



# User Operation Manual



Edition 2  
21 Nov, 2012

**NOVA NANOSEM**

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# System Capabilities

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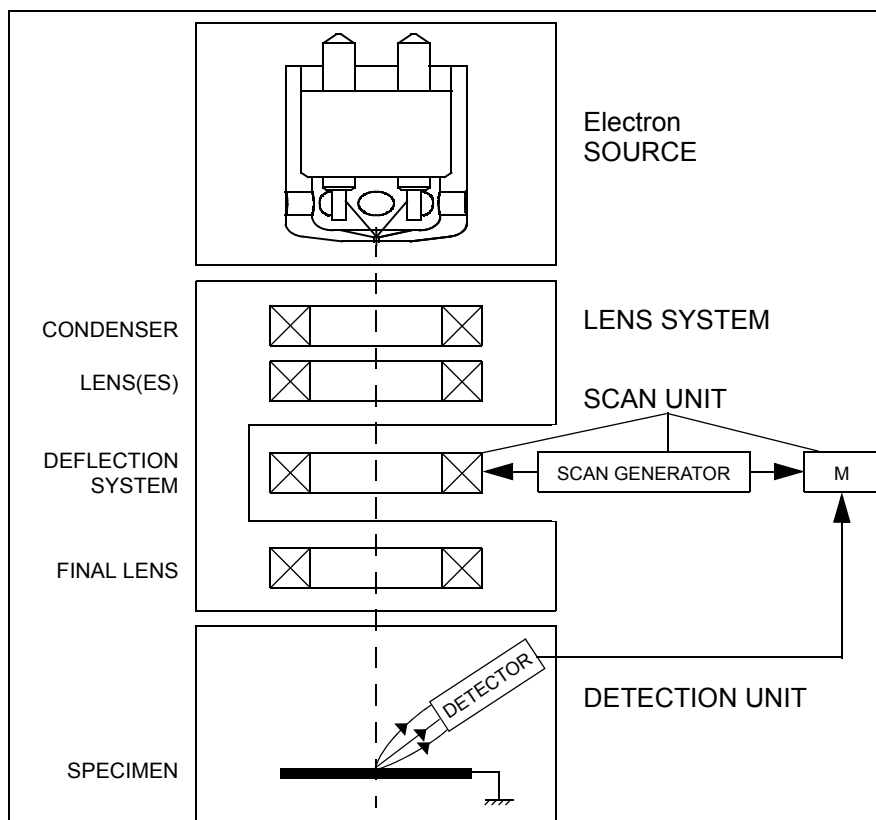
The Nova NanoSEM Scanning Electron Microscope (SEM) produces enlarged images of a variety of specimens, achieving magnifications of over 500 000× providing ultra high resolution imaging in a digital format. This important and widely used analytical tool provides exceptional depth of field, minimal specimen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

## SYSTEM PERFORMANCE

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

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

**FIGURE 1-1 COLUMN SCHEMATIC OVERVIEW**



### Computer Control

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

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

### Vacuum System

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

#### High Vacuum (HiVac)

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

#### Low Vacuum (LoVac)

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

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## HARDWARE

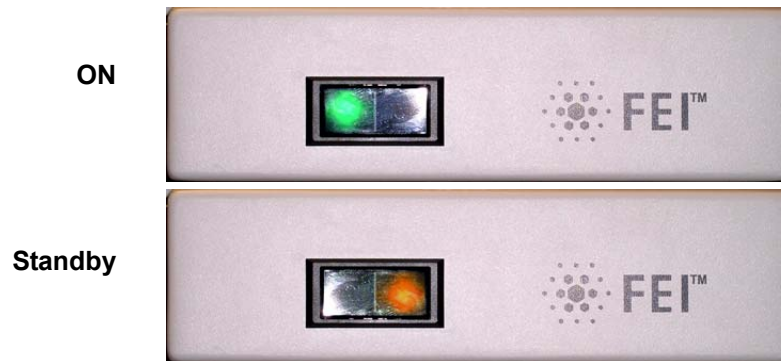
The system is computer controlled and as such has a **Microscope Controller** which must be turned on (use the power button on the PC) to operate the microscope by means of the software. The **Electrical Console** powers components of the **Microscope Console** (vacuum, gun, column, stage...). The **support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

### Microscope Console Control Panel

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

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**FIGURE 2-2** SYSTEM CONTROL PANEL POWER BUTTON



## 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, controlling horizontal plane fine movements.

**FIGURE 2-3** FINAL LENS APERTURE STRIP CONTROL KNOB



### **WARNING!**

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

*The aperture holes edges cleanness is also very important (see Chapter 8 for a detailed description).*

**TABLE 2-1** APERTURE SIZES AND THEIR USE

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

# Vacuum System

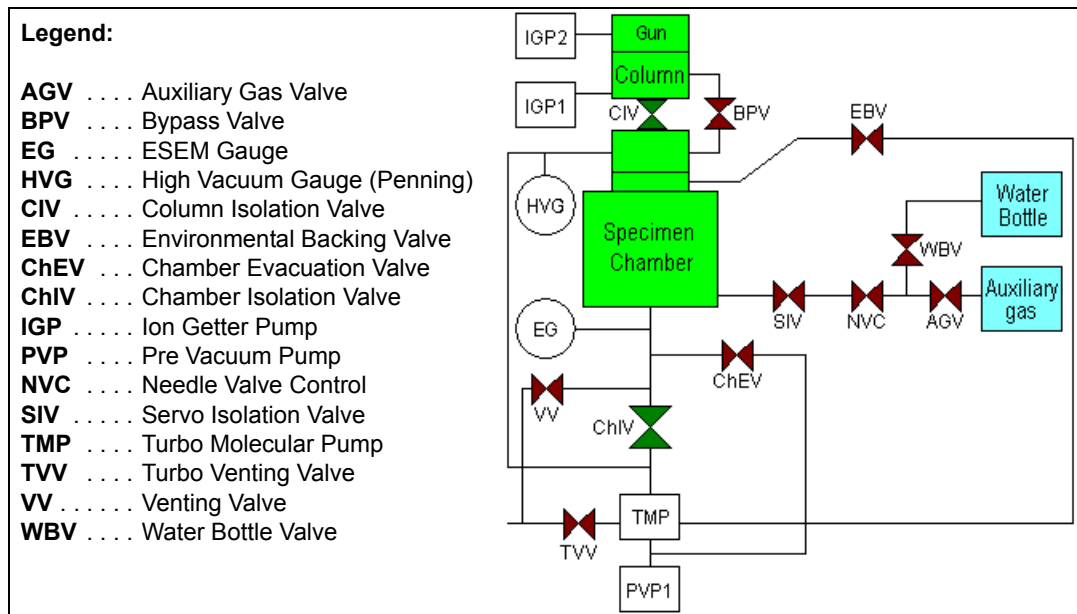
There are three main vacuum sections:

- Electron source
- Column
- Specimen chamber.

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

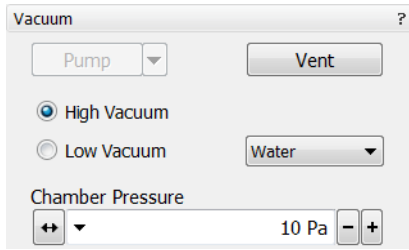
All valve and pumps operations are fully automatic.

**FIGURE 2-4** Nova NanoSEM VACUUM SYSTEM



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## VACUUM MODES



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

### High Vacuum (HiVac) Mode

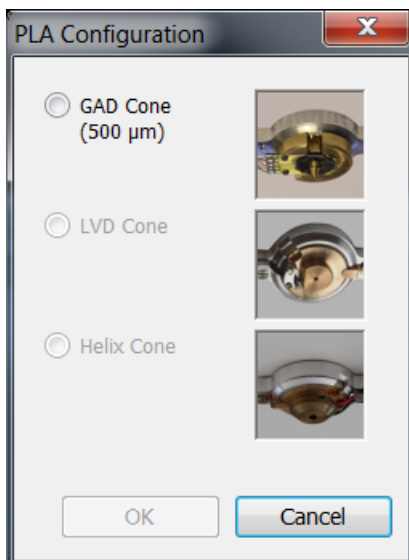
The high vacuum condition is common throughout the column and specimen chamber. The typical pressure value is within the order from  $10^{-2}$  to  $10^{-4}$  Pa.

### Low Vacuum (LoVac) Mode

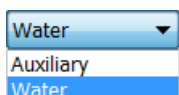
In this mode, the column section is under the lower pressure than the specimen chamber where the pressure ranges from 10 to 200 Pa (0.08 to 1.5 Torr). This mode uses water vapour from a built-in water reservoir or a gas from an auxiliary gas inlet (the drop down list).

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

If relevant detector is not in place, a warning appears informing a user that the detector should be installed for the mode selected. The system will not abort the pump sequence, however.



When **Low Vacuum** mode is entered from **HiVac** or from the **Vented** status, the system prompts a user with the PLA Configuration dialogue (this happens only for the first time after a particular Vent procedure).



- the **Water** vapour from a built-in water reservoir located on the left side of the microscope console,

**Note:**

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

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

**Caution!**

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

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

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

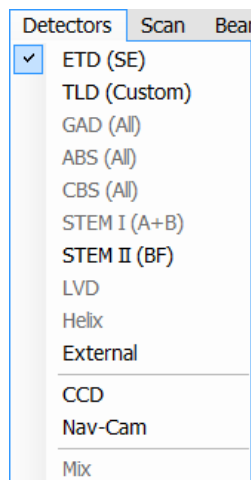
Working Gas	Maximum Chamber Pressure [Pa] (Torr)
Water - H <sub>2</sub> O	200 (1.6)
Nitrogen - N <sub>2</sub>	
Air	
Carbon Dioxide - CO <sub>2</sub>	
Nitrogen Dioxide - NO <sub>2</sub>	
Helium - He	100 (0.7)
70 % He + 30 % H <sub>2</sub>	65 (0.5)
Argon - Ar <sup>**)</sup>	50 (0.4)
C <sub>x</sub> H <sub>y</sub> <sup>*)</sup>	200 (1.6)

**Caution!**

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



# Equipment



## DETECTOR TYPES AND USAGE

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

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

**TABLE 2-5** STANDARD AND OPTION DETECTORS

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

**Note:**

SE = secondary electrons, BSE = back scattered electrons

S = standard, O = optional

**boldface** - preferred SEM modes



**Caution!**

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

## STAGES AND ACCESSORIES

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

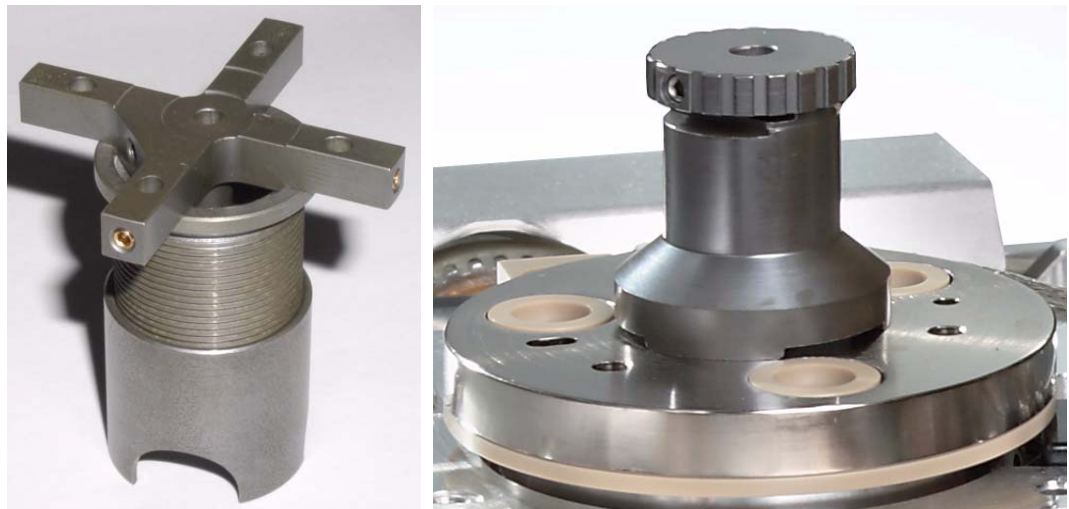
**FIGURE 2-6** NOVA NANOSEM 450 CHAMBER



### Standard Stub Holders

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

**FIGURE 2-7** 110 × 110 & 150 × 150 mm / 110 × 110 STUB HOLDER



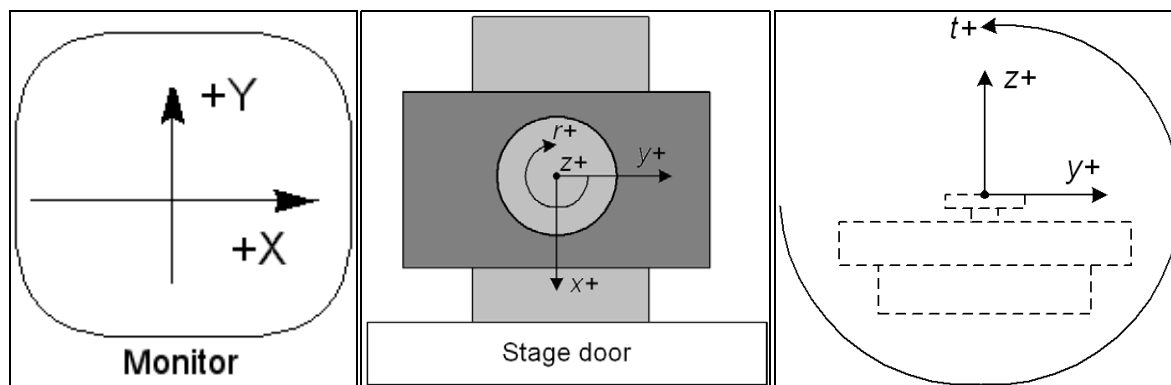
### Stage movement Limits

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

**Note:**

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

**FIGURE 2-8** STAGE MOVEMENT SCHEMA



**TABLE 2-6** STAGE FEATURES AND LIMITS

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

**Note:**

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

**Caution!**

The positive Z value direction depends on the **Link Z to FWD** status (see Chapter 5).

**Caution!**

If the maximum sample size is near to the limit, stage tilt could be limited. Beware of hitting the objective pole piece!

# SOFTWARE CONTROL

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## SOFTWARE INTERFACE

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

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

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

## OTHER SOFTWARE AND HARDWARE

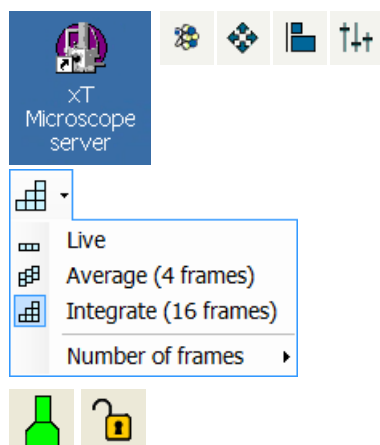
Call Customer Service for advice before installing software or hardware that is not required for system operation. Other software, such as screen savers or hardware network cards, may corrupt the xT microscope Server / Control software under some circumstances and may invalidate warranty.

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

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# Software Interface Elements

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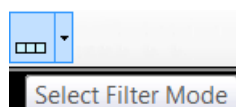
## ICONS

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

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

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

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



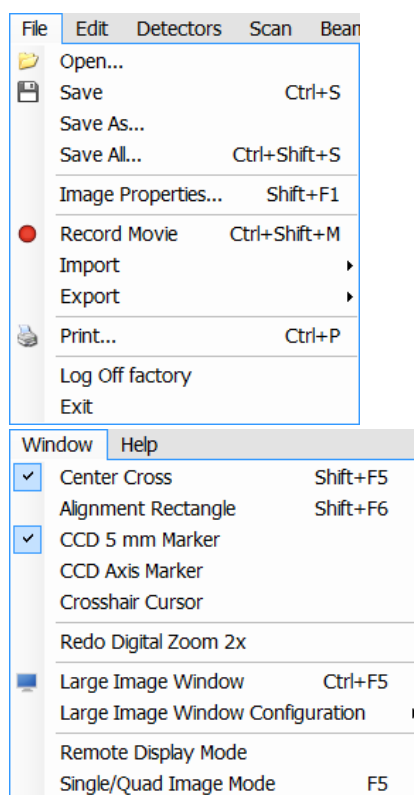
## TOOL-TIPS

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

## PULL-DOWN MENUS

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

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



## Using the Mouse

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

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

## Using the Keyboard

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

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

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## COMMAND BUTTONS

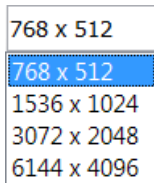


carry out or cancel functions. They activate when clicked and some are highlighted (changed color) to show the corresponding function activity.

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

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

## LIST BOXES



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

## PROPERTY EDITORS

Color	
Line Width	0
End Type	None
End Point	None
Direction	Any

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

## EDIT BOXES

<input type="checkbox"/> X	<input type="text" value="3.9195"/>	mm	<input type="button" value="-"/>
<input type="checkbox"/> Y	<input type="text" value="-8.4587"/>	mm	<input type="button" value="-"/>
<input type="checkbox"/> Z +↓	<input type="text" value="30.4069"/>	mm	<input type="button" value="-"/>

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

Automatic       Custom

Dynamic Focus

Tilt Correction

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

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

## ADJUSTERS



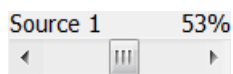
allow to change parameters, such as contrast, brightness, gamma etc. in a continuous way by clicking & dragging the middle adjuster or clicking in the grey bar. They always have a label in the upper left and right corners for readout information. Double-click the value in the upper right corner enables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



### Exponential Adjuster

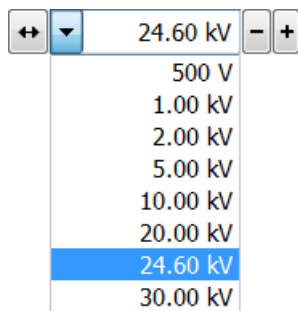
This is an exponential response adjuster – the further from the center is the large adjuster button pulled, the larger is the relative change. The adjuster button always snaps back to the center of the slider.

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



### Linear Adjuster

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



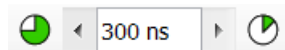
### Preset Adjuster

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

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

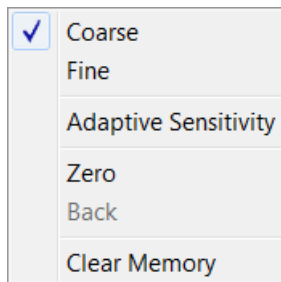
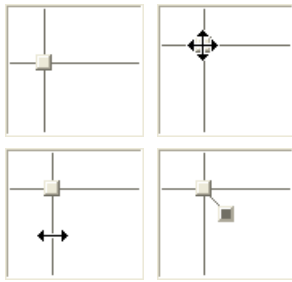


### Spinner



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

## 2D CONTROLS



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

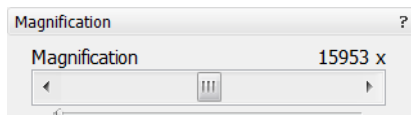
Clicking & dragging anywhere inside the box changes the active quad cursor to the four-ended arrow and positions it to the screen point corresponding to the actual control value (minimum in the middle of the screen and maximum at the edges). It can be dragged in four directions. Clicking & dragging directly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

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

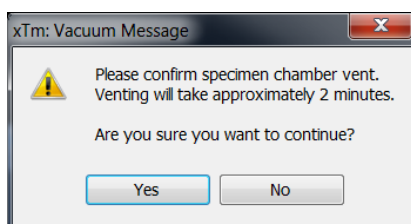
- The **Coarse / Fine** sets the mouse sensitivity – long / short mouse path necessary for the full range.
- The **Adaptive Sensitivity** adjusts the mouse control response to be the same at any magnification.
- The **Zero** brings the control value to zero and the cursor to the center of the box.
-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

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

## MODULES



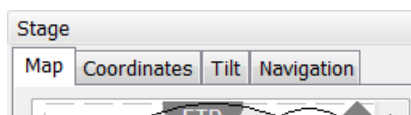
visually combine various software elements, which are related into a labeled group. Complex software elements like UI pages or dialogues are typically composed of modules.



## DIALOGUES

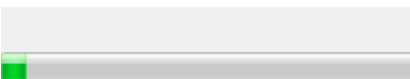
appear when the system needs more information from you before it can carry out a command, or want to give you some important actual information. Some dialogues do not let you access other functions until you close them, other ones let you perform other tasks while they remain onscreen and active (for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

## TABS



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

## PROGRESS BARS



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



# xT microscope Control Software

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

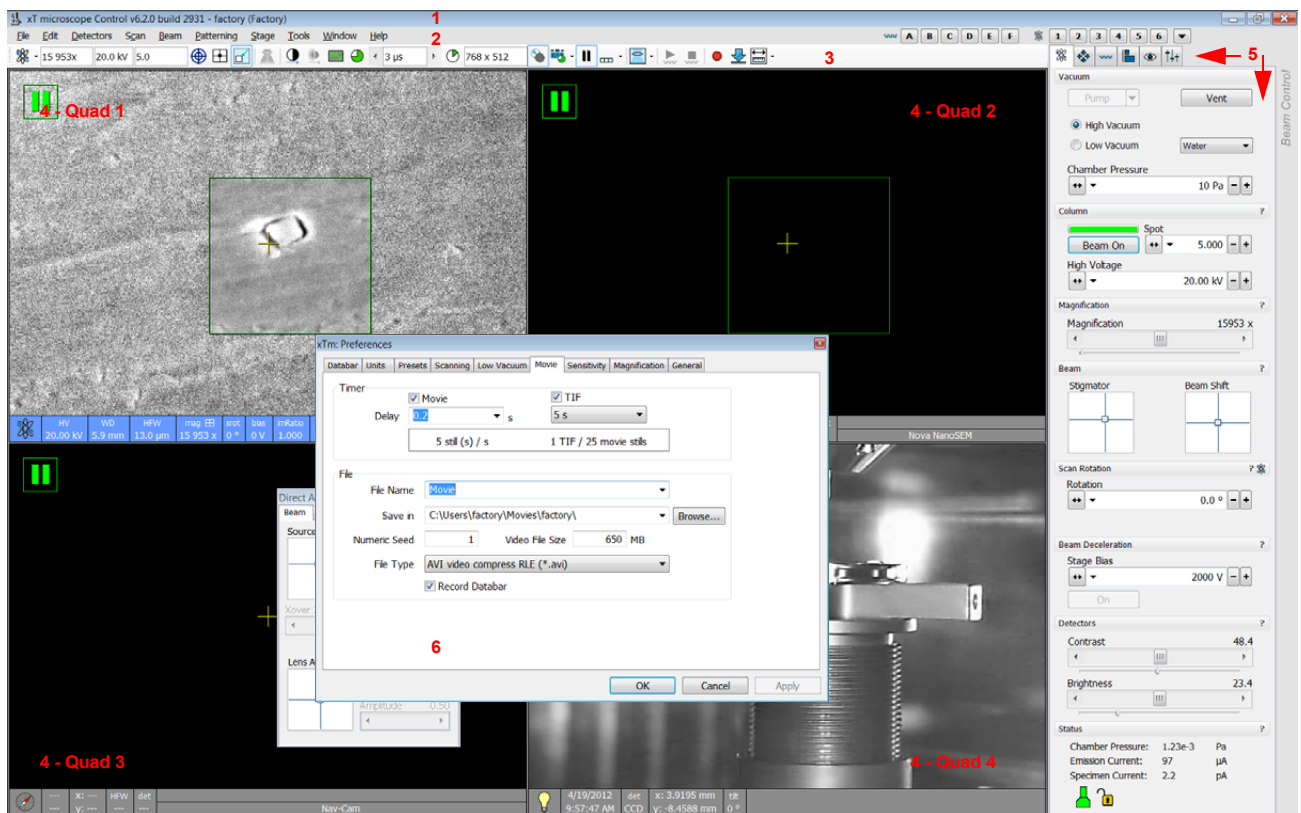
**Note:**

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

**Note:**

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

**FIGURE 3-2 THE MAIN WINDOW**

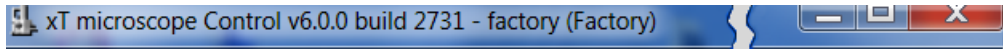


1. The **Title Bar** – labels the application
2. The **Menu Bar** – contains all operation menus and submenus
3. The **Toolbar** – contains functional icons for the most frequently used microscope controls and for the fast access to the Pages
4. **Image Windows** – image windows with adjustable Databar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

## TITLE BAR

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

**FIGURE 3-3** THE TITLE BAR



The Close button quits the xT microscope Control software (accelerating and detectors voltages are switched off for the security reasons).

## MENU BAR

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

**FIGURE 3-4** THE MENU BAR



Select pull-down menus from the menu bar by:

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

### Note:

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

### File Menu (Alt + F)

opens File menu administrative functions:

#### Open...

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

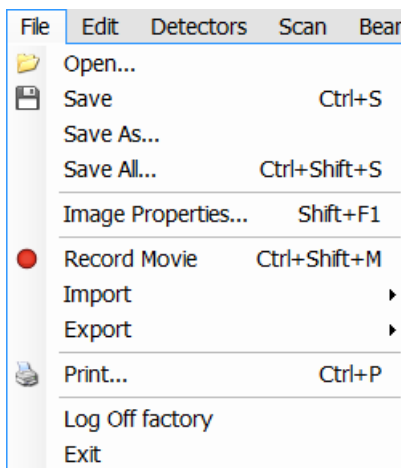
#### Save (Ctrl + S)

saves the image using the format, location and base of name set by the last used **Save As** function in that quad. An incremental suffix with a selectable number of digits ensures that every image is saved as a new file, e.g. Name\_001.tif, Name\_002.tif, etc.

#### Save As...

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

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



## IMAGE WINDOWS

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

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

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

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

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

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

### Note:

Due to a hardware limitations, some detectors cannot be used simultaneously. They can still be selected for different quads at the same time, but if one of them is started, the other quads with incompatible detectors are automatically paused.

The optical imaging is automatically activated (if it is paused), when the venting procedure starts.

When it is paused and any stage movement takes place, the pause icon turns red and a list of changed axes is displayed.



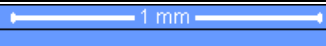


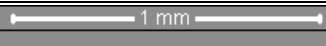



### The Databar

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

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

**FIGURE 3-10 DATA BAR EXAMPLES**

Active electron quad		2/24/2009 1:54:27 PM	HV 10.00 kV	mag  48 x	HFV 2.65 mm	
Inactive electron quad		2/24/2009 1:54:27 PM	HV 10.00 kV	mag  48 x	HFV 2.65 mm	
Active optical quad		2/24/2009 3:28:51 PM	det CCD	x: -16.2699 mm y: -2.0813 mm	z 9.4677 mm	temp ---






### Note:

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

## PAGES AND MODULES

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

**TABLE 3-1** PAGES AND MODULES LIST

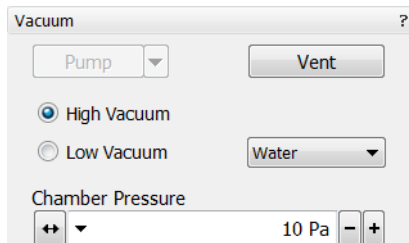
Pages	Modules (Tabs)
	<b>Beam Control</b> 1. Vacuum, 2. Column, 3. Magnification, 4. Beam, 5. Scan Rotation, 6. Beam Deceleration, 7. Detectors, 8. Status
	<b>Navigation</b> 9. Stage (Map / Coordinates / Tilt / Navigation) 10. Stage Z, 7. Detectors, 8. Status
	<b>Processing</b> 11. Measurement / Annotation,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

### Note:

The number in front of the module name represents an order in which the modules are introduced in the following text.

For Software Interface Elements control see above.

### 1. The Vacuum module



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

The **Mode** radio buttons bring the system to:

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

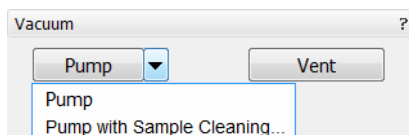
In this mode the system pumps continuously to achieve the lowest possible pressure.

- the **Low Vacuum** mode for observing non-coated and non-conductive or partially conductive specimens.

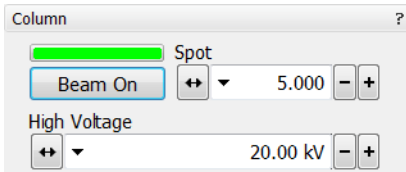
In this mode, the chamber pressure is controlled using the **Chamber Pressure** adjuster, while the column is at a much lower pressure. The gas environment can be selected from the list box.

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

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



## 2. The Column Module



contains controls for setting the electron beam conditions:

### The Beam On Button

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

### The Spot Preset / Continuous Adjuster

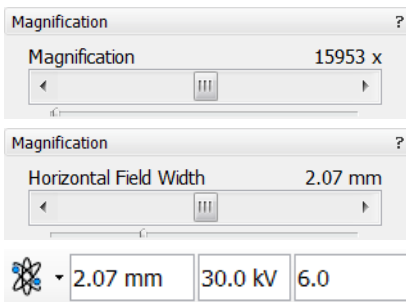
enables to adjust the electron beam **Spot** size in the selectable accuracy steps (see the **Preferences... / General** tab). The actual spot size number from the factory preset list is displayed in the text area of the adjuster, toolbar (default) and in the Databar (if selected). Only values usable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

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

### The High Voltage Preset / Continuous Adjuster

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

## 3. Magnification / HFW Module



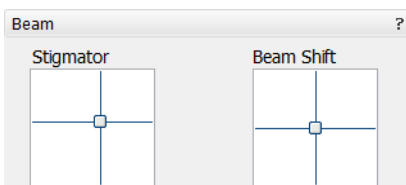
The continuous adjuster offers a variety of ways to control the imaging magnification (see above). The magnification range changes dynamically according to the working distance and can also be controlled with the use of other tools (see Chapter 5).

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

### Magnification Control

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

## 4. Beam Module



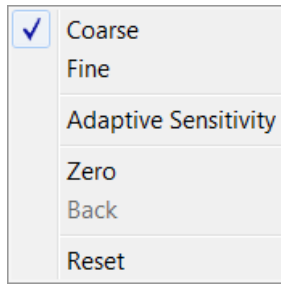
enables to correct image astigmatism. The crosshair indicates the actual setting of the stigmator.

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

### Beam Shift 2D Control

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

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



**Note:**

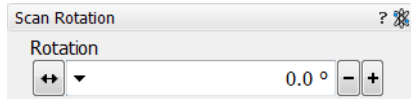
Right-clicking over the 2D box opens the menu with following particular choices:

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

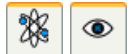
## 5. Scan Rotation Module



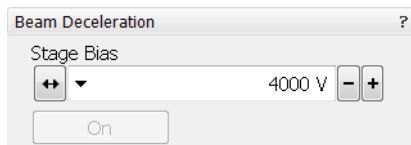
controls and displays the Scan Rotation value (see Chapter 5).



## 6. Beam Deceleration Module



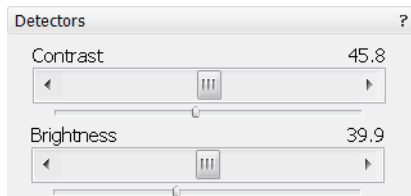
In the Beam Deceleration mode a negative potential (Stage Bias) is applied on the stage, which influences both primary and signal electrons. It allows to decelerate the primary beam up to 50 V landing energy (see Chapter 5).



## 7. Detectors Module

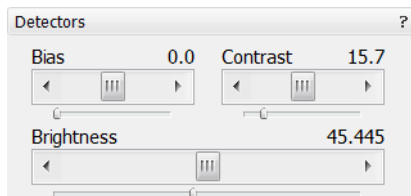


contains continuous adjusters to control the active detector **Contrast** (electronic gain) and **Brightness** (voltage offset). The values are remembered for each detector and quad. The adjusters are disabled if the detector is not available or cannot be controlled (e.g. CCD camera or an External detector).



### Contrast / Brightness / Enhance Continuous Adjusters

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



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

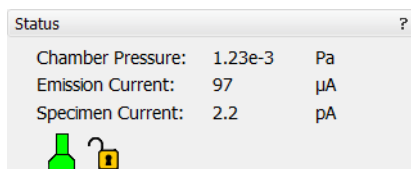
**Note:**

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

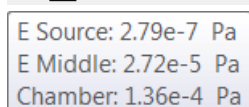
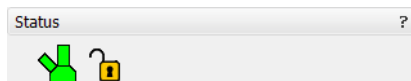
## 8. Status Module



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





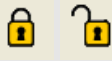





- The **Chamber Pressure**: shows the specimen chamber pressure.
- The **Emission Current**: shows the electron current emitted from the source.
- The **Specimen Current**: shows the electron current reaching the specimen.
- The **E Source / E Middle / Chamber**: shows pressure in the corresponding vacuum system section.



The system conditions are displayed by means of the icons:

**TABLE 3-2** STATUS ICON MEANING

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

## 9. Stage Module



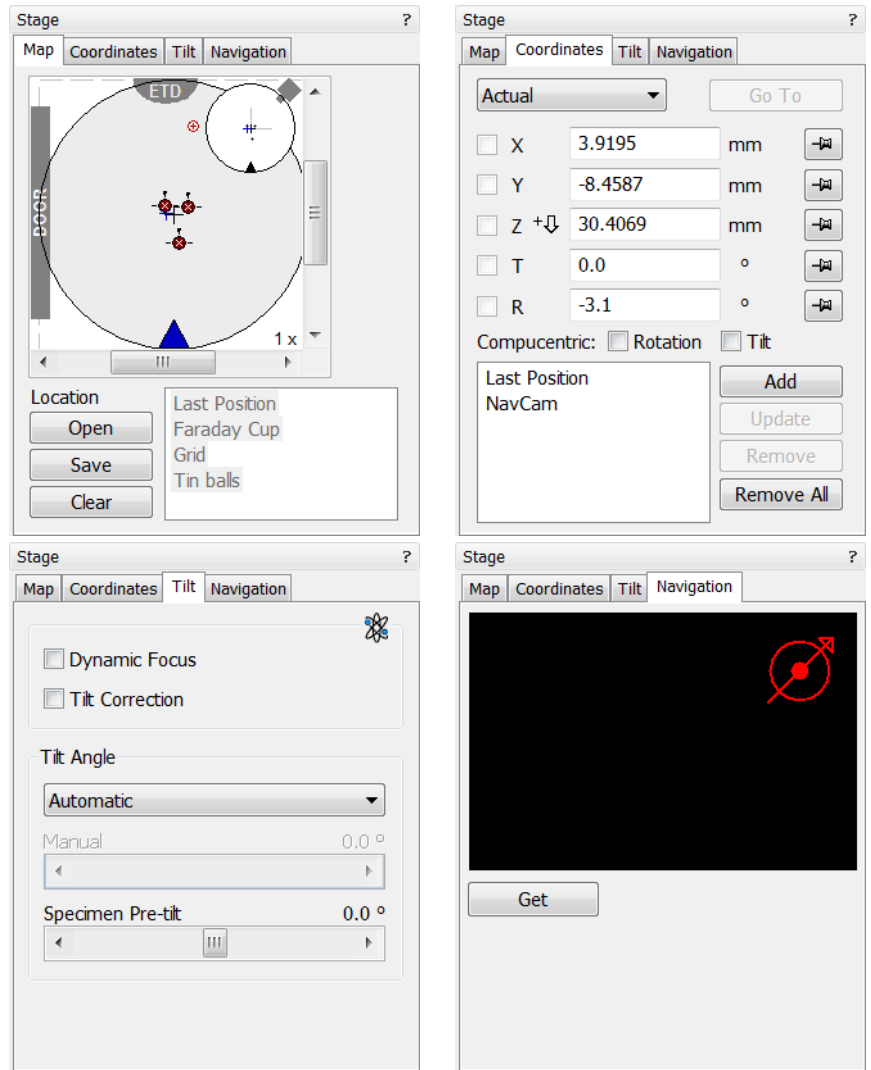
consists of the tabbed sections (see Chapter 5).

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

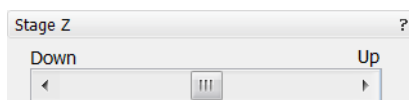
### Note:

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

**FIGURE 3-11 THE STAGE MODULE**

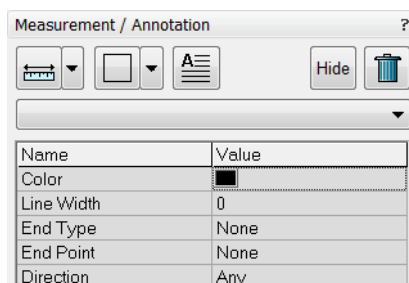


## 10. Stage Z Module



This module enables to softly move the stage in the Z-axis direction. The more the slider is pushed to the each side, the faster is the stage motion. Clicking the slider bar moves the stage by a small step.

## 11. Measurement / Annotation Module



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



## 12. Digital Zoom Module



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

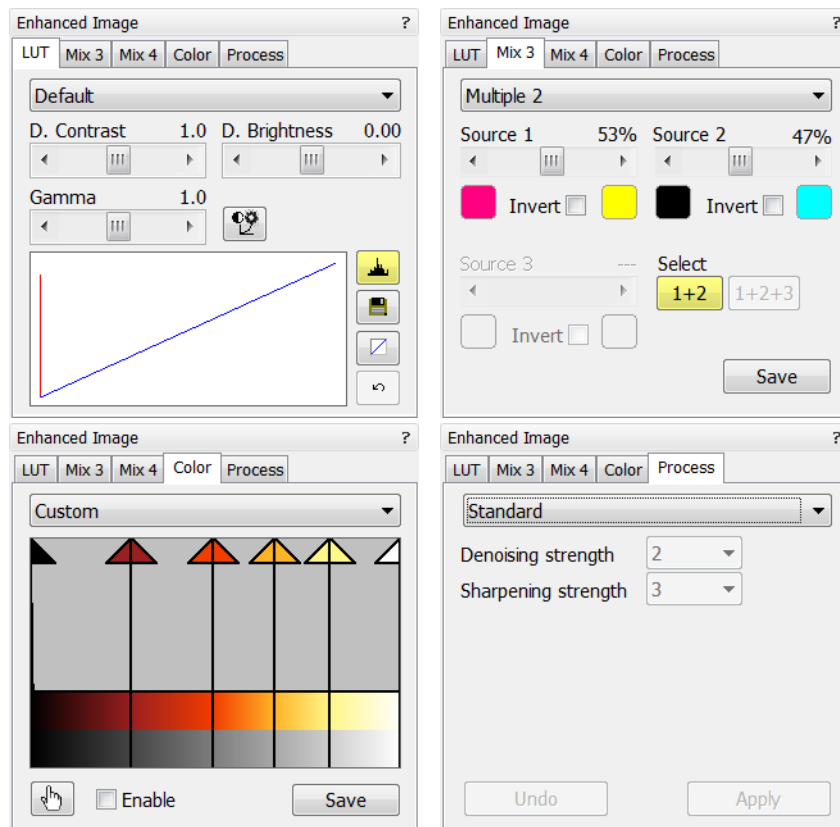
Click & drag the green bordered area inside the Digital Zoom image or click inside the green rectangle and move it by **Ctrl +** keyboard arrows to change an observed area in the selected quad. Change the observed area by dragging the green borders. Press the **Ctrl + + / -** keyboard button to enlarge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

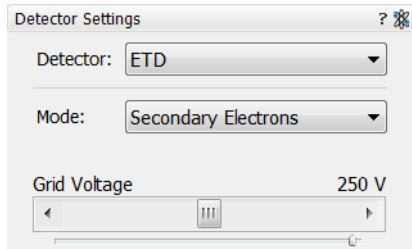
## 13. Enhanced Image Module



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

**FIGURE 3-12 THE ENHANCED IMAGE MODULE**





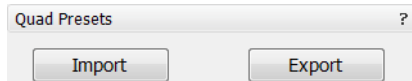
## 14. Detector Settings Module



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

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

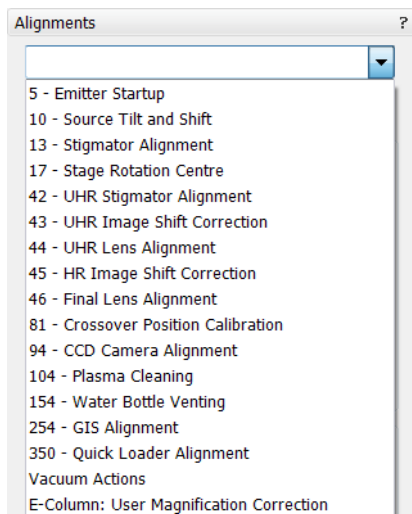
The rest of the module dynamically changes according to the selected detector and its parameters, which may change from quad to quad (see Chapters 5 and 7).



## 15. Quad Presets Module



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



## 16. Alignments Module



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

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

### **Caution!**

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

### **Note:**

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

---

# Specimen Preparation and Handling

---

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

**Note:**

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

## NEEDED ITEMS

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

## NATURAL SPECIMEN

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

## COATED SPECIMEN

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

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

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

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

## MOUNTING SPECIMEN TO HOLDER

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

**Note:**

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

---

## PRINCIPLES OF SEM IMAGING

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

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

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

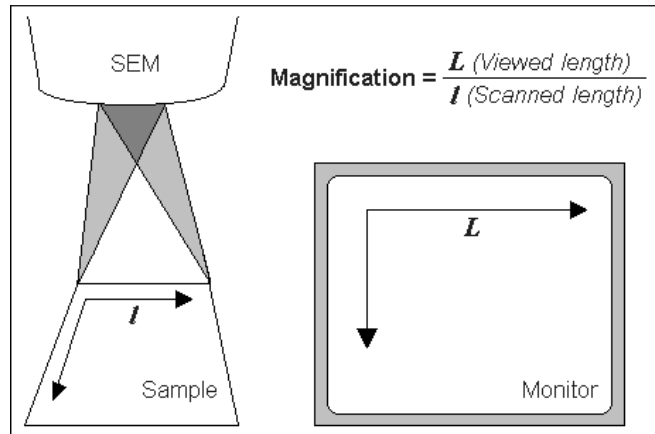
## MAGNIFICATION

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

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

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

**FIGURE 5-1** MONITOR IMAGING AND SCANNED SAMPLE

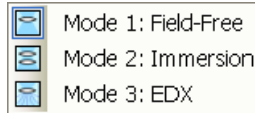


# SEM Modes

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

## Final lens modes

These modes can be selected in the **Beam** menu / **SEM Mode** or directly from the toolbar.



- **Mode 1: Field-Free**

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

- **Mode 2: Immersion**

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



### **Caution!**

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

- **Mode 3: EDX**

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

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

## Manual User Interface

---

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

**FIGURE 7-1** MUI



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