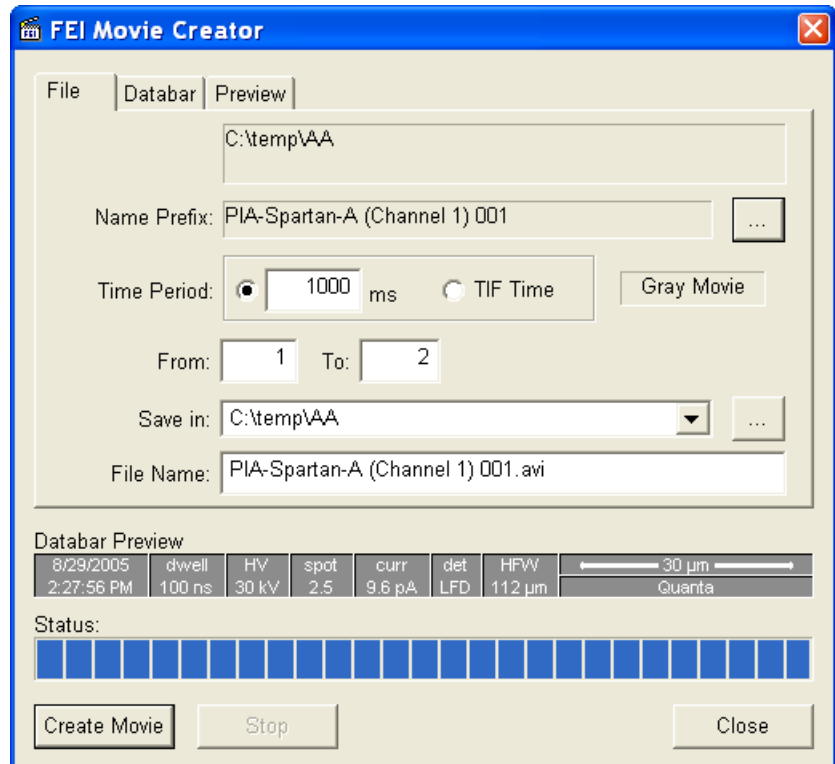
- The **Name Prefix** – click the **…** button to browse the TIF files (with the desired sequence prefix) directory. It is not necessary to choose the first file in a row.

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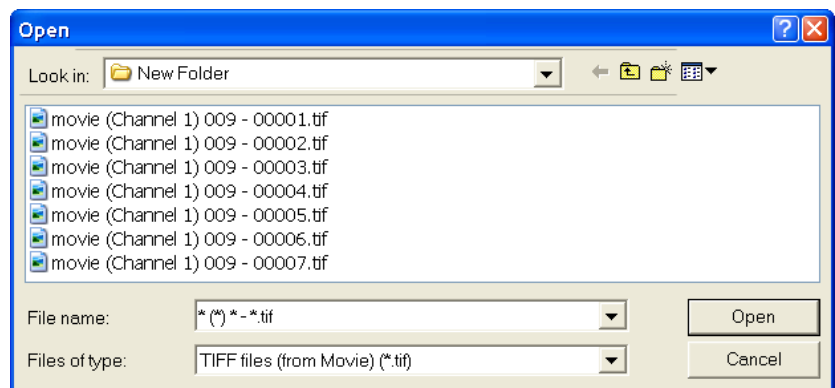
- The **Time Period** – select the **ms** radio button to select a custom timing for the movie playback. One may experiment (200 ms is good for most movies to speed it up). Select the **TIF Time** radio button to select a real timing for the movie playback.
- The **Gray Movie** button suppresses the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

FIGURE 5-6 FEI MOVIE CREATOR TAB: DATABAR
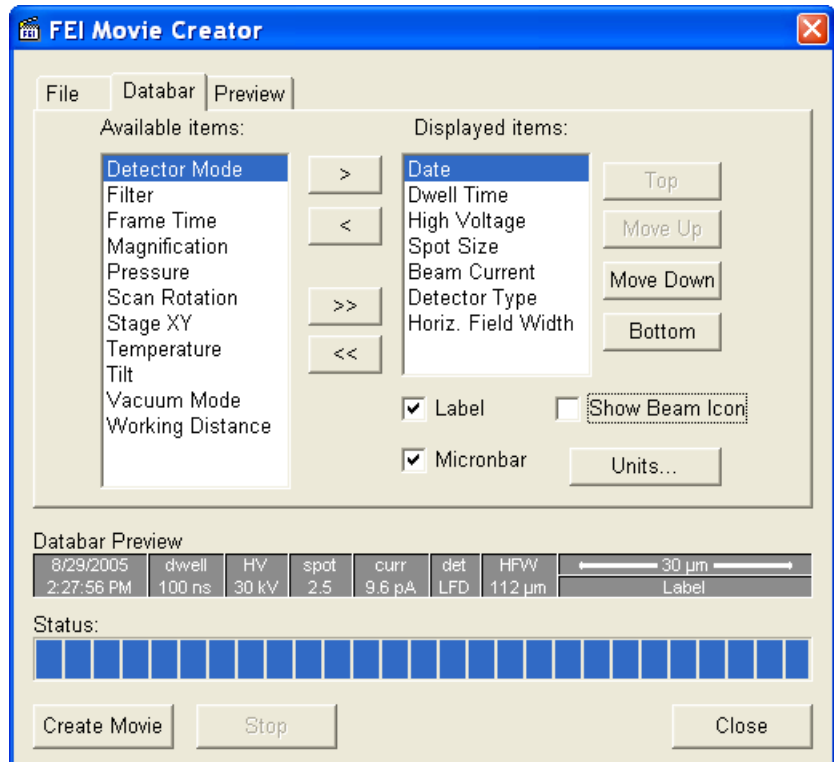
- The **Available** / **Displayed items:** lists – all items that can be entered in the databar / are already present in the databar.
- **> / >> (< / <<)** buttons adds one / all item(s) from the Available list to the Displayed list (removes one / all item(s) from the Displayed list back to the Available 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 5-7   FEI MOVIE CREATOR TAB: PREVIEW
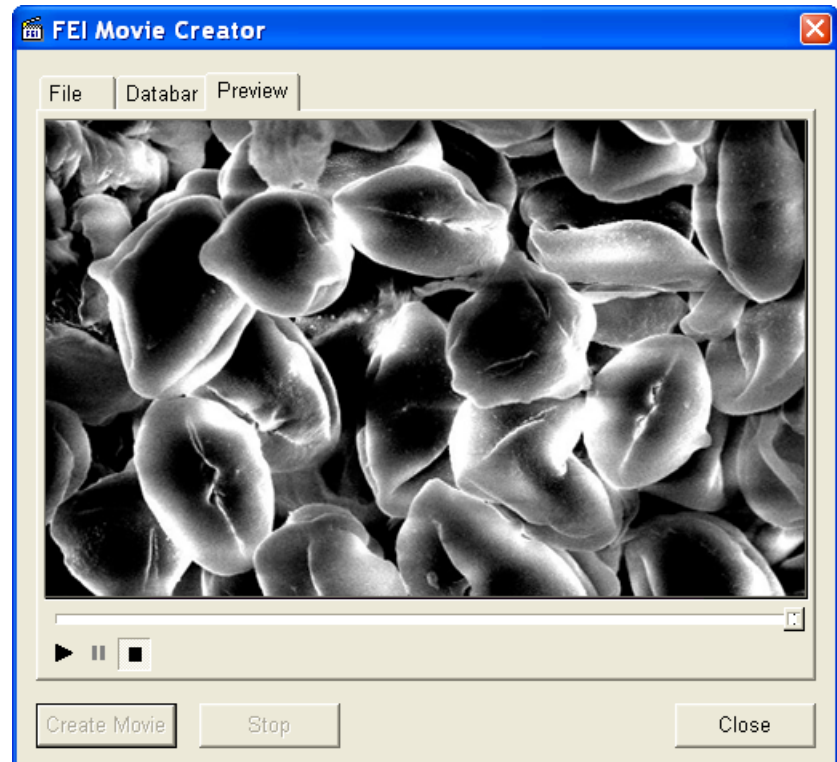
- The **Start** / **Pause** / **Stop** button starts / pauses / stops the movie play back. By dragging the adjuster one can run forward or backward through the movie.

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.

Beam Deceleration
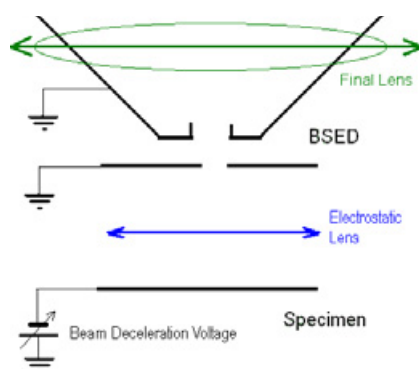
The Beam Deceleration mode (BDM) method is based on a negative voltage (up to -4 kV) applied to a sample (**Beam Deceleration Voltage** – BDV). The electrical field between the sample and the nearest surface above (a column bottom or a detector) is formed, acting as the additional electrostatic lens. Its power is described by the **Immersion Ratio** (IR = e.HV / LE) parameter, determining how many times the primary electron energy (e.HV) is lowered when reaching the sample surface with the **Landing Energy** (LE = e.(HV - BDV)).

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 SE and BSE are accelerated before the detection. When reaching the detector initial electron energy (when leaving the surface) is intensified by the BDV potential. SE / BSE are detected with approximately e.BDV / e.HV energy. The higher is the IR, the lower is the difference between SE and BSE energies.

- 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 Immersion Ratio an output angle distribution of electrons leaving a surface could be obtained.

FIGURE 5-8 TYPICAL TRAJECTORIES OF SECONDARY (RED) AND BACK SCATTERED (GREEN) ELECTRONS
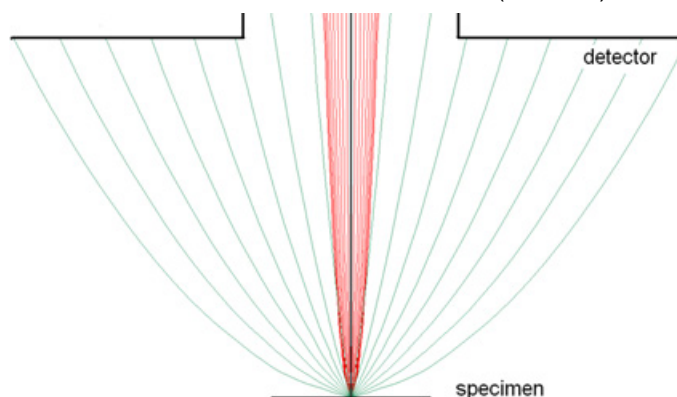
Detectors most convenient for the Beam Deceleration are BSE ones, placed closely under or directly inside the column. Their efficiency depends on their active area: the smaller the active area inner diameter the better. The standard ETD could also be used, but its efficiency is low.

Beam Deceleration Applications

- The BDM enables detection of the BSE when the landing energy is under the detection limit of the detector.
- The BDM expands the Landing Energy range under the minimum HV limit (200 V for the standard Quanta microscope). Besides it enables a smooth landing energy change with the 10 V precision.
- 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 landing energies is well compensated.
- The BDM enables to detect electrons heading nearly parallel to a surface which accentuates a surface roughness.

Application Restrictions

- In the LoVac mode the chamber environment is rather electrically conductive, so it is not possible to raise the BDV (it is disabled by a safety interlock) and the BDM is not available).
- The sample tilt causes an electrical field deformation, which adds not correctable aberrations (a chromatic aberration and an image distortion). An acceptable sample tilt is about a few degrees, for a higher immersion ratio preferably less.

FIGURE 5-9   SIGNAL DISTORTION AND IMAGE ABERRATIONS FOR TILTED AND ROUGH SAMPLE (TIN BALLS) AT HIGH IMMERSION RATIO
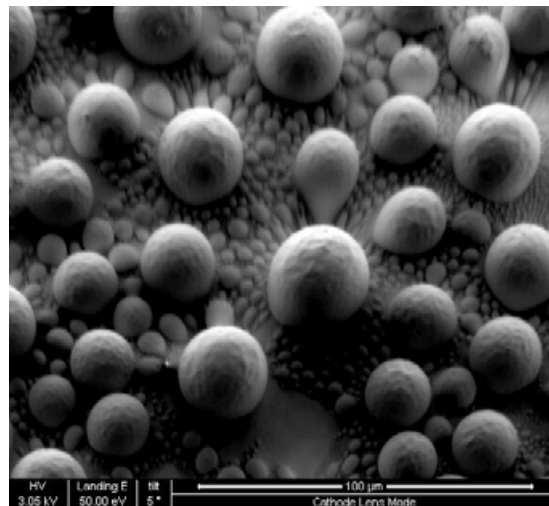
BEAM DECELERATION MODULE

The **Beam Deceleration** module is accessible from the **Beam Deceleration Control** page.

When starting the procedure for the first time after any vent procedure, the special **xTm: Pole Piece Configuration** dialogue asks to specify the actual attachment on the final lens pole:

- In case the GAD detector is attached on the final lens insert and selected, the system dialog ask an user to remove it.
- In case the LVD or HELIX detector is installed, the BD Mode button is not accessible.

The module has following features:

- The **BD Mode** button switches the BDM on / off. This is available only in the HiVac mode and with the Beam On. When switching the beam off, the BDM switches off too automatically.
- The **Modulator** button starts to modulate the BDV in the range ±100 V, thereby it periodically changes the immersion ratio. This is useful for an optimal sample tilt adjustment.
- The **Landing Energy** (LE) preset / continuous adjuster sets the energy of the electrons reaching a sample surface. This is achieved by changing the BDV, when reaching its marginal values by changing the HV.
- The **Beam Deceleration Voltage** (BDV)**:** reflects the voltage applied to a sample. Minimal value is 50 V.
- The **Immersion Ratio** (IR) continuous adjuster sets a ratio between a primary electron energy and the particular landing energy. It changes the HV and the BDV together. The higher is the immersion ratio, the more powerful is the Beam Deceleration.
- Clicking the **Maximum Immersion Ration** button keeps the IR at the maximum for a particular setting (BDV is at the maximum).

Note:
A Landing energy value can also be displayed in the databar. It is also stored within the TIF file header. In case the BD is not on, LE corresponds to the HV.

:
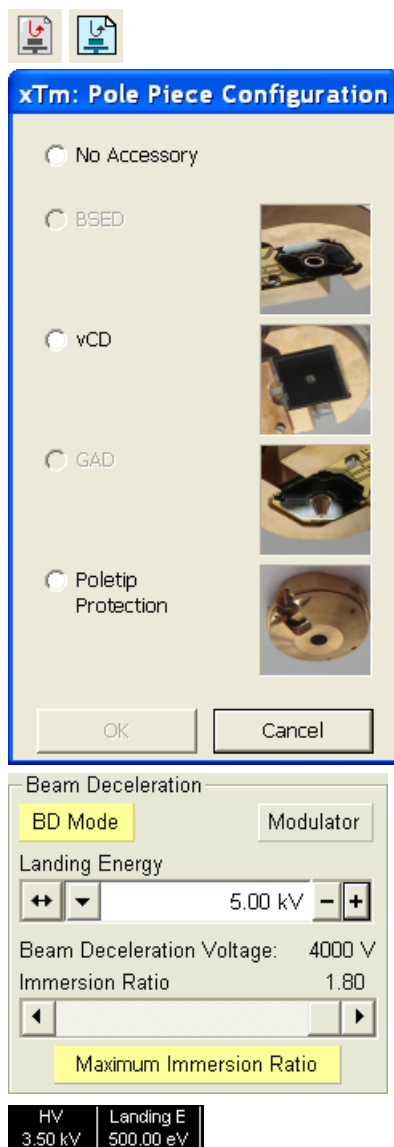
Beam Deceleration Mode Imaging Procedure

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

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

2. Select the suitable HV and find an area of interest. Set the Eucentric Position (see Chapter 7) and tune an image with the Lens Alignment and the Stigmator (see Chapter 4). In various quads get the SE (ETD) and BSE (BSED, PMD) images to observe different imaging simultaneously.

3. Click the Mode On button. Gradually raise the immersion ratio. The SE / BSE image is getting dark / light.

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

   When an image is shifted during an immersion ratio change, the sample is possibly not parallel with the detector. To correct this, click the Modulator button (the BDV starts to change periodically with the 100 V amplitude). With the use of the Compucentric stage rotation / stage tilt minimize the image shift in the X / Y axis until it is acceptable. Switch off the modulator.

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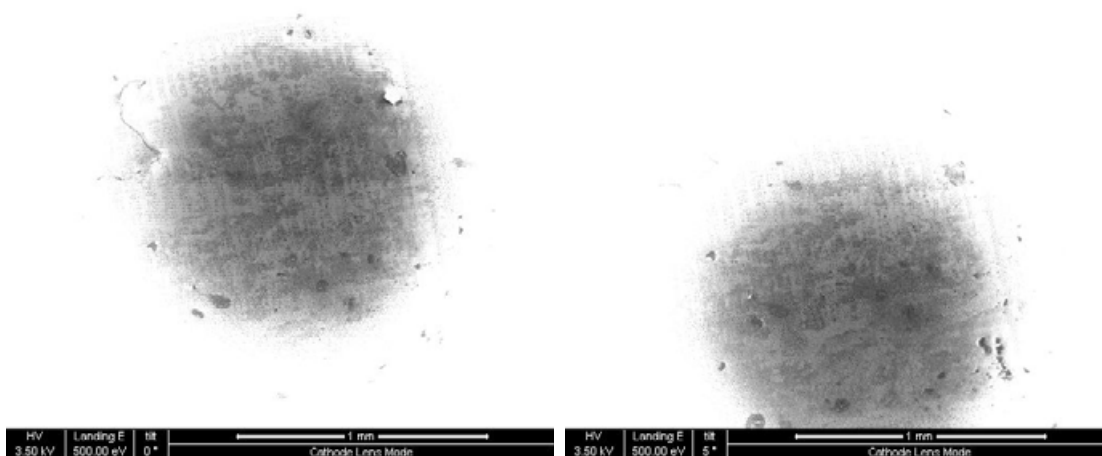
4. Set the landing energy considering the sample material (charging compensation, material contrast). Set the immersion ratio to optimize the signal. Set the brightness, contrast and WD according to the requirement.

5. Tune the Lens Alignment and the Stigmator (both factors remembers the HV and immersion ratio last used).

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

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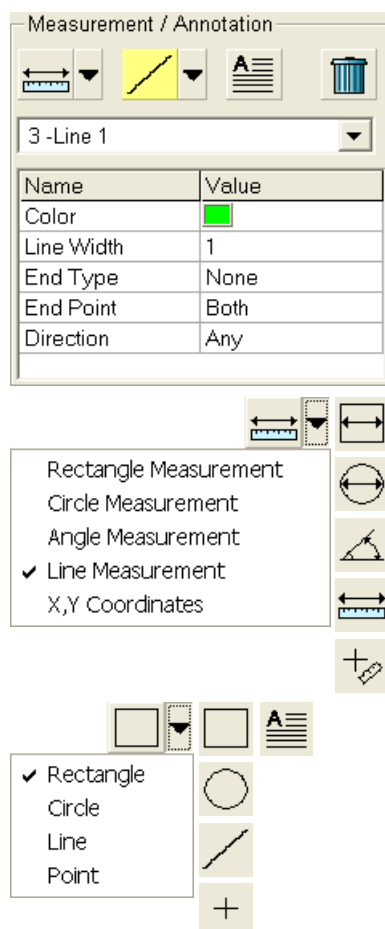
The **Processing** page / **Measurement / Annotation** functions give an user many capabilities to measure distances, angles, diameters and areas as well as locating and labelling items that are of significant interest on the sample area.

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).

Property Editor

enables to change a property of a selected Measurement / Annotation / Text graphic by a selection from the dropdown list or by a direct editing of a text or a value.

Shape Creating

1. Choose the suitable **Measurement / Annotation** graphic tool.
2. Draw the graphic over the area of interest. This can be done by:
   – dragging the cursor from the top left corner to the right lower corner of the shape.
   – holding SHIFT key while 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 with the left mouse button or press the enter key to confirm it and the text appears onscreen.

:
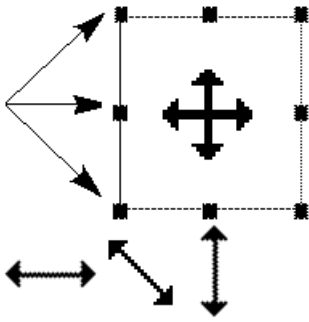
Shape Editing

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.

- **Moving graphic:** place the cursor inside the boundary of the graphic and hold the left mouse button while dragging it (use move cursor).
- **Resizing graphic:** hold the left mouse button and drag the resizing handle until the desired size is reached (use horizontal, vertical or diagonal resizing cursor). Holding 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.
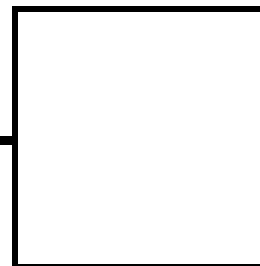
6 ALIGNMENTS

This section describes the set-up for source, stage and column e.g. the emitter start and emitter mode selection, stage rotation centre and the electronic alignment of the column using the software in the "Alignments" Pages.

Alignment list

List of alignments accessible for a supervisor:

- Manual Aperture Centring
- 5 - Emitter Startup
- 10 - Source Tilt and Shift
- 13 - Stigmator Alignment
- 17 - Stage Rotation Centre
- 44 - UHR Lens Alignment
- 42 - UHR Stigmator Alignment
- 43 - UHR Image Shift Correction
- 45 - HR Image Shift Correction
- 81 - Crossover Position Calibration

List of alignments accessible for an user:

- Manual Aperture Centring
- 17 - Stage Rotation Centre
- 13 - Stigmator Alignment

Recommendations

The alignment of the system should be made on an interval schedule as following :

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

Nova NanoSEM Systems Alignments
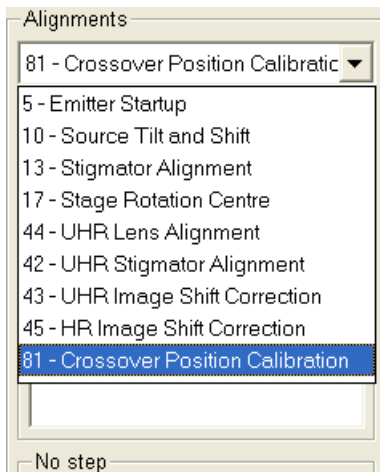
Go to the "Alignments" pages. Open the list box by clicking on the down arrow, then choose the **Alignment** needed. Always follow the instructions given in the **Instructions** module. Click on the **Start** button and proceed with following pages.

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

During adjustment procedures it is allowed to change magnification, scanning speed, to use reduced area and to optimize image brightness. If it is not forbidden for a particular alignment, it is also possible to stigmate and to focus an image. During adjustment procedures it is not allowed to manually change Mode, Spotsize, High Voltage and to use the beam shift .

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

Note:
Before you align the Electron column, be sure that the final lens aperture is clean and properly centred.
Do not use the Beam Shift at any time during the adjustment procedures, other than where specified, as this is set to zero value at each alignment section, and extra movement can offset the zero condition. All movement of the specimen can be made using the stage, either mechanical or motor driven, where appropriate.

COMMON BUTTONS BEHAVIOUR

The following buttons and behaviours are common for all alignment pages. When available, they have the following effects:

- the **Next** button moves the user to the following page after all the necessary settings have been selected.
- the **Previous** button moves the user to the previous page should a previous setting need to be changed.
- the **Finish** button completes the procedure and saves the new settings.
- the **Save** button saves the actual settings at that point.
- the **Cancel** button (at any time) returns to the start without having changed the original settings or the settings saved the last time by clicking the Save button.

Final Lens Strip Aperture Alignment

This mechanical alignment is pursued only for the systems with the manual aperture control. It is necesary to accomplish after each new aperture choice from the strip to eliminate image shift when focusing. The position of the final aperture should remain constant and should not be changed further during the alignment procedure.

1. Choose HR (field-free) mode and set HV=30 kV, Spot=2.5, FWD=5 mm. Select Zero Beam Shift from the Stage menu. Select Zero Lens Alignment by clicking the right mouse button on the 2D box center square (see Chapter 4 for more detailed description).

2. Make an image at a magnification of about 1000x.

3. Move the stage to find a good area of interest and focus as best one can.

4. Center a feature with the Get function.

5. Click on the objective Lens coil modulation (wobbler) icon in the tool bar. The scanning condition turns into the fastest scan value, the lens modulator turns on and the alignment cross appears in the center of all imaging quads. The image rotates about a point (maybe different from the image center).

6. Adjust the position of the aperture so that the center of the rotation is under the cross.

7. Increase the magnification to 20 000x and realign. If necessary, repeat at 40 000x. At higher magnification the image moves very slightly in a certain direction. By tuning the aperture, you can minimize this movement.

8. When corrected, switch off the Lens Alignment. There should be no image shift when the focus control is used.

:

5 - Emitter Startup

This procedure enables electron gun switching On / Off. In cases of emergency shut down it allows one to start the IGP (Ion Getter Pump) to pump the electron gun vacuum.

1. Check the **Gun Vacuum Page**: if the **IGP On** button is not accessible, click on the Next button. If it is accessible, click it to automatically start the ion pump. This procedure takes a few minutes. If the ion pump start is not successful, call service.

2. Check the **Emitter Startup Page** buttons and informational fields:

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

Alignments
5 - Emitter Startup
Start

Instructions
This alignnment starts the emitter.
Press the Start button

No step

Emitter Startup Alignment (continued)

Alignments

5 - Emitter Startup ▼

[Next]

Instructions

Press the IGP On button to
start the pumps.
Wait until the Vacuum status
is OK.
Press the Next button to
continue with Emitter startup or
Cancel to quit.

Step 1 of 2

Gun Vacuum Page

[IGP On]

IGP Upper: 0.38 µPa

IGP Lower: 29.06 µPa

[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 ramping is
finished.

Step 2 of 2

Emitter Startup Page:

[Emitter On]   [Operate]

[Restart] [Safe Start] [Shut Down]

[Emitter Off]   [Off]

Remaining time: 0 min 00 s

Extractor: 4030 V

Filament: 2.350 A

Emission: 112.0 µA

Coulomb Tube Current: 4.1 µA

Emitter Life Time:
3648 h 45 min 30 s

[Cancel]

10 - Source Tilt and Shift

Alignments

10 - Source Tilt and Shift ▼

Start

Instructions

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

No step
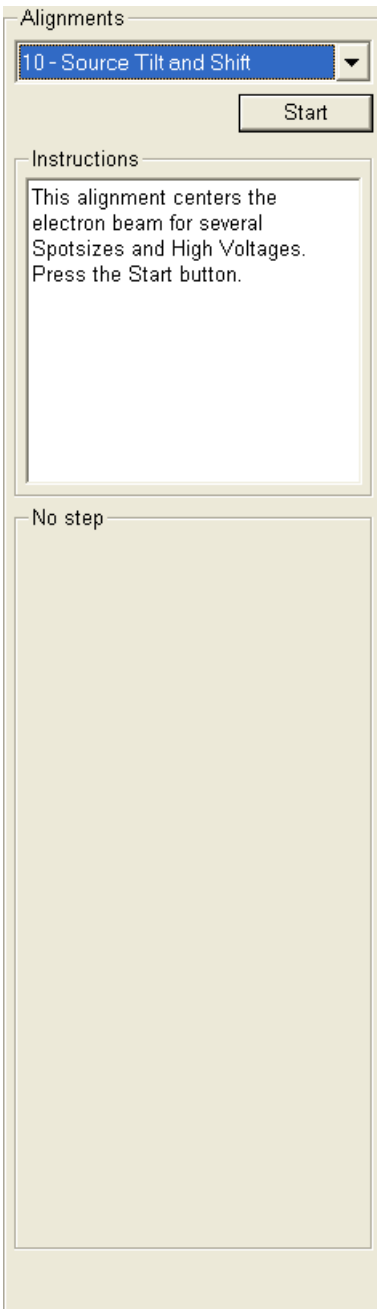
This procedure adjusts electron source in the whole range of voltages and spots. It is possible to complete it only for the voltages which are going to be used but for complete adjustment it is necessary to complete it for all values. Before starting this alignment it is necessary to complete Final Lens Strip Aperture Alignment.

1. Choose HR (field-free) mode and set **FWD=5 mm**.
2. **Select a High Voltage** required.
3. Choose Spots progressively (3.9, 2.5, 1, 4, 5, 6, 7) and for each one adjust **Source Tilt** for maximum brightness and **Source Shift** so there is no image shift during focusing.
4. If you are going to adjust the next voltage after finishing all of the steps for the selected HV, check the **Next HV** check button before clicking the **Next** button to save the adjustments.

Source Tilt Adjustment

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

Source Shift Adjustment

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

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

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

Source Tilt and Shift Alignment (continued)

Column 1

Alignments

10 - Source Tilt and Shift ▼

Next

Instructions

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

Step 1 of 5

Select a High Voltage:

30000
20000
10000
5000
2000
1000
500
300

Contrast   50.34
◄ ▬▬▬▬▬▬▬▬ ►

Brightness   -1.71
◄ ▬▬▬▬▬▬▬▬ ►

Cancel

Column 2

Alignments

10 - Source Tilt and Shift ▼

Previous   Next

Instructions

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

Step 3 of 5

Spot Size = 4.0

Source Tilt   Source Shift
Auto   Auto

Cross Over   Modulator

Mod. Amplitude   0.1244
◄ ▬▬▬▬▬▬▬▬ ►

Contrast   38.93
◄ ▬▬▬▬▬▬▬▬ ►

Brightness   -0.46
◄ ▬▬▬▬▬▬▬▬ ►

Cancel

Column 3

Alignments

10 - Source Tilt and Shift ▼

Previous   Next

Instructions

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

Step 4 of 5

☐ Next HV

Save

Cancel

13 - Stigmator Alignment

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

1. Adjust **Focus** and the **Contrast** and **Brightness** adjusters if necessary. Switch on the fast scan.

2. Click on the **Stig X / Y Wobbler** and by using the 2D box labelled **Stigmator X / Y Alignment**, eliminate the image shift. **Amplitude** slider sets the wobbler modulating depth.

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

Alignments

13 - Stigmator Alignment ▼

Start

Instructions

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

No step

Alignments

13 - Stigmator Alignment ▼

Next

Instructions

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

Step 1 of 2

Stigmator X alignment

Auto

Stig X Wobbler

Amplitude   0.0100

◄   ►

Contrast   50.34

◄   ►

Brightness   -1.71

◄   ►

Cancel

Alignments

13 - Stigmator Alignment ▼

Previous   Finish

Instructions

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

Step 2 of 2

Stigmator Y alignment

Auto

Stig Y Wobbler

Amplitude   0.0100

◄   ►

Contrast   50.34

◄   ►

Brightness   -1.71

◄   ►

Cancel

17 - Stage Rotation Centre

Alignments

17 - Stage Rotation Centre

[Start]

Instructions

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

No step

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

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

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

3. Wait until the stage movement is finished.

:

Stage Rotation Centre (continued)

Alignments	Alignments	Alignments
17 - Stage Rotation Centre ▼	17 - Stage Rotation Centre ▼	17 - Stage Rotation Centre ▼
Next	Previous Next	Previous Finish

Instructions (left):
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.

Instructions (middle):
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.

Instructions (right):
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 1 of 3

Position X = 0.000374 m

Position Y = -0.002626 m

Step 2 of 3

Position X = 0.000344 m

Position Y = -0.001742 m

Step 3 of 3

Cancel   Cancel   Cancel

44 - UHR Lens Alignment

Alignments

44 - UHR Lens Alignment ▼

Start

Instructions

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

No step

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

1. **Select a Working Distance**.
2. Optimize an image: focus with the Z stage movenet or with the tracking mode in the CCD image quad, use **Contrast** and **Brightness** sliders if necessary.
3. Click on **Modulator** button and with the use of 2D box eliminate the image shift. With the **Mod. Amplitude** slider one can set the modulating depth. Repeat for all offered voltages.
4. If you are going to adjust the next WD after finishing all of the steps for the selected WD, check the **Next WD** check button before clicking the **Next** button.

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

:

Alignments

44 - UHR Lens Alignment ▼

Next

Instructions

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

Step 1 of 5

Select a Working Distance.

1.0 mm

1.5 mm

2.0 mm

3.0 mm

4.0 mm

5.0 mm

6.0 mm

Contrast   55.23
◄ ▬▬▬▬▬▬▬ ►

Brightness   -0.10
◄ ▬▬▬▬▬▬▬ ►

Cancel

Alignments

44 - UHR Lens Alignment ▼

Previous   Next

Instructions

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

Step 2 of 5

Setting HV = 10.0 kV

Actual HV = 10.0 kV

(Maximum possible = 18.2 kV)

WD = 5.00 mm

Contrast   55.23
◄ ▬▬▬▬▬▬▬ ►

Brightness   -0.10
◄ ▬▬▬▬▬▬▬ ►

Cancel

Alignments

44 - UHR Lens Alignment ▼

Previous   Next

Instructions

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

Step 3 of 5

HV = 10.0 kV

CorrAngleSX/Y

Auto

0.000215

0.000347

Modulator

Mod. Amplitude   0.0431
◄ ▬▬▬▬▬▬▬ ►

Contrast   55.23
◄ ▬▬▬▬▬▬▬ ►

Brightness   -0.10
◄ ▬▬▬▬▬▬▬ ►

Cancel

UHR Lens Alignment (continued)

Alignments

44 - UHR Lens Alignment ▼

| Previous | Next |

Instructions

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

Step 4 of 5

☐ Next WD

Save

Cancel

Alignments

44 - UHR Lens Alignment ▼

| Previous | Finish |

Instructions

Press the Finish button to save and finish.

Step 5 of 5

Cancel

42 - UHR Stigmator Alignment

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

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

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

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

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

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

UHR Stigmator Alignment (continued)

Panel 1

Alignments

42 - UHR Stigmator Alignment ▼

[Next]

Instructions

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

Step 1 of 6

Select a Working Distance.

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

[Re-align All]

Contrast   65.70
◄ ▬▬▬▬▬▬ ►

Brightness   -0.10
◄ ▬▬▬▬▬▬ ►

[Cancel]

Panel 2

Alignments

42 - UHR Stigmator Alignment ▼

[Previous]   [Next]

Instructions

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

Step 2 of 6

Setting HV = 10.0 kV

Actual HV = 10.0 kV

(Maximum possible = 18.2 kV)

WD = 5.00 mm

Contrast   58.20
◄ ▬▬▬▬▬▬ ►

Brightness   -0.10
◄ ▬▬▬▬▬▬ ►

[Cancel]

Panel 3

Alignments

42 - UHR Stigmator Alignment ▼

[Previous]   [Next]

Instructions

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

Step 3 of 6

HV = 10.0 kV

Stigmator Alignment control

[Auto]

                  0.004
                  0.239

[Stig X Wobbler]

Amplitude   0.0025
◄ ▬▬▬▬▬▬ ►

Contrast   58.20
◄ ▬▬▬▬▬▬ ►

Brightness   -0.10
◄ ▬▬▬▬▬▬ ►

[Cancel]

UHR Stigmator Alignment (continued)

Alignments

42 - UHR Stigmator Alignment ▼

Previous	Next

Instructions

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

Step 4 of 6

HV = 10.0 kV

Stigmator Alignment control

Auto

Re-aligning All

-0.313

0.229

Stig Y Wobbler

Amplitude   0.0025
◄   ►

Contrast   58.20
◄   ►

Brightness   -0.10
◄   ►

Cancel

Alignments

42 - UHR Stigmator Alignment ▼

Previous	Next

Instructions

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

Step 5 of 6

☐ Next WD

Save

Cancel

Alignments

42 - UHR Stigmator Alignment ▼

Previous	Finish

Instructions

Press the Finish button to save
and finish.

Step 6 of 6

Cancel

43 - UHR Image Shift Correction

Alignments

43 - UHR Image Shift Correction ▼

Start

Instructions

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

No step

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

1. **Select a Working Distance**.

2. Bring a recognisable image feature under the screen **Centre Cross** with the use of stage movement (do not use the beam shift!). Optimize an image: focus with the Z stage movenet or with the tracking mode in the CCD image quad, use **Contrast** and **Brightness** sliders if necessary.

3. By using the 2D box labelled **ShiftCorrAngleSX/Y**, bring the image feature back under the screen center cross progressively for all offered voltages.

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

:

UHR Image Shift Correction (continued)

Panel 1

Alignments

43 - UHR Image Shift Correction ▼

[Next]

Instructions

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

Step 1 of 5

Select a Working Distance.

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

Contrast   36.07
◄ �▬▬▬▬▬▬ ►

Brightness   0.77
◄ ▬▬▬▬▬▬▬▬ ►

[Cancel]

Panel 2

Alignments

43 - UHR Image Shift Correction ▼

[Previous]   [Next]

Instructions

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

Step 2 of 5

Setting HV = 10.0 kV

Actual HV = 10.0 kV

(Maximum possible = 18.2 kV)

WD = 5.00 mm

Contrast   36.07
◄ ▬▬▬▬▬▬▬▬ ►

Brightness   0.77
◄ ▬▬▬▬▬▬▬▬ ►

[Cancel]

Panel 3

Alignments

43 - UHR Image Shift Correction ▼

[Previous]   [Next]

Instructions

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

Step 3 of 5

HT = 10.0 kV

WD = 5.00 mm

ShiftCorrAngleSX/Y

Contrast   36.07
◄ ▬▬▬▬▬▬▬▬ ►

Brightness   0.77
◄ ▬▬▬▬▬▬▬▬ ►

[Cancel]

UHR Image Shift Correction (continued)

Alignments

| 43 - UHR Image Shift Correction ▼ |

Previous | Next

Instructions

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

Step 4 of 5

☐ Next WD

Save

Cancel

Alignments

| 43 - UHR Image Shift Correction ▼ |

Previous | Finish

Instructions

Press the Finish button to save
and finish.

Step 5 of 5

Cancel

45 - HR Image Shift Correction

```
┌─ Alignments ──────────────────────┐
│ ┌───────────────────────────────┐ │
│ │ 45 - HR Image Shift Correction  ▼ │ │
│ └───────────────────────────────┘ │
│                        ┌─────────┐ │
│                        │  Start  │ │
│                        └─────────┘ │
│ ┌─ Instructions ────────────────┐ │
│ │ This adjustment minimizes the │ │
│ │ image shift during change of  │ │
│ │ kV in Field-Free Mode (HR).   │ │
│ │ Click on the Start button.    │ │
│ │                               │ │
│ │                               │ │
│ │                               │ │
│ │                               │ │
│ │                               │ │
│ └───────────────────────────────┘ │
│ ┌─ No step ─────────────────────┐ │
│ │                               │ │
│ │                               │ │
│ │                               │ │
│ │                               │ │
│ │                               │ │
│ │                               │ │
│ │                               │ │
│ │                               │ │
│ │                               │ │
│ │                               │ │
│ │                               │ │
│ │                               │ │
│ └───────────────────────────────┘ │
└───────────────────────────────────┘
```

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

1. Bring a recognisable image feature under the screen **Centre Cross** with the use of stage movement (do not use the beam shift!). Optimize an image: set the eucentric height and the WD=5 mm, focus with the Z stage movenet or with the tracking mode in the CCD image quad, use **Contrast** and **Brightness** sliders if necessary.

2. By using the 2D box labelled **ShiftCorrAngleX/Y**, bring the image feature back under the screen center cross progressively for all offered voltages.

HR Image Shift Correction (continued)

Alignments

45 - HR Image Shift Correction ▼

[Next]

Instructions

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

Step 1 of 3

Contrast   63.79
◄ [══════▮══════] ►

Brightness   -1.18
◄ [══════▮══════] ►

[Cancel]

Alignments

45 - HR Image Shift Correction ▼

[Previous]   [Next]

Instructions

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

Step 2 of 3

HT = 30000 V

ShiftCorrAngleX/Y

Contrast   44.08
◄ [══════▮══════] ►

Brightness   -0.07
◄ [══════▮══════] ►

[Cancel]

Alignments

45 - HR Image Shift Correction ▼

[Previous]   [Finish]

Instructions

Press the Finish button to save and finish.

Step 3 of 3

[Cancel]

81 - Crossover Position Calibration

Alignments

81 - Crossover Position Calibratic ▼

Start

Instructions

This alignment calibrates the
Crossover cross position.
Press the Start button.

Note:
Use Quad 1 for the procedure.

No step
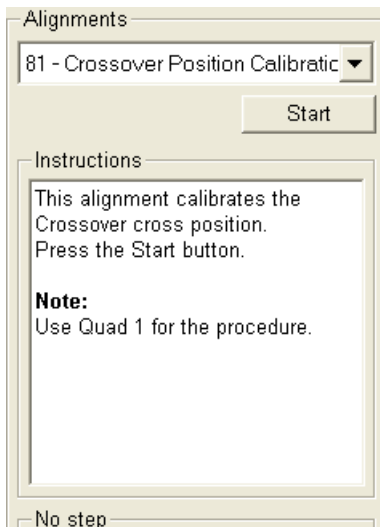
This procedure calibrates the green cross position indicating the ideal crossover center. The calibration is necessary for the proper Source Tilt Auto Alignment performance.

1. Maximize an image brightness in the normal mode with the Gun Tilt.
2. Press the Calibrate button. The system switches to the Crossover mode and the green cross will automatically jump into the crossover spot.
3. Press the Finish button to store the new cross position or Cancel to quit without change.

Alignments

81 - Crossover Position Calibratic ▼

Finish

Instructions

Maximize brightness in normal
mode.
Click on Calibration to start the
automatic calibration of the
Crossover position.
Click on Finish to save the
current Crossover position and
exit or Cancel to leave the
Alignment procedure and return
to original settings.

Step 1 of 1

Crossover X = 0.5664

Crossover Y = 0.4977

XOZoom = 1.0

Gun Tilt

Crossover

Calibration

Contrast   53.32
◄ _____ ►

Brightness   0.60
◄ _____ ►

Cancel

7 STAGES

This section describes the stages and their control possibilities.

The software control for each stage is similar and is an integrated part of the **xT microscope Control** software. The Work Page layout remains the same so that it is easily recognised by users of either stage systems. The significant differences are with such controls as Tilt angle limit, total Z movement, X and Y dimensions and clamping.

The scopes covered in this Chapter are the following:

- Stages types and accessories:
  Nova NanoSEM 230, 50 x 50 mm 4-axes motorised
  Nova NanoSEM 230, 50 x 50 mm 5-axes motorised
  Nova NanoSEM 430, 100 x 100 mm 5-axes motorised
  Nova NanoSEM 630, 150 x 150 mm 5-axes motorised
- Software Stage Functions
- Stage Related Functions

Note:
The clamping mechanism (100 x 100 mm stage) is controled via electrical valve and software control.

Stages Types and Accessories

NOVA NANOSEM 230
50 x 50 mm (4 / 5 -axes Motorised) STAGE

The stage has the **X, Y, Z,** and **Rotation** movements motorised, all with manual override and manual or motorized **Tilt** movement. All movements are read out on the screen, under software control.

The Z height of the specimen can be regulated by the external 25 mm Z control and or the 25 mm internal Z movement. This allows the flexibility to load large or differently sized specimens onto the stage by reducing the internal Z, while still being able to manipulate the difference in height from outside. The Z is eucentric at FWD = 5 mm for this stage.

FIGURE 7-1   NOVA NANOSEM 230 STAGE (4-AXES MOTORISED)

Legend:

1 = Tilt lever	A = Negative end stop
2 = Tilt monitor	B = 30° stop
3 = X axis	C = 45° stop
4 = Rotation	D = 75° stop
5 = Z height	E = Tilt scale
6 = Y axis	F = Stage lock
	G = HV cable
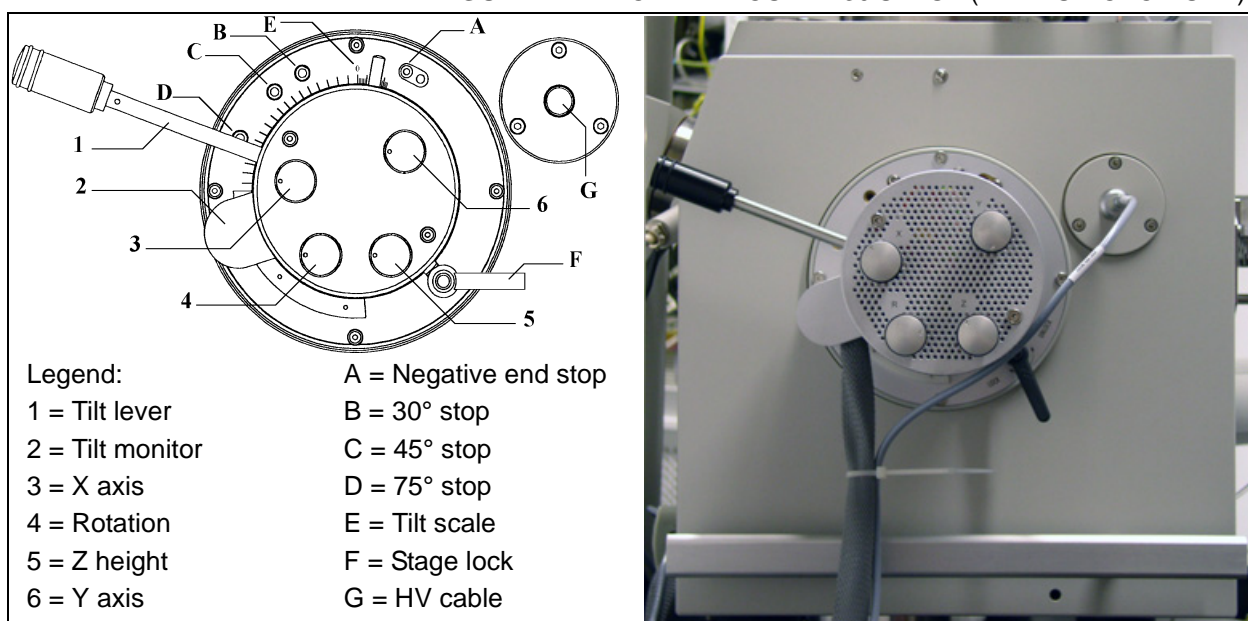
FIGURE 7-2   NOVA NANOSEM 230 STAGE (5-AXES MOTORISED)
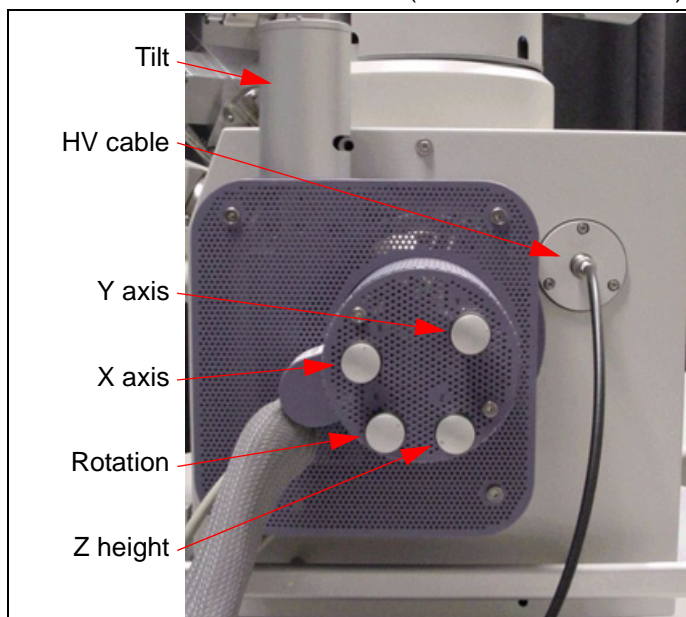
Nova NanoSEM 230 Standard Sample holder

The sample holders provided with the Nova NanoSEM 230 consist of a single stub holder. The single holder has a spring clip fitting and a secure-fitting screw.

FIGURE 7-3 NOVA NANOSEM 230 STANDARD SAMPLE HOLDER

The Nova NanoSEM 230 stage features eucentric tilting and must therefore have a Z position at a set height from the stage rotation head surface to bring the sample surface into eucentric focus.

The eucentric holder is screwed into the center of the rotation head of the stage. When the stub is fitted with the specimen, tilting the stage should bring the specimen to the same height as the tilt axis. The specimen should be no greater than 20 mm thick, or it is impossible to bring it into the eucentric focus.

Using Z (height) adjustment for 50 x 50 mm Stages

With the standard specimen holder it is possible to change the specimen height inside the chamber, to bring the sample to a eucentric position and to have the flexibility then to change the Z from outside the chamber to another position if required.

To set the specimen height to the eucentric position, and at the same time prevent any possibility that the specimen should touch the lens pole if the Z is increased, follow this sequence of steps:

1. Load a specimen onto the specimen holder.
2. With the stage still open adjust the external Z (5) to the highest position.
3. Set the Eucentric Height Adjuster on the stage base.
4. Bring the highest specimen or the highest point on the specimen to the 2 mm position on the Height Adjuster by turning the internal screw of the specimen holder. Lock the position with the locking cone.
5. Reduce the Z so that the specimen now coincides with the Eucentric position on the Height Adjuster by use of the external Z control.
6. Close the chamber, and pump down.
7. When the beam is switched on, focus the sample and perform the Z<->FWD function (se Chapter 4). The FWD will be recognised by the system as the value of Z in the Coordinates tab of the Work page.
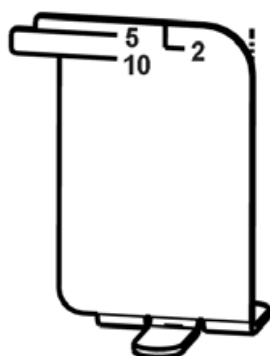
Now the Z can be changed from the external Z control around the eucentric position and further, but not less than 1 mm from the lens for safety reasons.

EUCENTRIC HEIGHT

This should be adjusted after loading any new sample (other than wafer) or for the greatest accuracy, as the sample loading procedure clears all position information. At the eucentric position, one can use various system components (such as the EDX) in a safe and optimal way.

FIGURE 7-4   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.
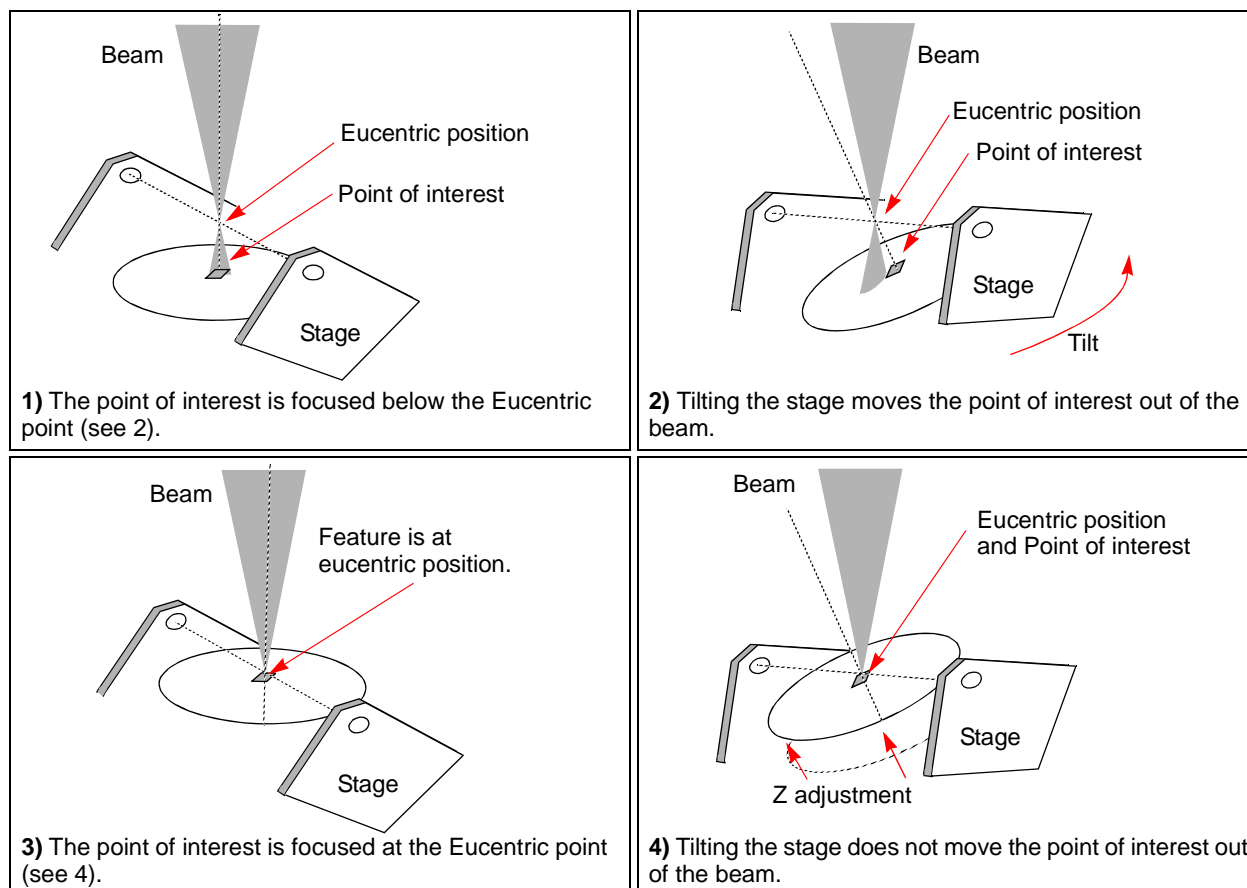
At the eucentric position the stage tilt, the electron and ion beams axes intersect. When the stage is tilted or rotated in any direction, this point remains focused and almost does not shift.

The following procedure is considered for the electron beam.

TABLE 7-1   FINDING EUCENTRIC POSITION PROCEDURE

Step	Action
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.

TABLE 7-1   FINDING EUCENTRIC POSITION PROCEDURE

Step	Action
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 6 to 9.

NOVA NANOSEM 430 100 x100 mm STAGE

The stage has the **X, Y, Z, Rotation** and **Tilt** movements motorised, all with manual override. All movements are read out on the screen, under software control.

FIGURE 7-5   NOVA NANOSEM 430 STAGE CONTROLS
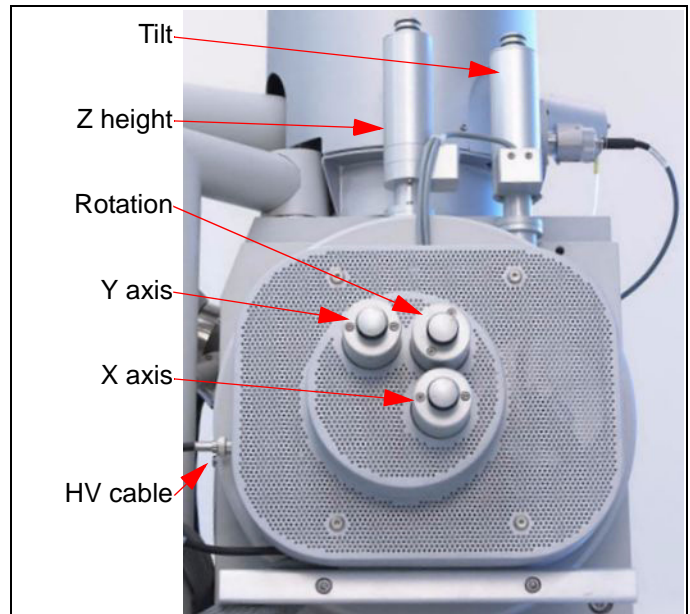
NOVA NANOSEM 630 150 x 150 mm STAGE

The stage has the **X, Y, Z, Rotation** and **Tilt** movements motorised. All movements are read out on the screen, under software control.

FIGURE 7-6 NOVA NANOSEM 630 STAGE CONTROLS
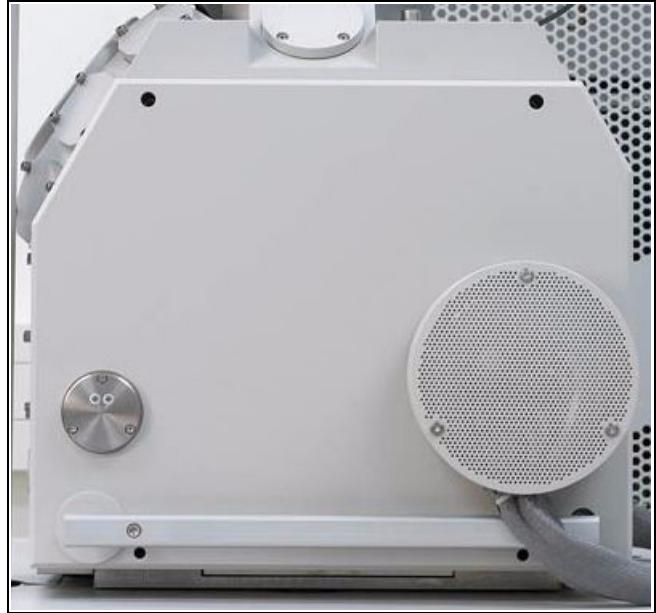
Nova NanoSEM 430 / 630 Standard Sample Holders

FIGURE 7-7 100 / 150 MM STAGE STANDARD SAMPLE HOLDERS
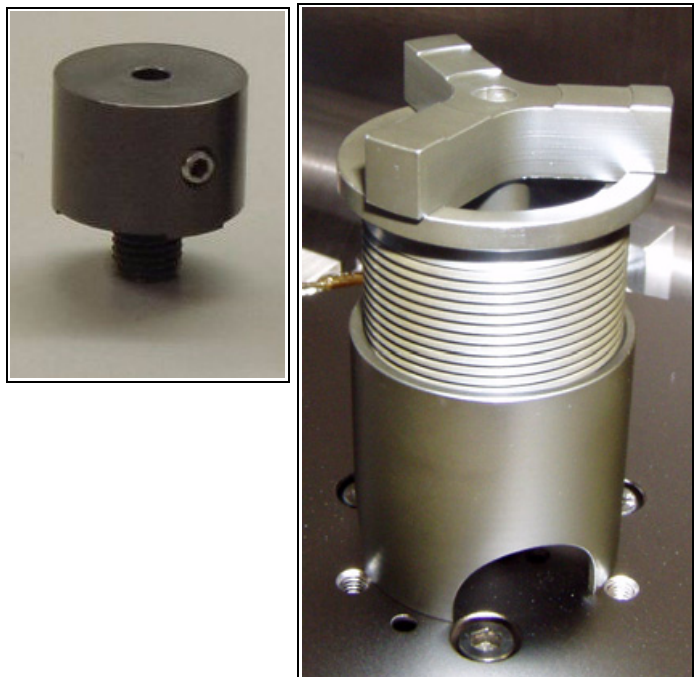
Using Z (height) adjustment
for 100 x 100 / 150 x 150 mm Stages

With the standard specimen holder it is possible to move Z to another position if required from outside the chamber. The external movement (Z) is 60 mm. This allows a flexibility to load large height specimens onto the stage.

To set the specimen height and at the same time prevent any possibility that the specimen should touch the lens pole if the Z is increased can be done as follows:

1. Load a specimen onto the specimen holder.
2. Adjust the Z, so that the highest specimen point is approximately 5 mm below the lens.
3. Close the chamber, and pump down.
4. When the beam is switched on focus the highest specimen point and click on the Z<->FWD button icon on the Tool bar. The FWD is recognised by the system as the value of Z in the Coordinates tab of the Work page.

Now the Z can be changed by the software interface or the manual external Z control to other positions, but for safety, not less than 1 mm from the lens.

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STAGE MOVEMENT LIMITS

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

Note:
When moving the stage or tilting the specimen, the magnification may need to be reduced so the feature of interest on the screen will not be lost.

FIGURE 7-8 STAGE MOVEMENT SCHEMA
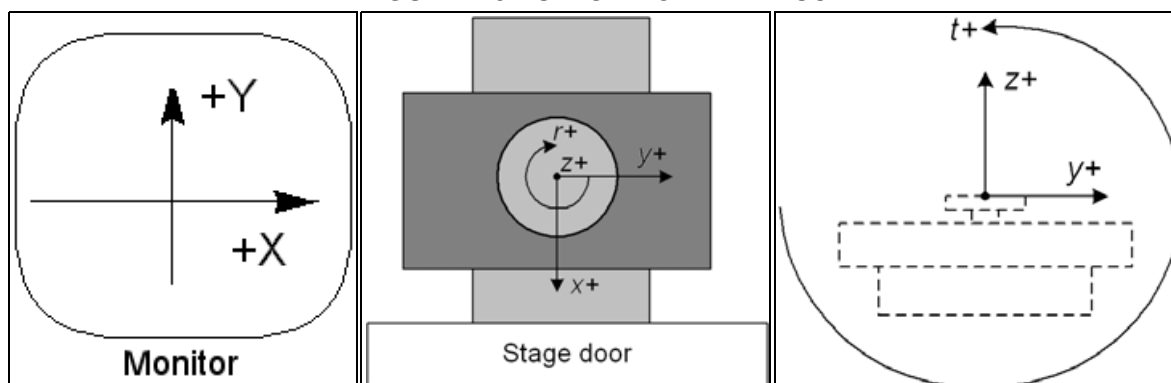
TABLE 7-2 STAGE FEATURES AND LIMITS

Item	50 mm	100 mm	150 mm	Note
X	-25 to +25 mm	-50 to +50 mm	-75 to +75 mm	
Y	-25 to +25 mm	-50 to +50 mm	-75 to +75 mm	
Z	25 + 25 mm	0 + 60 mm	0 + 60 mm	internal + external
R	360°	360°	360°	continuous
T	-15° to +75°	-5° to +70°	-10° to +60°	
Eucentric Position	WD = 5 mm	WD = 5 mm	WD = 5 mm	
Clamp	No	Yes	Yes	
Maximum sample weight	250 g	2 000 g	5 000 g	for all tilt angles
	1 000 g	3 000 g	15 000 g	at Tilt = 0°

Software Stage Functions

The **Stage** module on the **Navigation Page** controls the movements of the stage that locate the position of the specimen by reference to coordinate points. It consists of **Map** / **Coordinates** / **Tilt** 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.
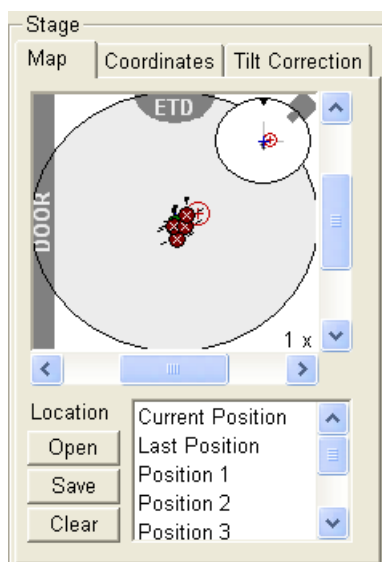
FIGURE 7-9 MAP AREA ELEMENTS
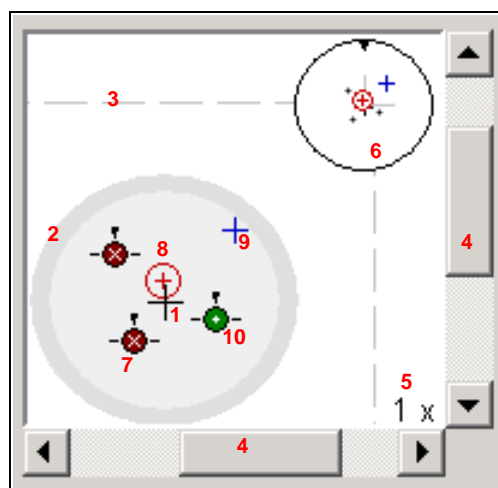
TABLE 7-3   MAP AREA ELEMET FUNCTIONS

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 mapped area in a X / Y (stage) direction at different magnification factors.
5.	**Magnification factor** of the map area (1x–100x).
6.	**Radarview:** **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 in the Location list with rotation noted by position of the black key.
8.	**Red + in a red circle:** the current targeted position.
9.	**Blue +:** a new location not stored.
10.	**White + on a green background**: indicates that a stored position is highlighted in the location list.

Radarview

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

Location area

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

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

The position selected becomes the current 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 4).

Map Dialogue

Clicking the right mouse button while over the Map area, provides the dropdown menu.

FIGURE 7-10 THE MAP DIALOGUE
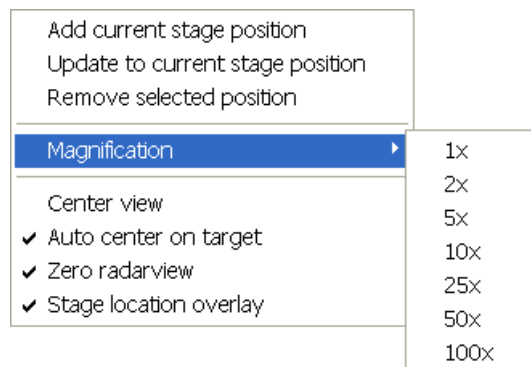
- Clicking the **Add current stage position** item adds a new Location list entry, using the current active position. The new entry is named **Position X** (**X** = 1, 2, 3…). If a name already exists (because the user loaded a Map list from a Stage Map file), the value is heightened until a unique name 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 currently selected name (an overwriting confirmation dialogue appears).

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

- Clicking the **Remove selected position** item deletes the selected location(s) from the map and from the Location list.
  The **Coordinates** tab / **Remove** button has the same functionality.
- Clicking the **Magnification** item provides menu allowing the **Map** area magnification factor (**5**) to be selected. Scroll bars (**4**) appear if necessary to move over the whole Map area.
- The **Center view** item brings the selected location to the center of view.
- When the **Auto center on target** item is ticked and the Magnification factor is used, the active location remains in the center of view.
- The **Zero radar view** item resets the stage rotation to 0°, which is represented by the black triangle 12 o'clock position.
- The **Stage location overlay** item toggles the detector and chamber door position display in relationship to a sample.

COORDINATES TAB
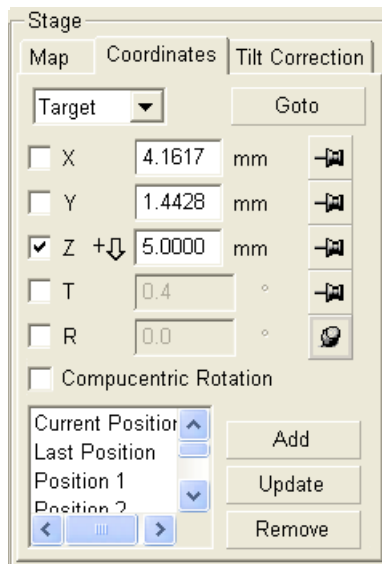
Three modes are possible via the list box:

- 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.

C a u t i o n !

- Danger of hitting the pole piece! The **Link Z to FWD** procedure did not pass (see Chapter 4). 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.

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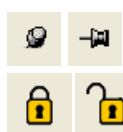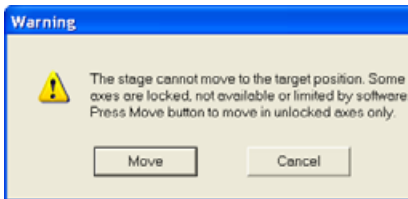
When any axis is locked and the stage movement is required in that direction (trying to move to the stored position), the warning dialogue appears.

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

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

TILT CORRECTION TAB

When the appropriate check box is ticked, the function becomes active.
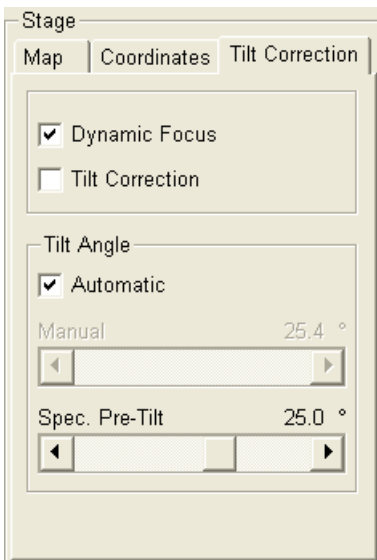
- The **Dynamic Focus** check box ticked – the focus automatically changes as the beam scans from the image top to its bottom, trying to follow the tilted specimen working distance change.
- The **Tilt Correction** check box ticked – the flat specimen foreshortening compensation is on (in one direction, 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.
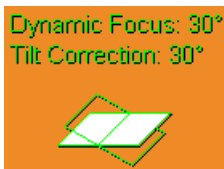
Notes:
Both Dynamic Focus and Tilt Correction work properly only if the specimen (scanned area) is tilted around the X-axis (in the same direction as the stage Tilt). Therefore they cannot be used with Automatic Tilt Angle in combination with a non-zero Scan Rotation. If the specimen is tilted in a different 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).

Stage Related Functions

STAGE MOVEMENTS

Track

The **Track** function allows continuous directional movement of the stage with variable speed. The speed range is coupled to the magnification and selectable within certain limits.

Select the Track function by pressing on the **Mouse Wheel** while in an active SEM image quad. A Yellow enhanced **Dot** and **Arrow** appear onscreen. The Dot appears where the mouse command cursor was when the wheel was pressed and the Arrow denotes the direction to move. The speed depends on the distance the Arrow is separated from the Dot. The direction can be changed by moving the mouse in a circular motion to obtain the correct path.

The movement axis center depends on the initial positioning of the command cursor, which can be at any position on the image. Moving away from the Dot with the Arrow increases the stage speed; moving toward the Dot decreases stage speed.The direction of movement is always toward the central Dot along a straight line. You can move the cursor around on the field of view; direction and speed change accordingly. When you are done release the mouse wheel. The action stops, Dot and Arrow disappear from the image.
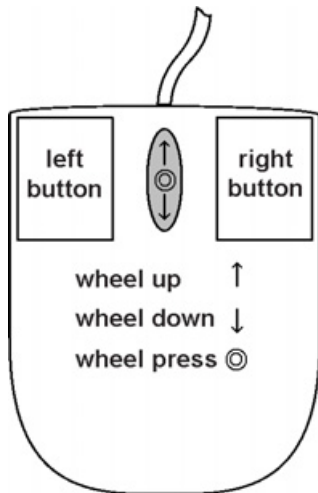
FIGURE 7-11 TRACK FUNCTION
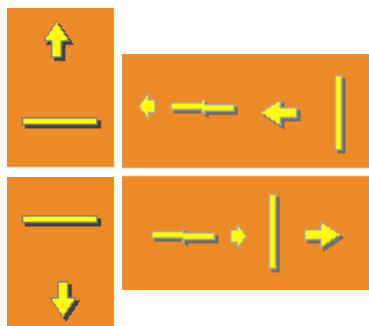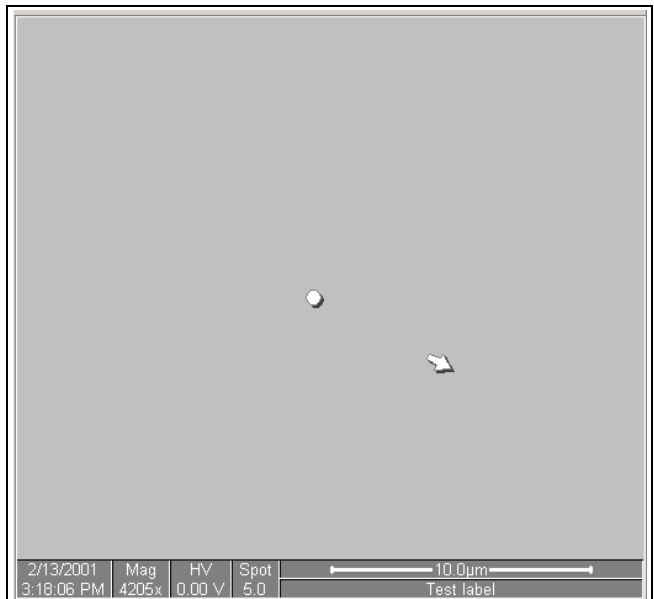
In the optical quad pressing the mouse wheel activates the stage Z movement, which can be seen live.

- With the **Mouse Wheel** pressed, moving the mouse up / down moves the stage up / down (Z-coordinate).
- Holding **Ctrl** key together with the **Mouse 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.

:

Get

When you double-click an image feature with the left mouse button, **Get** function brings it to the screen center. The system automatically calculates whether to use **Beam Shift** (for higher magnification), **Stage movement** (for lower magnification) or the combination of both.

When Beam Shift comes to the limit in any direction it is set to zero and necessary Stage movement brings the object to the center (only if Auto Beam Shift Zero function is checked).

FIGURE 7-12 GET FUNCTION
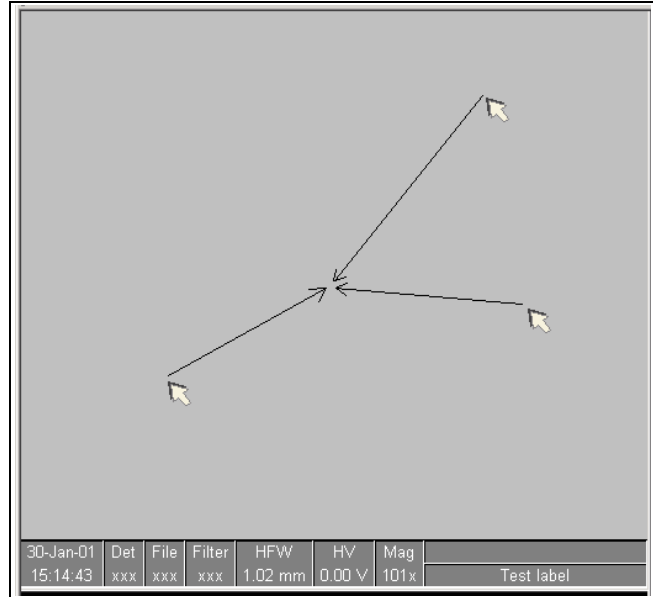
Keyboard Stage Shift

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%).
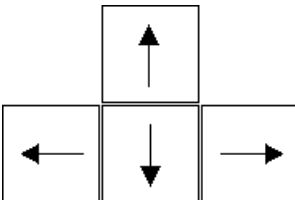
Compucentric Rotation (F12)
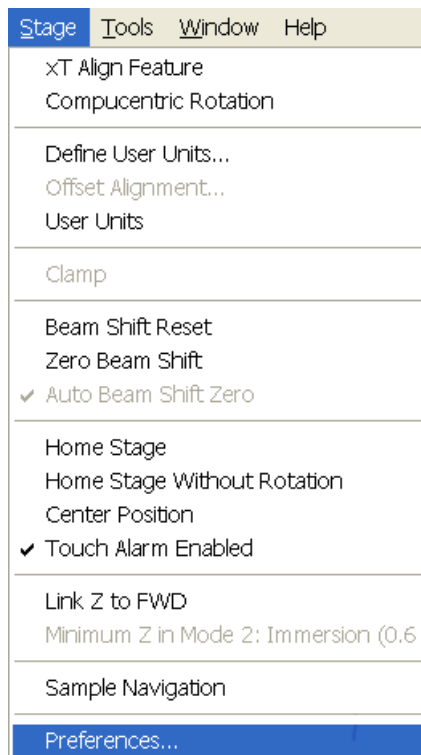
Clicking on **Compucentric Rotation** in the **Stage** menu places a green circle in the active quad. At a point on the perimeter of the green circle is a green triangle which denotes, by its position, the sample's angle of orientation relative to its original position when placed on the stage. Initially, this is in the 12 o'clock position. While holding the left mouse button down on the green triangle, drag it around the circle to choose a new sample orientation relative to the detection position. On release of the left mouse button the computer software updates the position orientation and offset from the mechanical stage center to deliver the same object center but rotated to the angle selected. This creates a different direction of illumination for the sample while keeping the object of interest in the center of the display area. With the sample at the eucentric height this can be performed at any position on the sample irrespective of the mechanical stage center. Clicking on or near the numbered angles around the perimeter of the circle causes the stage to drive to that angle and the green triangle updates on screen. Zeroing is accomplished by clicking on the zero on the top of the green circle.

FIGURE 7-13 COMPUCENTRIC ROTATION
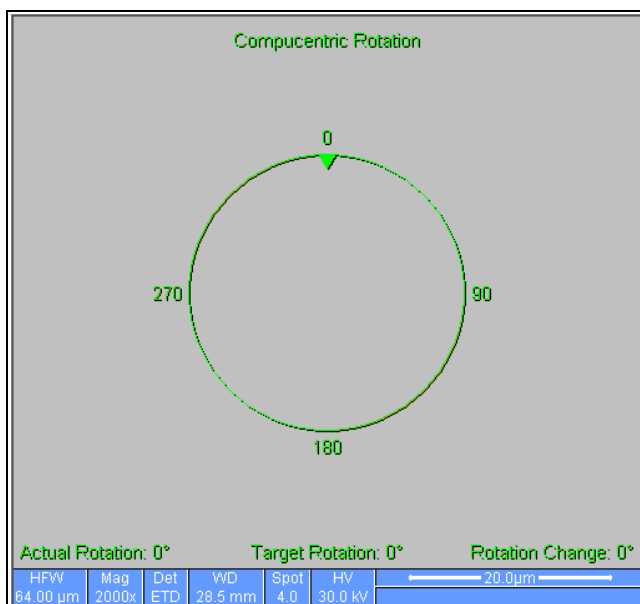
The readout positions displayed at the bottom of the quad provide information about the **Actual Rotation** (original position in degrees), the **Target Rotation** (the selected position in degrees) and the **Rotation Change** (the difference in degrees of rotation). Once selected, the control disappears automatically after 10 seconds of no use. The timer is reset each time an adjustment or movement is made.

SPECIMEN ALIGNMENT

xT Align Feature
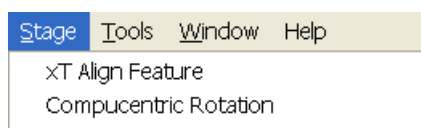
xT Align Feature is designed specifically for long features, or for when there is need to navigate along a feature that extends off the screen at the magnification required for an observation. Align Feature applies the mapping process across the entire length, bringing the long feature either to the chosen horizontal or vertical axis to make navigation easier. This can be performed at any point within the stage

field limits and takes into account the offset for a stage rotation. Point 1 is first located and then point 2. When this occurs, point 2 is not fixed but subtends point 1 with an elastic cord until the left mouse button is released. Point 2 is located at this position. Longer distances result in greater accuracy.

FIGURE 7-14 XT ALIGN FEATURE
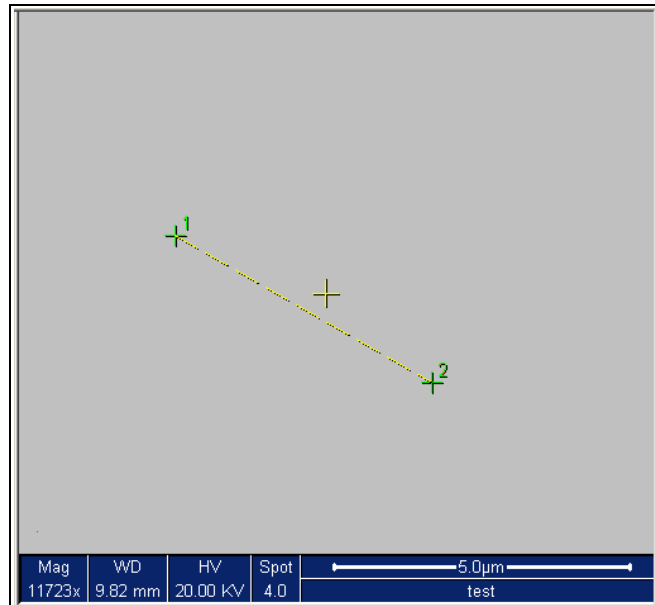
Note:

Align Feature is designed to work best at the eucentric height of 5 mm. The Z to FWD should be corrected to the eucentric height as described in the section 'Eucentric Height' on page 7-4.

C a u t i o n !

Because the stage makes movements by software control, care should be taken that there are no obstacles significantly higher on the sample plane set at the eucentric height, as these may interfere with equipment under the lens.

TABLE 7-4 XT ALIGN FEATURE PROCEDURE

Step	Action
1.	Select a long feature on the sample.
2.	Click on **xT Align Feature** from the **Stage** menu. Follow the directions in the dialogue box that appears and choose either Horizontal or Vertical, which relates to the orientation needed on the sample.
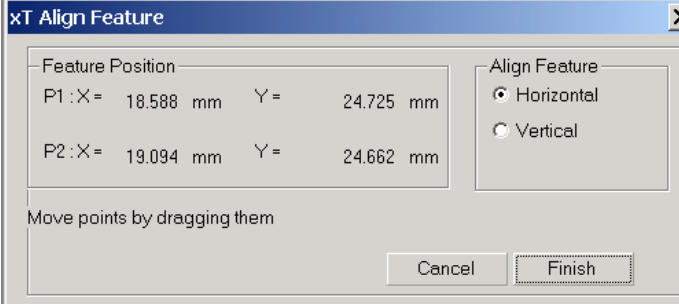
TABLE 7-4   XT ALIGN FEATURE PROCEDURE

3.	Click with the left mouse button on the first point somewhere along the feature. The coordinates are updated in the dialog. Now drag the line out from the first point to the second point using the mouse. The second coordinates update continuously until released by clicking again. Click on **Finish** to end the selection and for the program to orient the feature to the selected horizontal or vertical. Click on **Cancel** to cancel the function.
	xT Align Feature ▶ Feature Position P1 : X = 18.588 mm Y = 24.725 mm P2 : X = 19.094 mm Y = 24.662 mm Align Feature: ⦿ Horizontal ○ Vertical Move points by dragging them Cancel Finish
4.	The stage moves to that location and apply the alignment across the length of the feature.

User Units

To activate User Units as the basis of the stage coordination system, click on **User Units** in the **Stage** menu. A tick mark appears next to the label. The stage coordinate system reverts to the last defined user unit configuration for 1, 2 or 3 Point Alignment. From this point on the stage can operate in Actual, Target or Relative mode with User Units to perform specific movements.

Define User Units

This associates stage points with user-defined points to set up a mapping between stage and user coordinate system. After that, the computer uses these specimen coordinates rather than stage coordinates for positioning.

For example, a die of an integrated circuit has its own coordinate system. If you choose a 0,0 position, you can drive the stage relative to that position using your own coordinate system. These are expressed in User Unit (UU) coordinates, which may be microns, multiples or fractions of microns, etc. Coordination of the stage can be anchored to either 1, 2 or 3 points, depending on the sample management or application.

Choose points that are not in a straight line, for example at the corners of a die or at the edges of an area or wafer. You can align up to three points, by which the greatest accuracy is achieved.

The following procedure sets up the 1–3 Point alignment for any given sample where repeated structures are checked.

Common dialog buttons
- **Next:** moves you to the next dialog
- **Previous:** moves you to the previous dialog
- **Cancel:** cancels the procedure
- **Finish:** ends the alignment at point one / two / three
- **Details:** displays the resulting coordinates at any stage (1 / 2 / 3 points) with the possibility to change the settings and confirm it by clicking on the **Apply** button.

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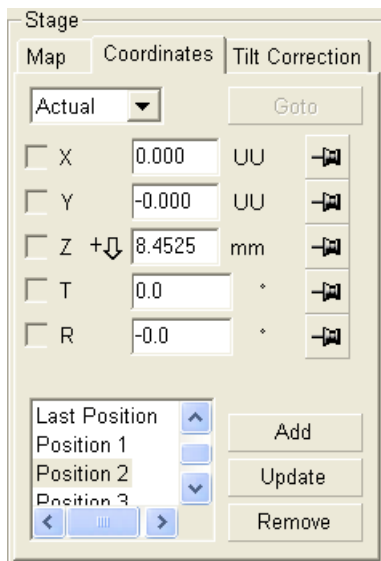
FIGURE 7-15 USER UNITS DETAILS

TABLE 7-5 USER UNITS DEFINING PROCEDURE
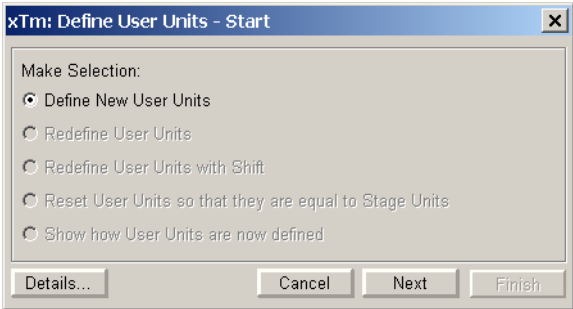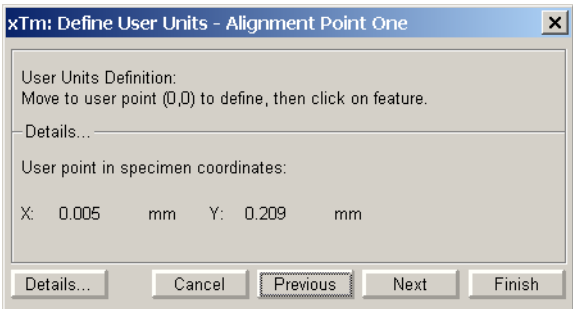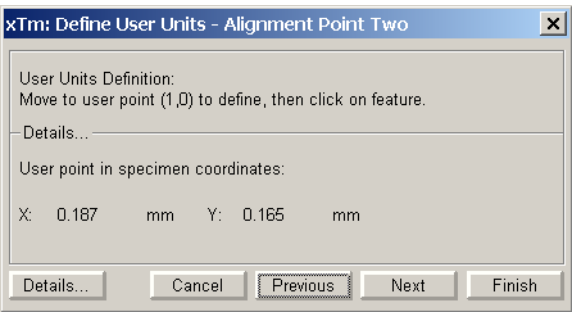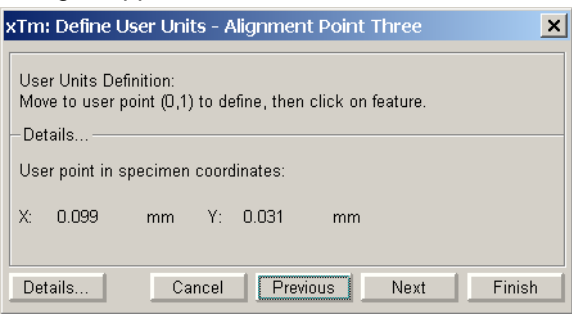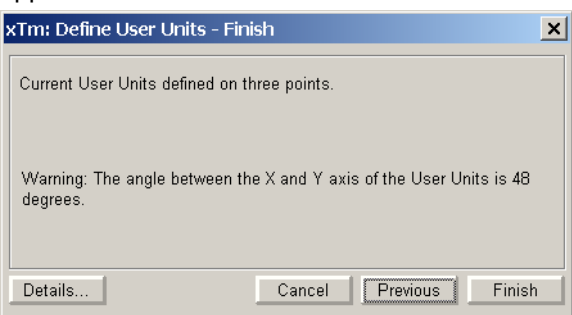
Step	Action
1.	Select a feature on the sample surface and bring it into the field of view at an appropriate magnification so that it relates to other structures.
2.	Click on **Define User Units** in the **Stage** menu. A dialogue appears. Select from the Start dialogue the **Define New User Units** process by clicking on the radio button.
3.	After clicking on the **Next** button the user point (0,0) a dialogue appears. Follow the instruction in the dialogue to move to a point and click on it with the left mouse button. The coordinates of point (0,0) appear in the **Details…** section of the dialogue.

TABLE 7-5 USER UNITS DEFINING PROCEDURE

4.	After clicking on the **Next** button the user point (1,0) a dialogue appears.
	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: 0.187 mm Y: 0.165 mm [Details...] [Cancel] [Previous] [Next] [Finish] Repeat the procedure as in step 3.
5.	After clicking on the **Next** button the user point (0,1) a dialogue appears.
	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: 0.099 mm Y: 0.031 mm [Details...] [Cancel] [Previous] [Next] [Finish] Repeat the procedure as in Step 3.
6.	After clicking on the **Next** button a confirmation dialogue appears.
	xTm: Define User Units - Finish ☒ Current User Units defined on three points. Warning: The angle between the X and Y axis of the User Units is 48 degrees. [Details...] [Cancel] [Previous] [Finish]

There are a number of choices in the Define User Unit Start dialogue. They are listed here to explain their functionality:

- **Define New User Units** as explained in this chapter.
- **Redefine User Units** for changing or updating User Units.
- **Redefine User Units with Shift** for changing or updating with Beam Shift.
- **Show how User Units are now defined** displays the current details.

While establishing points in the procedure any incorrect point made can be overwritten just by clicking on a new point in the active quad.

Using 1-, 2- or 3- Point Alignments

The following table shows the different uses of the different alignment types.

:

TABLE 7-6   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 skew	Rescaling to nonstandard units on dies or RAM arrays; correcting for any skew
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 orientations can be different

Sample Navigation / Navigation Montage...
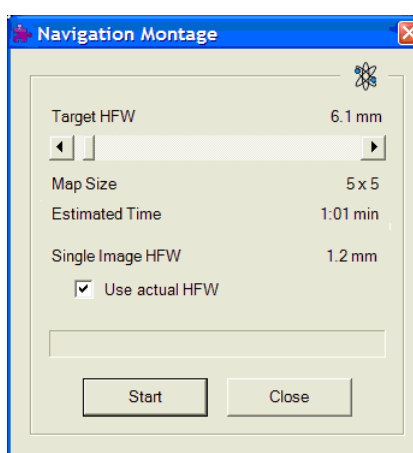
This **Tools** menu / **Navigation Montage…** procedure enables to navigate along the sample surface when the field of view is smaller than desired (limited by an aperture for instance). For this purpose it is possible to use up to 3 images (quads) which could be changed dynamically (captured, saved or loaded anytime).

This function takes the scanning parameters from the selected quad setting. The **Target HFW** means the number of the **Map Size** (tiles) time the **Single Image HFW**, which is set automatically during the procedure. In case any detector or cone is used which influences the field of view, an user can set advantageous magnification before the procedure starts (crop a circle with no contrast from an imaging limiting the field of view) and then check the **Use actual HFW** check box. The **Estimated Time** shows the time needed for the montage to finish and to be represented in the paused quad.

The **Stage** menu / **Sample Navigation** mode is automatically set after the Navigation Montage procedure finishes. For the active quad the upper right corner green icon indicates the functionality.

A green rectangle limiting the actually selected field of view (in an active quad) appears with the size corresponding to the magnification. In case the rectangle is too small, only green cross appears in the middle of the field of view.

If the HFW is less then 10 µm the navigation montage functionality doesn't work. In quad(s) using Sample Navigation Selected Area Zooming and Get functionality could be used.

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

CLAMP

While the stage is clamped, normal operation of X / Y / Rotation movement is possible, but the Z height and Tilt cannot be changed. This feature is dedicated to all stages except the 50 x 50 mm 4 and 5 Axes Stage which has no Clamp.The 4 axes stage has a Tilt lock.

SCAN ROTATION (SHIFT + F12)

This function activates the on-screen 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. Rather, it is used to orient the image relative to mechanical rotation and detector direction.

Using Scan Rotation

Clicking on **Scan Rotation**, in the **Scan** menu, places a large green circle in the active quad with a small circle in the top right corner. At a point on the perimeter of the large green circle is a green triangle which denotes, by its position, the sample's angle of orientation relative to its original position when placed on the stage. Initially this is at 12 o'clock position. While holding the left mouse button down on the green triangle, drag it around the circle to choose a new scan orientation. The small circle follows suit.The computer software continuously updates the orientation of the scan.This creates a different orientation on the viewing screen but retains the scanning direction on the specimen. The readout positions displayed at the bottom of the quad provide information on the **Actual Rotation** (original position in degrees), the **Target Rotation** (the selected position in degrees) and the **Rotation Change** (the difference in degrees of rotation).

FIGURE 7-16 SCAN ROTATION
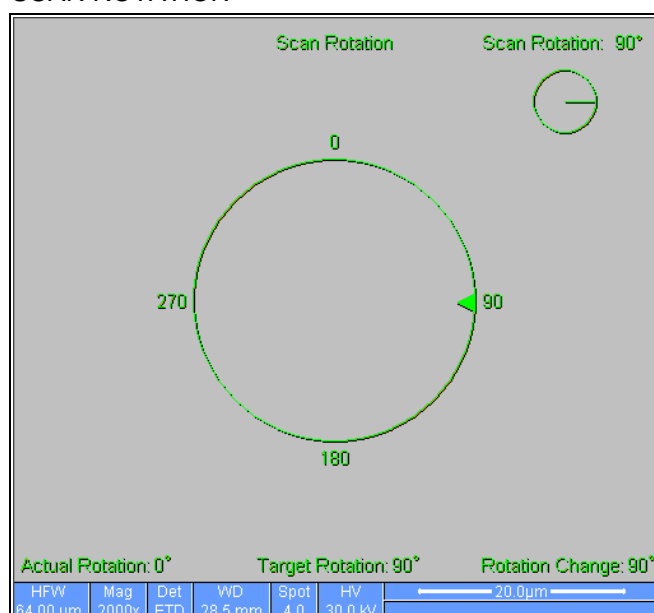
Clicking on or near the numbered angles around the perimeter of the circle causes the beam to drive to that angle and the green triangle updates on-screen on both circles. The smaller circle in the top right of quad 4 remains on-screen when Scan Rotation is switched off, if the angle is greater than 0°, to inform the user of the orientation.

:
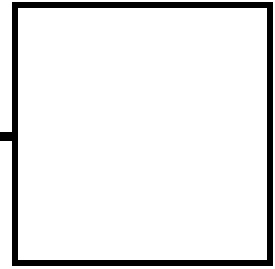
8 MAINTENANCE

This section describes the procedures necessary for the maintenance of the microscope that can be carried out by the **Supervisor / User**. For the User maintenance is at a minimum due to Gun and Column design and the long uptime expected from this class of instrumentation. Therefore the more complicated maintenance is normally contained in a service contract to be performed by a qualified service engineer.

At the user level items such as the following can be maintained:

- 8.1 Cleaning Procedures Overview
- 8.2 The Strip Aperture Module
- 8.3 Gaseous Detectors
- 8.4 Stage Maintenance
- 8.5 Refilling the Water Bottle
- 8.6 Rotary Pump Maintenance

Caution!
- read Chapter 1 (Safety and Handling) before proceeding with any maintenance.
- Parts that operate in vacuum should be handled carefully using clean powder-free gloves. Parts not in use should be stored in suitable containers or packed in aluminium foil.
- the **EDX window** (if present) **is very fragile** and **must be protected from air burst or vacuum turbulence**. It is recommended to remove the detector before major cleaning activities.

Note:
Gas back fill (N_2) should be maintained while the specimen chamber is at ambient pressure. However, to avoid gas waste it is recommended that the chamber should be left vented no longer than necessary.

This chapter is organized differently from the rest of the manual to make it easier to find particular procedural items. The sections and subsections are numbered as follows:

Main section: **8.1, 8.2**, etc. Subsection: **8.1.1, 8.1.2 … 8.2.1, 8.2.2**, etc.

:

8.1 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. These procedures are common to all Nova NanoSEM instrument configurations.

8.1.1 LIST OF APPLIED CLEANERS

- De-ionized or distilled water – H_2O
- Ethanol – C_2H_5OH
- Ethanol p/a (Pro Analysis: 99.8% pure) – C_2H_5OH
- Isopropanol
- Neutral pH cleaning fluid (soap solution)
- CIF* or SOFT SCRUB (fine abrasive household cleaner) or 0.05 μm alumina powder

TABLE 8-1   HOUSEHOLD CLEANERS

Country	Name
Austria	CIF
Australia	CIF
Finland	CIF
France	CIF
Germany	CIF
Italy	CIF
Japan	CIF
Netherlands	CIF
Switzerland	CIF
UK	CIF
USA	Soft Scrub

WARNING!

The cleaning solvents ethanol and isopropanol are highly flammable! Do not use open flames and do not smoke while cleaning. Ventilate the room properly.

8.1.2 CLEANING COLUMN PARTS

All column parts are polished before the instrument is delivered. For this reason only occasional light polishing is required to remove contamination that may build up on components in the column and specimen chamber as part of normal operation. Any part that is exposed to the electron beam should be highly polished, and free of contamination and / or scratches that can charge and thus degrade the image.

Parts that can be removed by the general Supervisor / User and polished include the following:

• LVD and Helix detectors

C a u t i o n !
Gold plated parts should not be polished with abrasives.

8.1.3 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 20x magnification to ensure that there is no remaining contamination or polish residue. Wash the part in de-ionized or distilled water in a beaker with an ultrasonic cleaner for several minutes.Transfer the part to a clean beaker with alcohol or isopropanol and clean ultrasonically again for several minutes.

Note:
Do not use an ultrasonic bath to clean the LVD or Helix detectors.

When the components are dry (a compressed air 'duster' can speed drying), reassemble and return to the column. If a part is stained, heat it with hot water and immediately rinse with alcohol and dry using compressed air.

Cleaning Tips

Parts exposed to the electron beam require periodic polishing. This will ensure maximum performance of the instrument for many years.

Do not use metal polishes such as POL or WENOL to clean parts as these can leave outgassing material. Be aware that threaded surfaces should not be polished as these do not have contact to the beam and are a source of outgassing if polish is trapped. Wash threads with alcohol or isopropanol if absolutely necessary.

After cleaning, inspect all parts for residue and stains using a light microscope.

Down time can be reduced by purchasing detector assemblies and having them cleaned and stored in a safe place, where they can be ready to be installed into the microscope.

8.2 Strip Aperture Module

The objective appertures are holed on a Molybdenum strip which is mounted on a metal holder. The strip has 5 aperture positions with a 1 mm alignment hole in the frame and not the aperture. The strip comes prealigned in a metal module which is connected to the end of the Aperture rod by a screw. The module is considered as a consumable and therefore would be normally replaced when heavily contaminated. If a Fischione plasma cleaner is available, aperture module can be cleaned while connected to the Aperture rod. There is a heater in the rod to assist cleaning / anti-contamination. All screws are made of Titanium not to have any magnetic effect.

FIGURE 8-1   STRIP APERTURE MODULE

8.2.1 REMOVING THE APERTURE ROD

1. With the high voltage off, vent the specimen chamber to the atmospheric pressure. The Aperture rod is held at the same vacuum as the specimen chamber, no vacuum needs be broken to remove it.
2. If connected remove the heater cable from the outer end of the rod.
3. Unscrew the end of the Aperture rod and carefully remove it from the microscope.

Note:
Preparation to clean or replace apertures should be immediately available as the specimen chamber has to stay at atmospheric pressure for the duration of maintenance.

8.2.2 CLEANING THE APERTURE MODULE

This is only possible if a Fischione Plasma cleaner is available.

1. Take the complete rod with module attached and place in the TEM opening on the plasma cleaner. The screw at the end of the Aperture rod screws into the TEM opening and seals against the rod 'o' ring.
2. Give the rod 5 minutes at 4.5 volts plasma generation. This should remove all hydrocarbon base contamination. If the contamination is stubborn longer times will be necessary, this should not damage the aperture as the plasma only removes organic bases.

8.2.3 REPLACING THE APERTURE MODULE

The new Aperture Module comes in a fluoroware container, has been pre-cleaned. and is ready to be fitted to the rod.

1. Unscrew the Titanium screw holding the old module onto the rod. Keep the screw in the hole of the rod and let the module fall away.

2. Open the new module pack and let the new module sit with the connection end uppermost to the edge of the container base.

3. Pick up the new module with the Titanium screw end and fasten, making sure of a good fit.

8.2.4 REPLACING THE APERTURE ROD

1. Check that there are no fibres on the rod 'o' ring. Do not grease the 'o' ring.

2. Replace the Aperture rod back into the Aperture Adjuster assembly on the column and turn the end screw mechanism until the holder is hand tight.

3. Pump the microscope specimen chamber

4. Reconnect the heater cable to the outer end of the rod if necessary.

5. Set the aperture at a 30 micron hole so that alignment can be performed.

8.2.5 APERTURE AVAILABILITY

These apertures are the present used and come in two size types.

1. FP 6174/33 Mo Strip Aperture (30, 30, 40, 50, 100 µm)
This type can be used for general applications including EDX.

2. FP 6174/53 Mo Strip Aperture (30, 30, 50, 30, 30 µm)
This type can be used for high resolution applications such as low voltage.

3. FP 6174/37 Mo Strip Aperture (10, 15, 20, 30, 30 µm)

4. FP 6174/39 Mo Strip Aperture (20, 30, 30, 40, 50 µm)

Note:
These apertures are on purpose made for the 7 position Aperture Adjuster assembly, although they will fit the earlier 4 position design not all apertures can be accessed.

8.3 Gaseous Detectors

WARNING!
Before removing the LVD, disconnect the microscope from the mains and apply the LOTO procedure (see The Safety Manual for a detailed description).

8.3.1 CLEANING THE HELIX OR LVD

This section will describe how to remove and disassemble the Helix assembly for cleaning.

1. Vent the chamber.
2. Turn the detector bayonet lock counterclockwise to the stop and pull it out from the final lens tip.
3. Disconnect the detector cable from the connector placed the specimen chamber.

The PLA is a part of the Helix detector and can be cleaned by inserting carefully a toothpick (or a similar soft pointed pick) into the hole and twisting gently.

8.4 Stage Maintenance

8.4.1 STAGE MECHANICS

Checking the condition of the stage should be a weekly exercise as many differing samples may be exchanged in this time period. Some samples may be powders or composite materials that inadvertently drop particles on or in the stage. If a silicon wafer breaks in the chamber it can shatter into hundreds of pieces. In this case the stage should be thoroughly cleaned before attempting movement again.

Cleaning Stage parts

Abrasives and solvents must not be used on the moving stage parts. Cleaning with a vacuum is the ideal method. If not available, cleaning should be done by using dry nitrogen gas bursts around the stage mechanics to blow out any foreign materials. Make sure the final lens and detectors are protected from the turbulence. Do not use sharp metal objects to scrape away debris. A fine pair of plastic tweezers can be used to pick up difficult particles. Spillages on the stage should be wiped up using a lint-free cloth, followed by vacuuming or blowing with clean gaseous nitrogen.

8.4.2 SPECIMEN HOLDERS

Recommended cleaning procedures are given below for parts which operate in vacuum and which are subject to possible contamination. Frequency of cleaning is, in most cases, determined by necessity (image quality or astigmatism level).

Cleaning

1. Clean these parts using a lint free cloth and a mild abrasive domestic cleaner (see list of preferred cleaners at the end of this chapter).
2. Rinse in tap water.
3. Clean in an ultrasonic cleaner for 5 minutes using distilled water.
4. Clean in an ultrasonic cleaner for 5 minutes using alcohol p/a or isopropanol.

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!

8.5 Refilling the Water Bottle

The water bottle in the instrument will typically need to be filled about once a month if the instrument is used on a regular basis at a high pressure. The water reservoir is located in the rear of the column console, beneath the frame. To fill the bottle, do the following:

1. Vent the system.
2. Turn off any gas connected to the gas inlet.
3. Disconnect the quick-coupler and pull out the water bottle.
4. Remove the rubber plug and refill with distilled water (not de-ionized) until 1/3 full.
5. Mount the rubber plug and install the water bottle in the reverse order of that described above.
6. Pump the system. Switch to Low Vacuum mode to force automatic purging to flush any air out of the bottle and connecting tubes.

Note:
The first time the system is pumped in LoVac mode after filling the bottle, Auto-purging may be erratic until the bottle vacuum has recovered. The removal of all the gas from the liquid must be accomplished before good imaging is possible. This is done correctly when no bubbles are produced in the water when increasing the pressure in the chamber. It is recommended to use 6 to 8 purging cycles 20 to 200 Pa (where applicable) after refilling the bottle.

8.6 Pre-Vacuum Pump Maintenance

The dry pre-vacuum pump is used to directly pump parts of the vacuum system (for instance the specimen chamber after a sample exchange) and for backing the Turbo Mechanical Pump (TMP). It also controls the pressure in the specimen chamber when operating in the LoVac mode.

8.6.1 PERIODIC CHECK

The Rotary pump may become very hot while in use, be careful not to touch the main frame of the pump. Venting the chamber will shut off the rotary pump.

C A U T I O N !
When using GISes (option), do not allow the pre-vacuum pump to emit gases into the work place, as this can be a health hazard.

9 ■ SYSTEM OPTIONS
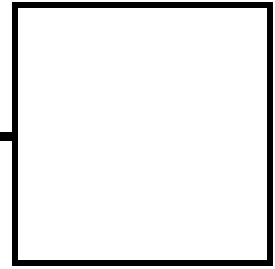
This chapter covers hardware and software that is an option either integrated in, or accessory to the Nova NanoSEM System Series.

The items covered here are:

- Manual User Interface
- Joystick
- Optional Detectors
- X-ray Analysis
- Patterning
- Cryo Can option
- E-beam deposition kit
- Electrostatic Beam Blanker
- UMB Stub Holder Kit

For further information on any of these items please contact your local FEI representative.

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Manual User Interface (FP 2311/05)

The Manual User Interface (MUI) provides knobs to perform functions that can also be performed with the software. It is connected to the USB connector located on the microscope controller.

FIGURE 9-1   MUI

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

Joystick (FP 2311/01)

The Joystick 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 9-2   JOYSTICK

- The Up / Down **lever** motion moves the stage in Y axis.
  The Left / Right **lever** motion moves the stage in X axis.
  The Left / Right **lever** rotation rotates the stage left / right.
- The button **1** is not used.
- The button **2** is used together with the lever motion:
  - Up / Down moves the stage up / down
  (regardless the Link Z to FWD status).
  - Left / Right tilts the stage left / right
  (only available for 100 mm and 150 mm stages).
- The button **3** speeds up the stage motion:
  - 10x in X / Y axis
  - 5x in Z axis
  - 2x in R / T axis

Optional Detectors

HELIX DETECTOR (OPTION – FP 2304/26)

is used as an optional detector for the Low Vacuum mode in the whole pressure range from 0.08 to 1.5 Torr (10 - 200 Pa). The Helix detector limits the field of view to about 0.5 mm at the working distance of 5 mm. The minimum working distance is limited to about 3 mm.

FIGURE 9-3   HELIX DETECTOR

This detector is in fact the combination of the LVD and Helix detectors. Usage of the LVD part is the same as described for the standard LVD (see Chapter 5). The Helix part can be used in all SEM imaging Modes, but is primarily designated and gives superior signal in Mode 2 (immersion). It is the best detector for high resolution imaging at Low Vacuum conditions.

Only one of the LVD / Helix detector signals can be acquired at a time. Therefore the LVD / Helix detector appears in the xT microscope Control software as two independent incompatible detectors. Selecting either the LVD or Helix detector in the software activates the corresponding part of the physical detector and de-activates the other one. If the other detector is chosen in another Quad, this Quad is automatically paused.

Installing the Helix Detector

Installation and removing of the Helix detetor is the same as described for the standard LVD (see Chapter 5).

Obtaining the image

After the pumpdown and purge process, switch on the HV. The Detector Voltage is automaticaly set to the last used value. Adjust the **Detector Voltage** to increase the signal or stop possible discharges. Keep the pressure as low as possible.

Spot 4 will always give a sufficient signal. Go to the lowest possible magnification and increase the Contrast until a small bright circle can be seen in the center of the screen. Increase the magnification and set Contrast and Brightness. In SEM Mode 2 it is possible to use Spot 3 (or smaller).

:
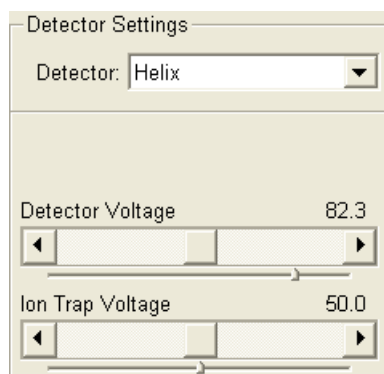
BACK SCATTERED DETECTOR
(BSED – FP 2304/28)
GASEOUS ANALYTICAL DETECTOR
(GAD – FP 2304/07)

The low voltage Solid State Back Scattered Detectors (SSBSD) are two segment diodes provided in two versions:

The **BSED** with no PLA for **High Vacuum** operation with relatively large field of view, and the **GAD** with 500 µm PLA cone for **Low Vacuum** operation, especially the X-ray analysis. The GAD cone extends from the objective pole piece down to working distance of about 4 mm. This reduces the gas path length of the primary beam about 1 mm for a specimen at the standard 5 mm analytical working distance (compared to 5 mm path lenght with the standard LVD). The diode of both backscattered detectors has an active area of approximately 35 mm^2 per segment and it is positioned directly above the sample to achieve maximum detection efficiency. Therefore it causes some limitation in the tilt range.

FIGURE 9-4   BSED AND GAD
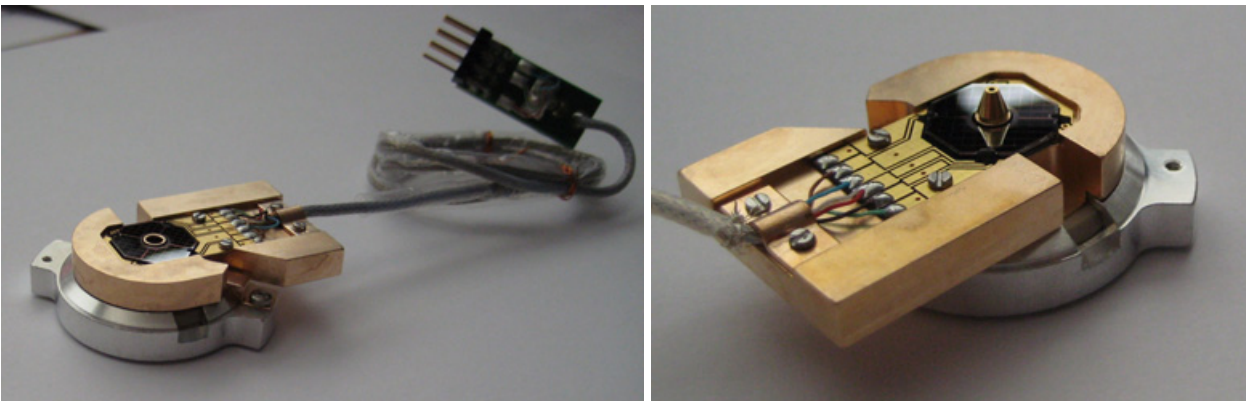
Both detectors are connected to an input board of the dual SSD pre-amplifier. They can be used down to High Voltage of about 1 kV.

Installing the BSED / GAD

Remove the detector from its parking holder. Hold the detector by its aluminium handle (diode pointing downwards) and put it gently on bayonet base of the objective lens. Turn to the left to fix it on the base.

Caution!
The diode is sensitive to mechanical damage so the active area (shiny diode) should never be touched. The BSED / GAD is mounted close to the (optional) X-ray detector collimator, which must not be touched when changing detectors. It is advisable to retract the EDX collimator when mounting / removing a detector on / from the objective pole piece.
With the GAD mounted on the objective pole piece, the minimum working distance is limited to about 4 mm.

Detector home position

While the Nova NanoSEM system has the BSED / GAD detectors, only one diode can be used at a time. The other diode that is not used is placed into a holder which is mounted on the upper edge of the pole piece. This keeps the unused diode safe from being hit by the the stage or a specimen.
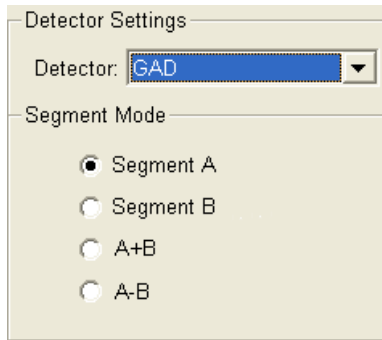
Settings for BSED / GAD

Select the BSED or GAD from the Detector menu or from the Detector list box in the **Detector Settings** module. Using the **Segment Mode** list box in this module, either of the two detector segments (A, B) or their combinations can be selected:

- **Segment A / B** (Left / Right) – uses shadows to create strong topographical and atomic number contrast
- **A+B** (Z - contrats) – is the normal BSE image with suppressed topographical contrast and maximum atomic number contrast
- **(A-B)** (Topography) – is pseudo-topographical image with suppressed atomic number contrast and maximum topographical contrast

Low-voltage High-contrast Detector (vCD – FP 2304/29)

This is a solid State detector ideal for low accelerating voltages down to about 200 V. It has the 500 µm PLA for **Low Vacuum** operation, especially the X-ray analysis. The diode has an active area of approximately 100 mm^2 and it is positioned directly above the sample to achieve maximum detection efficiency. Therefore it causes some limitation in a tilt range (see below).
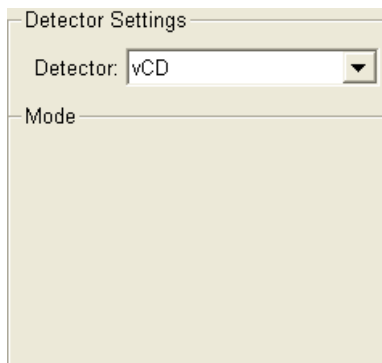
Select the **Detector Settings** module / **Detector** list box / **vCD** or from the menu **Detectors**. A detector offers BSE atomic number contrats imaging with suppressed topographical contrast.

The detector is connected to an input board of the dual SSD pre-amplifier. It can be used in parallel with special LVD, which allows simultaneous use of SE, BSE in a gaseous environment.

FIGURE 9-5   vCD DETECTOR

Installing the vCD

Remove the detector from its parking holder. Hold the detector by its aluminium handle (diode pointing downwards) and put it gently on bayonet base of the objective lens. Turn to the left to fix it on the base.
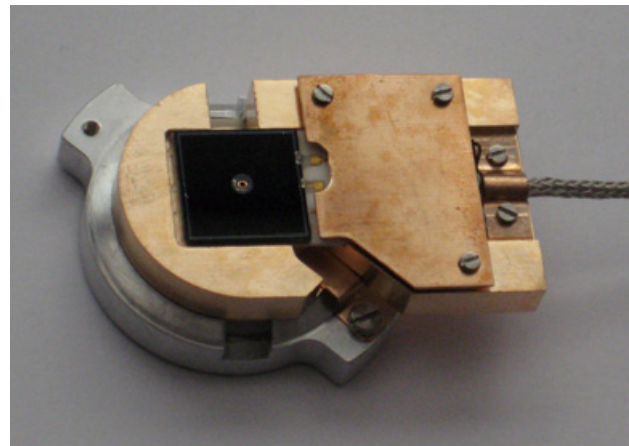
Caution!

The diode is sensitive to mechanical damage so the active area (shiny diode) should never be touched. The detector is mounted close to the (optional) X-ray detector collimator, which must not be touched when changing detectors. It is advisable to retract the EDX collimator when mounting / removing a detector on / from the objective pole piece.

With the vCD mounted on the objective pole piece, the minimum working distance is limited to about 4 mm.

Detector home position

The diode that is not used is placed into a holder which is mounted on the upper edge of the pole piece. This keeps the unused diode safe from being hit by the the stage or a specimen.

OBTAINING AN IMAGE IN BSE MODE

Install one of the diodes and select the corresponding Detector in a live Quad. The BSED can be used only for HiVac operation. The GAD and vCD can be used both for HiVac and LoVac operation, but because it limits the minimum achievable working distance, it is disadvantageous for high resolution imaging in HiVac.

Close the chamber door and pump down the chamber. Select appropriate PLA (GAD or vCD) when the Pole Piece Configuration dialogue appears. With the GAD or vCD installed, the available chamber pressure ranges from 0.08 to 1.5 Torr (10 - 200 Pa). When the Vacuum is ready, switch on HV and slowly increase contrast and brightness to obtain an image. The detector works best at a slow scan conditions.

Note:
Whenever the BSED / GAD / vCD / STEM I / STEM II is selected in a live Quad, the CCD camera is paused. This is because the CCD camera IR LEDs have to be switched off, because the infra-red photons produce a strong signal in the SSD diode. If the LEDs are turned on by un-pausing the CCD Quad, they saturate the diode making the imaging white. If you try and adjust the contrast or brightness, the system will assist you by pausing the CCD and turning off the LEDs inside the chamber.

Note:
The special LVD (without PLA) is attached to the GAD and vCD option, which can be used in parallel with it. This allows simultaneous use of SE, BSE in a gaseous environment.

PMD

See separate manual.

SOLID STATE STEM DETECTOR (STEM I – FP 6903/01)

The STEM I detector is a two segment solid-state device mounted underneath a Grid holder assembly. Since the STEM I Detector is mounted on the stage it can be used at any available working distance preferably close to the lens for high resolution or at the eucentric position for simultaneous use of EDX. The mounting pin below the detector locates into the standard conical single stub mount. The plug located at the end of the cable from the detector is connected to the solid state amplifier (usually on the back right port).

FIGURE 9-6   STEM I
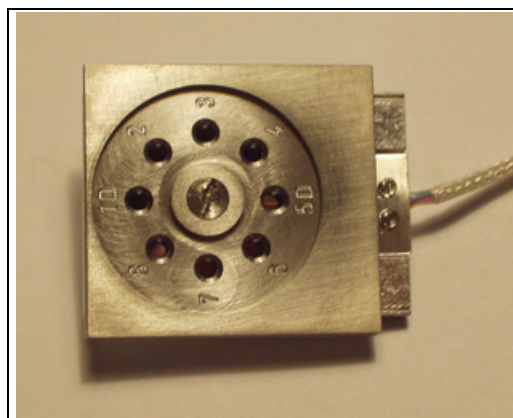
The STEM I detector uses slowscan rates for normal imaging. Automatic contrast and brightness routines are not applicable. Materials or hard samples should also be prepared as for the TEM by appropriate thinning technique.

Settings for STEM I Detector

The two detector segments, A (left) and B (right) can be switched independently, enabling the possibility of Brightfield (BF) / Darkfield (DF) contrast mode. Operation is fully integrated in the xT microscope Control software.

The STEM I holder has 8 positions for sample (TEM) grids. The following table refers to the numbering of the positions and their related capabilities.

TABLE 9-1   STEM I HOLDER POSITIONS

Grid Position	Mode and Diode switching
D1 and D5	DF / BF observation – if the observed object is left / right of the segment separator then A segment switch gives BF / DF observation and B segment switch gives DF / BF.
2,3,4	BF observation – use B segment switch only.
6,7,8	BF observation – use A segment switch only.

The **A+B** condition (default) can be used for the first time as the total detector is then working. To switch BF / DF use the capability of switching either side of the detector diode by means of A / B in the sub-menu.

Choosing **A-B** from the sub-menu gives a negative image that although will not be used frequently may highlight features by contrast not otherwise easily seen.

Loading samples

The STEM I holder part of the detector can either be loaded with samples while outside the SEM or when it is mounted and fixed to the stage movement. It is more convenient to load the holder before attaching to the stage.

The central screw on the top of the holder can be loosened and the top removed. This exposes the 8 grid positions as recessed round

holes with tweezers slots on the base plate. Load the TEM Grids (samples) sample face-up in the grid holes. The holder top has raised rings to press down in the grid holes to hold the TEM grids firmly in place. The numbers on the top should overlay the same numbers on the base plate when replacing the holder top. Replace the holder top carefully and tighten down the central screw.

The detector and sample holder is now primed for use. The removal of sample grids is in the reverse order.

Obtaining an image.

Free Working Distance

When vacuum is obtained in the system switch on the HV for the electron column at 20 kV, spot 3. Using a fast scan focus on the top of the STEM I holder surface with SE detector. Link Z to FWD and bring the focused surface to 5 mm FWD by changing the Z value on the Stage Control Page. Move to the appropriate sample position and refocus on the grid bars of the TEM grid. The FWD and Z position has now lengthened and re-selection of 5 mm in the Z value on the Stage Control Page is necessary. This procedure is necessary to prevent inadvertently bringing the detector in contact with the final lens. The minimum safe distance to the sample surface for FWD is 1 mm, be aware that the holder surface is now closer to the lens than the sample.

By moving off the grid bars and fine focusing on the sample most correction of image rotation and astigmatism can be performed in the SE Mode.

Choose the STEM I detector and in the Detector Settings module select the correct diode operation depending on the sample position in the holder. An image should be visible of the transmission sample at low magnification.

The STEM I detector like the BSE detector is a solid state one and must be operated at slow scan rates for the best imaging.

- **BF image:** change the HV to suit the contrast necessary through the sample. For example light element materials such as poly-silicon or silicon oxide samples which may work better with 5 - 10 kV to create contrast, whereas dense materials such as metals may require 10 - 20 kV or higher. Finally increase the magnification to that required, fine focus and stigmate the image.

  If adjustment of the aperture is needed while in the STEM mode by momentarily switching to ETD or TLD mode the procedure may be achieved more easily because a faster scan speed can be used.

- **DF image:** the samples that reside in the D1 and D5 positions can be observed in the Darkfield mode. The separator line of the two diodes crosses vertically the positions of D1 and D5 so that an area of interest on the left side of the line can be observed with the right-hand diode for DF and with the left-hand diode for BF observation. The opposite is true for the right side of the line.

  DF observation may require higher HV to create a suitable image as the angle subtended to the detection diode can be wide. Choosing 2x the value used for BF is a good guide level.

RETRACTABLE ANNULAR STEM DETECTOR (STEM II – FP 6903/06)

This is a 14 segments solid-state diode mounted on the retractable arm. It must be used only with a special sample holder, oriented in a exact position monitored by the software (see below).

Note:
When the STEM II detector is inserted to the chamber, stage rotation and tilt are locked automatically for the safety. It is possible to unlock these stage movements manually, but beware of possible STEM II cable damage while rotating or tilting the stage.

Holder Arm Installation

1. Run the Home Stage (Shift + F3] procedure.
2. Remove all sample holders from the stage plate.
3. Rotate the stage to +90°.
4. Screw the holder arm to the stage plate according to the following picture.

FIGURE 9-7   HOLDER ARM INSTALLED

## Load 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.

FIGURE 9-8   ROW HOLDER ON THE LOAD BASE
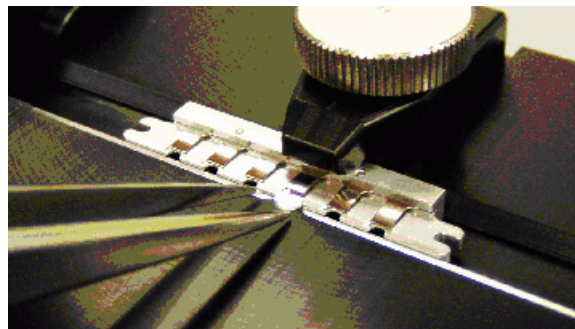
3. Release the screw knob and the entire row holder from the load base.

4. Repeat steps No. 1 - 4 to load in / out another samples.

5. Put the row holder to the holder arm.

FIGURE 9-9   ATTACH ROW HOLDER INTO HOLDER ARM
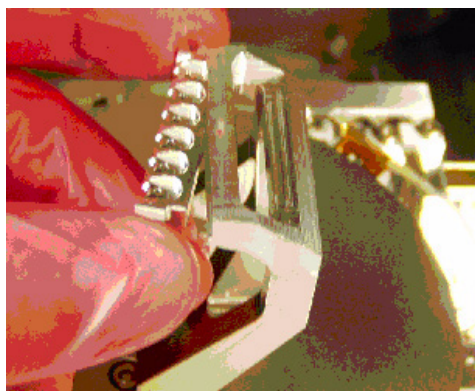
Stage Movement Limits

Following stage movement specification gives a guideline to prevent the STEM II detector crash.

TABLE 9-2   STEM I HOLDER POSITIONS

| Axis	model 230 / 430	model 630
X	**min:** -1.5 mm **max:** unlimited	unlimited
Y	unlimited	**min:** -1.5 mm **max:** unlimited
Z	**min:** 3 mm / **max:** 10 mm	**min:** 3 mm / **max:** 10 mm
Rotation	90°	90°
Tilt	**min:** -1.5° / **max:** 1.5°	**min:** -1.5° / **max:** 1.5°

Caution!
Always make sure any stage movement does not hit the STEM II detector. Any collision can cause its damage.

Settings for STEM II Detector

1. Position the desired sample grid in the field of view using the ETD. Focus and link Z coordinate to FWD.

2. Select the **Detector Settings** module / **Detector** list box / **STEM II** detector.

3. Clicking the **Insert** button causes a dialogue to appear. Confirm the appropriate holder arm is mounted on the stage, otherwise there is a danger of detector damage.

   Note:
   The stage has to be within a specified range of X / Y / Z / R / T to enable a safe insertion of the STEM II detector. Insert button is greyed in case that one or more axes are not in within specified limits. Tooltip on this button shows which axes are out of limits.

   To Retract the detector click the **Retract** button.
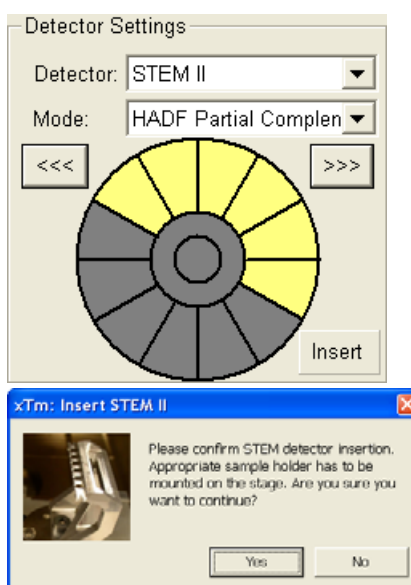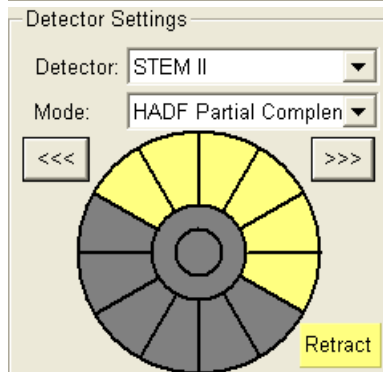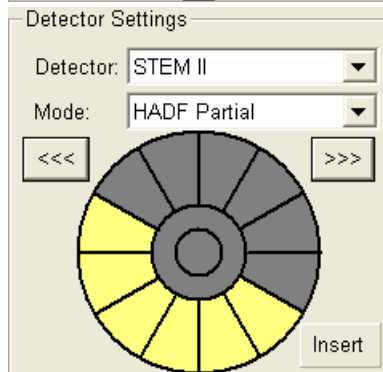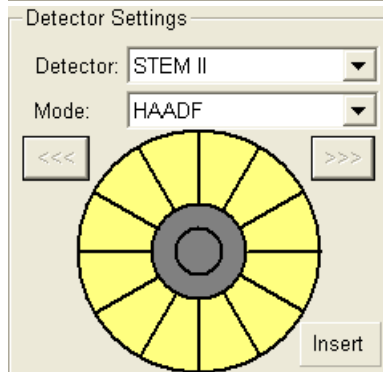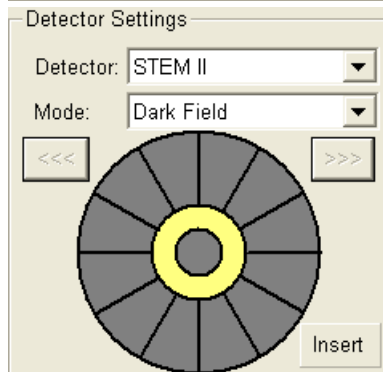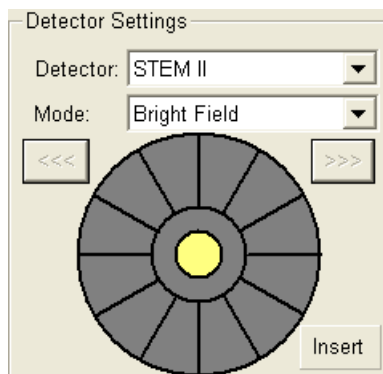
Bright Field imaging

1. Select the **Detector Settings** module / **Mode** list / **Bright Field**.
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. Select the **Detector Settings** module / **Mode** list / **Dark Field**.
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 2x the value used for Brightfield is a good guide level.

1. Obtain a Bright Field image first.
2. Select the **Detector Settings** module / **Mode** list / **HAADF**.

HAADF Partial imaging

1. Select the **Detector Settings** module / **Mode** list / **HADF Partial**.

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.

Selecting the **Detector Settings** module / **Mode** list / **HADF Partial Complementary** gives the signal from complementary segments to those selected in **HADF Partial**.
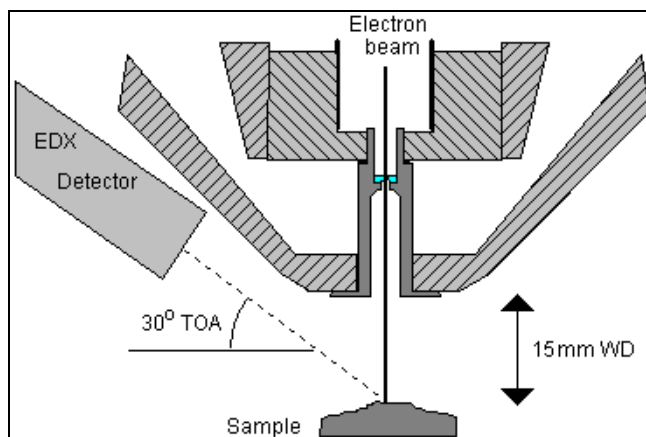
X-ray Analysis

For a X-ray analysis using either EDX or WDX spectrometers, the sample should be positioned to the eucentric height (WD = 5 mm).

HIGH VACUUM

HiVac operation gives the most accurate X-ray results, but the sample must be electrically conducting.

FIGURE 9-10 X-RAY IMAGING IN HIVAC MODE

LOW VACUUM

X-ray analysis in LoVac mode is possible in combination either with the standard LVD detector, or with optional GAD or LVD/Helix detector. The GAD is recommended to achieve the best signal-to-noice ratio, especially when using lower HV values, because the long GAD cone minimizes the primary beam path and therefore its dispersion in the gaseous environment of the chamber. On the other hand, the LVD detector offers the largest field of view for the LoVac operation. vCD is not suitable to use with X-ray detector because vCD diode blocks colection angle of the X-ray analyzer.

The X-ray analysis should be performed at the lowest possible gas pressure to minimize the interaction of electrons with the chamber gas. Normally, it is performed with a relatively high beam current so that there is enough signal for a good LVD image even at very low gas pressures.

EDX ANALYSIS WITH STEM

Set the sample surface to 5 mm FWD.

Select the area of interest in the STEM mode and perform X-ray analysis, Mapping or Linescans as appropriate.

Because the samples are not bulk in nature the beam spread normally associated with SEM samples is greatly reduced and therefore higher spatial resolution can be obtained in the STEM mode. This also provides less background in the spectrum and allows better separation of peaks as well as more accurate lower count rate mapping. The HV chosen for the analysis still depends mainly on the composition of the sample.

Patterning (Option – FP 2400/09)
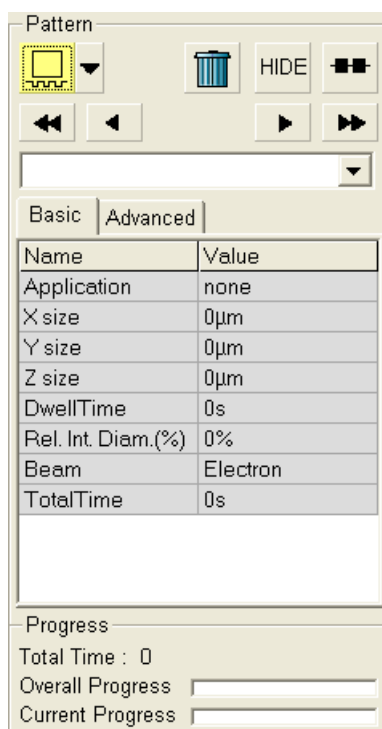
Patterning is the process of moving a beam over the specimen with the purpose of:

- **milling** – removing well-defined amounts of existing material
- **deposition** – depositing well-defined amounts of new material

at well-defined locations (the shapes such as rectangles or circles), leaving other areas untouched. The electron beam is generally used only for deposition.

Shapes have many associated parameters, such as the gas that can optionally be used during patterning to increase the speed of the process. A Gas Injection System (GIS) delivers this gas. As different applications require different gases, there could be two GISes installed on your system. One can select an application file (Pt deposition) for a given pattern in Patterning property editor. It automatically sets the appropriate GIS, the dwell and overlap, calculates the proper dose appropriate to the beam chemistry. A pattern must be defined before the material file is selected.

The GIS can be selected manually, but note that overlap and dwell should be set carefully with particular gasses in mind to avoid disappointing results. Before the patterning with the GIS starts the GIS needle must be inserted manually and the gas reservoir heated. The opening / closing of GIS valves is done automatically during patterning.

The **Progress** area displays information updated as the milling progresses:

- the **Total Time:** estimated total patterning time
- the **Overall Progress** – related to the total patterning time
- the **Current Progress** – related to the current pattern

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.

PATTERNING TOOLS

The selected icon (denoting a tool for patterns handling and setting) is highlighted. Clicking the icon activates / deactivates the tool.
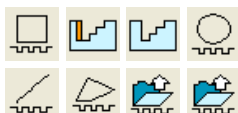
- The **Pattern selector:** Clicking the arrow next to the icon activates the dropdown list. When a selection is made, the area displays an appropriate icon (**Rectangle / Cleaning Cross Section / Regular Cross Section / Circle / Line / Polygon / Bitmap / Stream File**
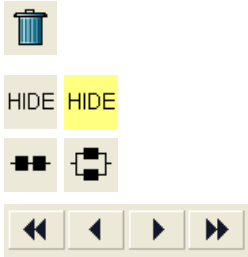
see below) with an yellow background, enabling to draw a pattern. Clicking the selected icon again brings a normal background colour and the pattern selection cursor (arrow) is active.

- The **Trash Can (Delete)** button deletes the selected patterns.

- The **Hide / Show** button hides the currently selected pattern.
- The **Patterning Serial / Parallel sequence** button switches between two possibilities (see below).
- The **Patterning sequence** buttons set the pattern milling order (see below).

Bitmap Pattern

From the patterning page a pattern is available that allows you to import bitmaps as a pattern. In this 24 bits RGB bitmap each pixel consists of:

- The **Red** component – currently not used.
- The **Green** component – determines if the beam is blanked. Any other value then 0 activates the beam.
- The **Blue** component – determines the dwell time per pixel. If blue is set to 0 the dwell time of a pixel is 100 ns. If blue is set to 255 the maximum UI dwell time is used. The dwell time for the pixels in between these values is linearly interpolated and then rounded to the value from a (fixed) dwell time table with 124 entries.

Note:
When drawing a bitmap it is recommended to use black (0 / 0 / 0) for none milling points and white (255 / 255 / 255) for milling points.
Do not forget to optimize other properties such as application file, depth, leading edge etc.

Stream File Pattern

A stream file, created as an ASCII text or binary file that addresses the patterning DAC directly, produces custom pattern files. Because a 12-bit DAC is used, the patterning field of view is divided into 4096 steps. The range in X is 0-4095, but in Y is approximately 280-3816. Y values outside of this range will be off the image area and may not scan correctly.

s	96 2867 2867	96 1639 2048	96 2457 1639
40	96 1229 2457	96 2048 2048	96 2867 1639
25	96 1639 2457	96 2457 2048	96 1229 1229
96 1229 2867	96 2048 2457	96 2867 2048	96 1639 1229
96 1639 2867	96 2457 2457	96 1229 1639	96 2048 1229
96 2048 2867	96 2867 2457	96 1639 1639	96 2457 1229
96 2457 2867	96 1229 2048	96 2048 1639	96 2867 1229

The file must begin with an **s**, indicating a stream file. The second line defines the number of loop repeats (**40** times). The third line indicates the total number of X, Y coordinates (pixels) in one loop (5 x 5 = **25** in this case). The **96** figure represents dwell time in units of 0.1 µm (9.6 µs). The range of dwell time is 0.1 µs to 4.6 ms, with 124 values distributed approximately logarithmically within this range.

Note:
Stream files are for users who write their own programs for specific applications. They cannot be created directly from xT UI, use any suitable text processor.

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 shape properties in the group must necessarily be the same: Number of Passes, Beam, and Gas properties. The first selected shape determines these values for all other ones.

Other properties (Material File, Overlap, Sputter Rate, Recovery Time and Depth) are also all set to those of the first selected shape to avoid confusion, even though they could theoretically remain unchanged. Restoring Serial mode does not undo these changes; the properties remain as in the Parallel mode.
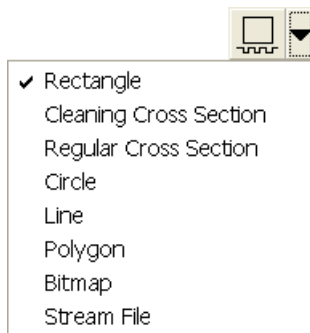
PATTERN AREA PROCESSING

Select one of the patterns from the **Pattern selector** drop down list. Once selected, the cursor is ready to draw a pattern onscreen. This is possible in the quad or in the single screen, whichever is selected. Draw a suitable pattern size with the draw cursor.

Importing / Exporting Patterns

Defined patterns may be imported via menu File / Import / Patterns and exported (saved) via menu File / Export / Patterns.

Pattern Area Editing

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

- **Selected Pattern** is denoted by the addition of resizing handles to the pattern outline (use pointer cursor).
- **Moving Pattern:** place the cursor inside the boundary of the pattern and hold the left mouse button while dragging it (use move cursor).
- **Resizing Patterns:** hold the left mouse button and drag the resizing handle until the desired size is reached (use horizontal, vertical or diagonal resizing cursor). This can also be achieved by entering values in the Property list.
- **Selecting all Patterns** (in an selected quad)**:** press **Ctrl + A** keys or click the **Select All** button.
- **Delete selected Pattern(s):** click the **Trashcan** icon or press the **Delete** key.
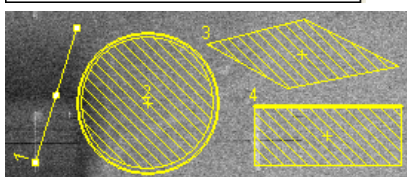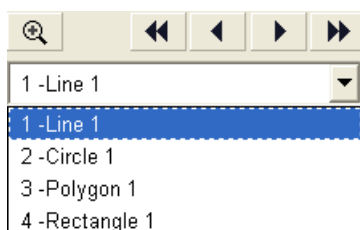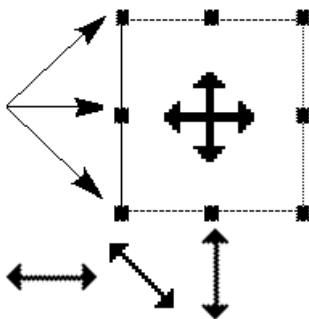
Pattern Milling Order

Patterns are milled in the order they are created (for parallel patterning this is valid for all beam passes). Numbers are displayed close to the pattern and in front of its name to indicate the current 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.

PATTERNING PROPERTY EDITOR

allows changing the properties of the selected shape or shapes. It displays the properties in a fixed sequence, such that the most often needed properties are at the top.
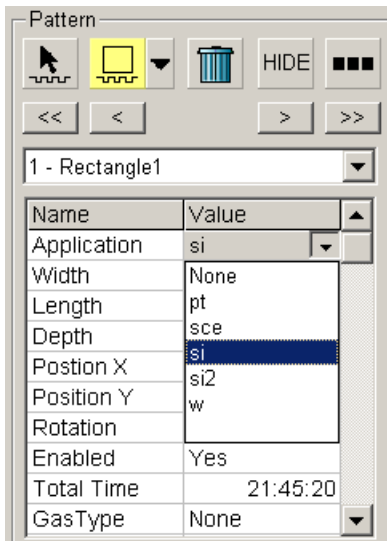
- **Application**: Clicking the value slot produces a dropdown arrow with a list of applications. Choose the one required and it resides in the Value slot. This sets the subsequent properties. There are pre-defined (non-editable) and user-defined (saved) applications. Some of these Application files use GISes. The appropriate application file should be used with the gas type (GIS) it was written for.
- **Width / Length / Depth**: dimensions of the pattern when finished.
- **Position X / Y** of the pattern relative to the origin (the quad center).
- **Rotation** of the patterns. The positive direction is counter-clockwise, default value is 0°.
- **Enabled**: If a shape is disabled then it is not included in patterning.
- **Total Time**: Time required to pattern this shape.
- **Gas Type**: The gas that must be used to pattern this shape (or None if no gas is to be used). Note that this determines the colour of the pattern on the screen.
- **Beam**: Not editable - always electron.
- **(total volume) Sputter Rate (RV-total)**: The speed at which material is removed or deposited.
- **Dwell Time (tdwell)**: The time the beam spends on a single pixel per pass. Changing this influences the Total Depth and Total time, assuming a constant Number of passes.
- **Volume per dose (Vd)**: The volume of material that is removed per Coulomb.
- **Saturation sputter rate (RL-sat)**: The maximum linear sputter rate for a given gas. For Gas=None this is 0.
- **Saturation current density (Jsat)**: The current at which 63% of the saturation sputter rate is reached.
- **Maximum dose per area (Dpa-max)**: 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.
- **Refresh Time**: The minimum loop time that must at least elapse before the next pass, so that the adsorbed gas can be refreshed.
- **Loop Time**: The time between the start of one pass and the next (read only).
- **Shape Area**: The surface area of the pattern. Note that the area is not simply the bounding rectangle, for example a Grouped shape may have a much smaller Area (the sum of the Area's of the grouped shapes) than its bounding rectangle.
- **Number of Passes**: That the beam makes over the pattern. Changing this will change the Depth.
- **Defocus (WD)**: of the beam (WD change).
- **Blur (dblur)**: Like Defocus, but specifying the (additional) diameter of the blurred spot.
- **Interaction diameter (dinteraction)**: for an infinitely small beam.
- **Total Diameter (dtotal)**: The combination of the beam diameter and interaction diameter (read-only).
- **Total Beam Time**: the total time that the beam is unblanked for this shape.
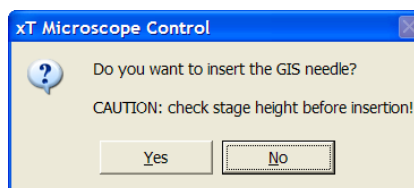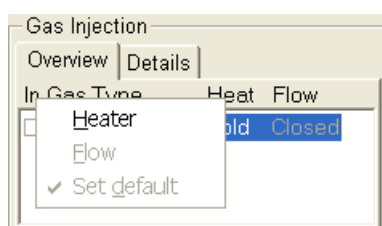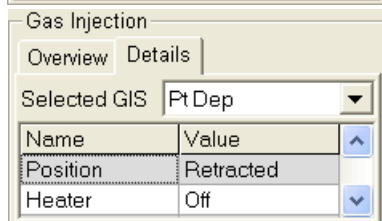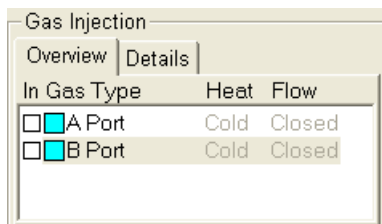
THE GAS INJECTION MODULE

This module enables to control installed GISes. A Gas Type is allocated to each GIS. One or two injectors may be mounted on the system in total. The GIS may be controlled via **Overview** Tab or **Datails** Tab.

Setting up the GIS

The GIS to be used should be set up before patterning is started. It must be held heated and inserted but not open until it is necessary to use.

When not in use, the GIS should be closed (to save filling 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.

TABLE 9-3   SETTING UP THE GIS

Step	Action
1.	Open the **Overview** tab in the **Gas Injector** module: Double click or click the right mouse button over the installed GIS module line. A dialog list opens.
2.	Click on the **Heater**. The word **Cold** is replaced by a progress bar, which in turn is replaced by the word **Warm** when the GIS is fully heated.
3.	Tick the **In** box to the left of the GIS chosen. A dialog appears asking for confirmation of insertion of the GIS. **Note:** The GIS can't be inserted (the **In** box remains grayed out) if the **Link Z to FWD** (**Shift + F9**) action was not carried out. A tooltip gives an advice to do so if this condition is not met. 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!
4.	Open / Close the GIS valve by double clicking the Closed / Opened text 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.

:

CryoCan (9432 909 96541)

This option allows to decrease the contamination level in the system. The kit consists of:

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

WARNING!

This option uses liquid Nitrogen (LN2), which may cause a serious cold burns. Read Safety instructions in Chapter 1.

FIGURE 9-11 CRYOCAN MOUNTED ON SPECIMEN CHAMBER

The Cryo-Can consists of a NITROGEN VESSEL that is surrounded by an outer container. The space between the two components is pumped by the microscope vacuum system. The VACUUM VESSEL is connected to one of the SEM specimen chamber ports by a vacuum seal. A connection tube between the port and outer vessel allows SEM vacuum to evacuate the outer vessel. When the specimen chamber and Cryo-Can are vacated liquid Nitrogen is introduced to the NITROGEN VESSEL.The evacuated outside cold surface of the NITROGEN VESSEL absorbs contaminating products from the specimen chamber. The vacuum in the specimen chamber improves over a short period and contamination build-up previously seen on the sample is now reduced. Although the dewar can be effective to approximately 5 hours duration, after 1.5 to 2 hours the NITROGEN VESSEL can be removed. This is achieved by letting the specimen chamber to atmosphere and removing the NITROGEN VESSEL by unclipping it from the VACUUM VESSEL. A VACUUM VESSEL LID is then placed over the VACUUM VESSEL to seal it from the atmosphere. The specimen chamber can be vacated once again, however the microscope vacuum remains cleaner than before and sample contamination is still reduced.The NITROGEN VESSEL is then emptied of residue liquid Nitrogen and baked either in an oven at 90° C or placed on the stand provided and baked with an infra-red lamp (type Philips infrafil).

Regenerating the dewar by heat allows removal of condensed contamination and subsequent reuse of the vessel.

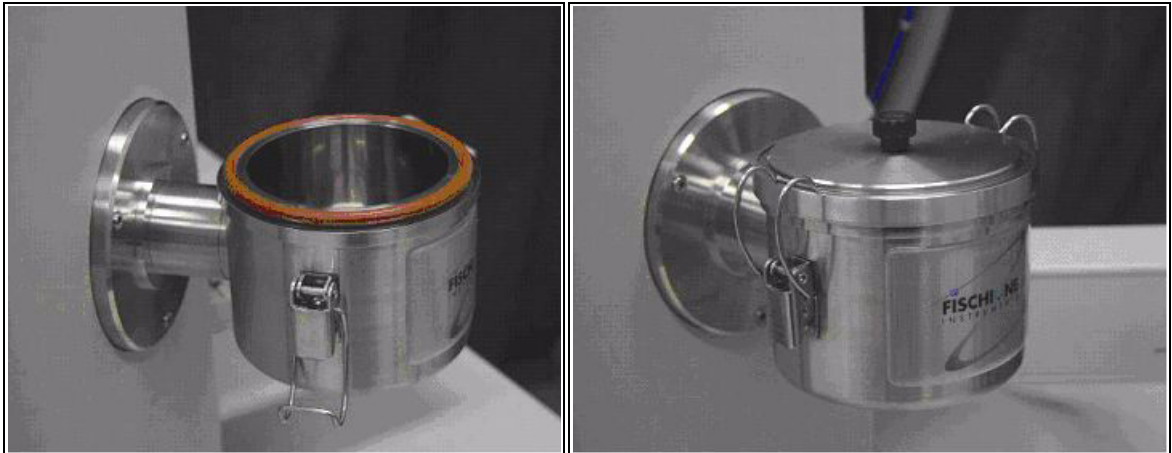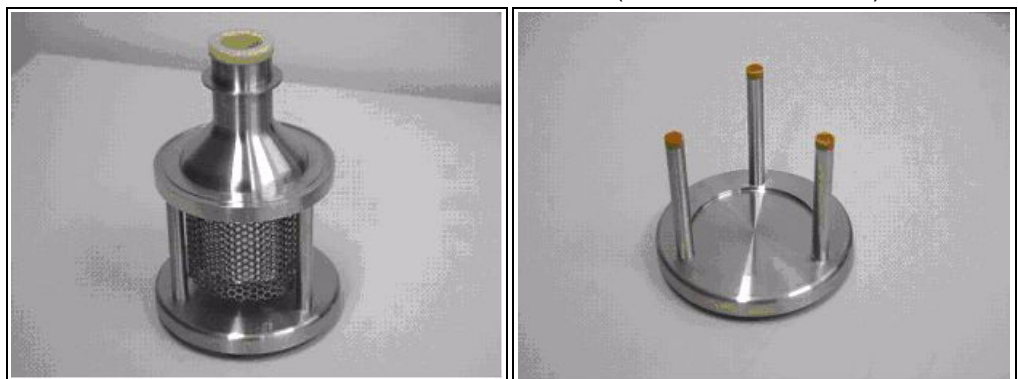FIGURE 9-12 CRYOCAN VACUUM VESSEL WITHOUT / WITH LID

FIGURE 9-13 CRYOCAN DEWAR (NITROGEN VESSEL) / STAND

MOUNTING THE CRYO-CAN

The Cryo-Can is made to fit recommended Port types on the FEI SEM or SDB specimen chamber. See the manufacturer´s operating manual for the correct mounting port.

The VACUUM VESSEL can be mounted on the port 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 the VACUUM VESSEL.

Once mounted 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.

Start the SEM specimen chamber pumping cycle. The VACUUM VESSEL will be pumped along with the specimen chamber.

OPERATING THE CRYO-CAN

Charging the Cryo-Can

When the specimen chamber vacuum is ready and chamber pressure drops below 0,01 Pa (8.10^{-5} Torr) first partially fill the dewar and wait until boiling has stopped. Then fill the dewar and place the cap on top

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of the Cryo-Can. The volume of liquid Nitrogen needed is approximately 250 mil.

WARNING!

The handling of LN2 should be performed wearing face and hand protection in the form of a face visor and a pair of thermal protective gloves.

The LN2 will stop boiling very quickly so that no vibration will be seen from this device. If the Cryo-Can needs to be used for longer periods it can be recharged with LN2.

Note:

Before re-filling it is recommended to perform Baking procedure (see below).

Users must not touch the cold surfaces of the dewar as this could result in burns. Use the Safety SAFETY TONGS provided, when handling the NITROGEN VESSEL.

Removing the Nitrogen Vessel

Removing the NITROGEN VESSEL will depend on the level of contamination found in the SEM. If the contamination level is unusually high then the Cryo-Can can be worked continuously till improvement is seen, otherwise normally after approximately 2 to 3 hours the NITROGEN VESSEL can be removed.

Bring the specimen chamber to atmosphere, the excess LN2 will start to boil, do not be concerned. Unlock the two clips holding the NITROGEN VESSEL in the VACUUM VESSEL.

FIGURE 9-14 NITROGEN VESSEL SAFETY TONGS
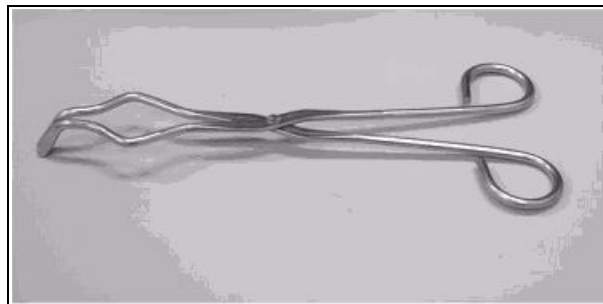
WARNING!

Use the Safety SAFETY TONGS provided when handling the NITROGEN VESSEL.

With the Safety SAFETY TONGS placed under the ring on the neck of the NITROGEN VESSEL lift the Dewar cylinder out of the VACUUM VESSEL.

Place the VACUUM VESSEL LID over the VACUUM VESSEL and secure the two components by fixing the clips to the VACUUM VESSEL LID and locking the clips down.

Start the SEM specimen chamber vacuum system. The VACUUM VESSEL will be vacated along with the specimen chamber.

Remove the cap from the NITROGEN VESSEL and pour out the excess LN2 into a suitable LN2 container.

WARNING!

When the LN2 is removed from the nitrogen vessel, the bottle still remains at a very low temperature.

Place the NITROGEN VESSEL onto the NITROGEN VESSEL STAND ready for baking.

Baking the Nitrogen Vessel

Place the NITROGEN VESSEL STAND on a suitable heat resistant surface.

Place the NITROGEN VESSEL onto the NITROGEN VESSEL STAND 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.

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 a infra-red lamp.

FIGURE 9-15 BAKING THE NITROGEN VESSEL
WITH AN INFRA-RED LAMP
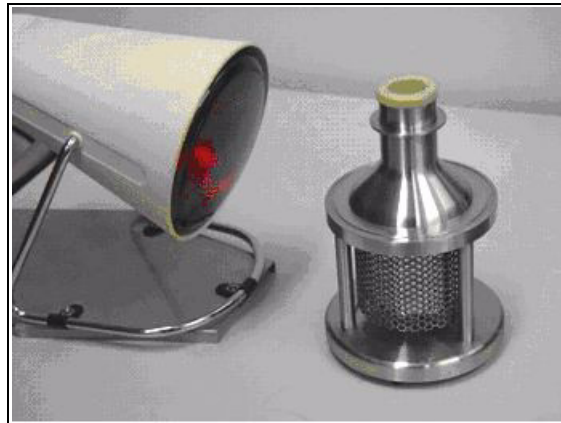
Replacing the Nitrogen Vessel

1. Allow the NITROGEN VESSEL to cool down before handling.
2. Bring the specimen chamber to atmosphere (Vent command).
3. Unlock the two clips holding the VACUUM VESSEL LID on the VACUUM VESSEL.
4. Remove the VACUUM VESSEL LID from the VACUUM VESSEL.
5. 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.
6. Start the SEM specimen chamber pump cycle. The VACUUM VESSEL will be pumped along with the specimen chamber.

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MAINTENANCE

The only maintenance necessary is to the following:

- 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 SEM 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.

TECHNICAL

The available ports for mounting the Cryo-Can without restriction are as follows:

- **Nova NanoSEM 230 / 430**: Port A
- **Nova NanoSEM 630**: Port U, Port H

E-Beam Deposition Kit (FP 3401/11)

The kit consists of:

- GIS controller
- Cable (control)
- Cable (power)

The system may be equipped with Gas Injection System (GIS). This system is used for deposition by selecting a material file for a given pattern. You must define a pattern before a material file can be selected. A given material file will automatically select the appropriate GIS check box, calculate the proper dose, and set the dwell and overlap appropriate to the beam chemistry.

The GIS check boxes can be selected manually, but note that overlap and dwell should be set carefully with particular gasses in mind to avoid disappointing results.

You can select a pattern with the arrow tool, change the appropriate GIS valve status from closed to open, and thereby change the patterns.

Electrostatic BeamBlanker (FP 6842/25)

On the Nova NanoSEM a High-speed electrostatic beam blanker can be mounted next to the Signal lens aperture (FLA).

INSTALLING THE BEAM BLANKER

1. Vent the specimen chamber.

   The BB holder mechanism can be found to the right of the FLA holder mechanism.

   Note:

   These units looks similar

2. Replace the Vacuum seal dummy in the BB holder mechanism with the Beam blanker rod.

3. Pump down the specimen chamber.

   Make sure that the blanking plates are either short circuited or connected to a supply that controls the blanking.

4. Align the blanking plates in all 4 positions (see below) to the electron beam in the lowest magnification, not the other way around!

   Beam blanking will take place when a +5 V signal is applied to the blanking plates. The position of the blanking plates depends on the accelerating voltage of the electron beam.

TABLE 9-4   ALIGNMENT OF PLATES TO VOLTAGE

High Voltage [kV]	Position	Plate Gap Distance [mm]
> 20	1D	0.25
> 10	2D	0.5
> 5	3D	1.0
> 5	4D	2.0

FIGURE 9-16 BEAM BLANKER PLATES
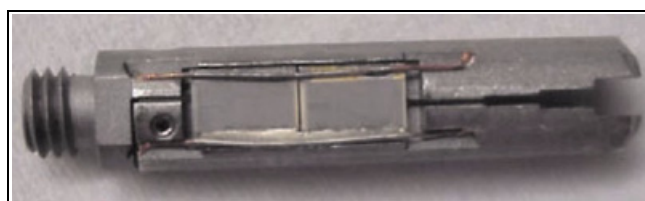
In order to get maximum blanking effect of the beam the Aperture rod can be moved a little outwards of the column axis in the direction of the FLA holder mechanism. The best position is just before the beam current starts decreasing because of misalignment of the aperture.

Other options for increasing the On/Off ration of the blanker rate are:

• Use a smaller distance between the blanker plates (lower position number) than is prescribed in the table above. This may also increase chances of charging effects on the blanker plates.

• Use a higher voltage on the blanker plates. To allow voltages significantly above the standard value of +5V the 50 Ohm resistor between the plates has been disconnected to prevent overheating.

This has resulted in a lower maximum operating frequency of the electrostatic beam blanker. The 50 Ohm resistor should always remain connected to ground, otherwise there is a chance of charging problems.

When the beam blanker plates are positioned correctly with reference to the electron beam there should be no limitation in the field-of-view of the SEM image. Place the beam blanker in position 4 when it is not in used. Also disconnect the external cable and short-circuit the plates.

Re-align the FLA for high resolution performance.

CAUTION!
Do not fully retract the aperture rod when the Beam Blanker is mounted. You must (partially) retract the Beam Blanker first before the aperture rod can be fully retracted. Otherwise damage to the aperture strip and/or the blanker plates may occur.

CLEANING THE BEAM BLANKER

After intensive use the blanking plates of the Electrostatic Beam Blanker can get contaminated. This will lead to charging, beam drift effects and / or additional astigmatism that will make the SEM useless for lithography applications.

FIGURE 9-17 BEAM BLANKER PLATES
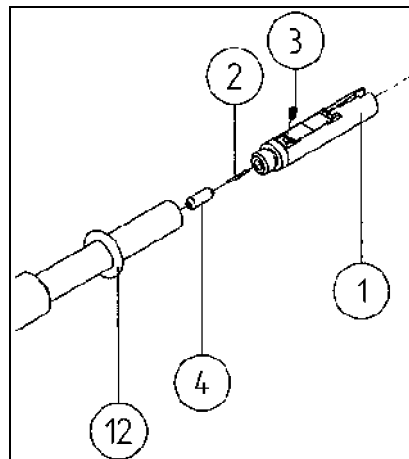
For initial cleaning a plasma cleaner is ideal as this can remove hydrocarbon based material very efectively. In case where the Beam Blanker cannot be cleaned with a Plasma system only because it has been excessively contamined, follow the procedure described below:

Cleaning of the blanking plates normally involves Cyclo Hexane (or Isopropanol) with ultrasonic aggitation.

1. Take t he BEAM BLANKER ROD with the blanking plates out of the column and replace it with the VACUUM SEAL DUMMY.
2. Release the blanking plates (item 1 in drawing) from the BEAM BLANKER ROD.
3. Clean the blanking plates for 15 minutes in an ultrasonic bath with Cyclohexane.
4. Clean the blanking plates for 15 minutes in a Cyclohexane vapour bath.
5. Make sure that all the Cyclohexane has left the openings of the blanking plates.

6. Dry the blanking plates with dry nitrogen gas.

7. Do a visual inspection (magnifying glasses, light microscope) for dust particles etc. between the blanking plates. Repeat the cleaning steps 3-6 if necessary.

8. Mount the blanking plates again on the BEAM BLANKER ROD, using clean gloves.

9. Do not touch the blanking plates and repeat inspection of step 7.

10. Measure the resistance between the blanking plates (50 Ohm or infinite in case of a large [>10 V] blanking signal) and the resistance between connector and plates (< 1 Ohm).

11. Short circuit the plates by making contact between the connector kernel and shield.

12. Place the beam blanker in a clean holder and insert in the plasma cleaner.

13. Plasma cleaning: Ar/O 75/25% with 4 V pressure reading for 5 minutes

14. Take the beam blanker out of the plasma cleaner, remove short circuit and repeat step 10.

15. Remove VACUUM SEAL DUMMY from column and put the BEAM BLANKER ROD in without hitting anything inside.

16. Align the blanker plates to the beam for all four positions (gap widths). Also make sure that the plate surface is parallel to the beam.

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UMB Stub Holder Kit (FP 3660/00)

FIGURE 9-18 UNIVERSAL MOUNTING BASE
FOR SMALL STAGE SYSTEMS

This option contains the following items:

- Universal mounting base (UMB)
- Storage box
- 2 stub modules each holding 3x 1/2" stubs or 2x 1" stubs
- 2 clamp bars
- User guide
- System calibration sample

The whole stub holder is mounted on the stage interface plate.