

**Scanning Electron Microscope**

**VEGA3<sub>SEM</sub>**

**Instructions For Use**

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We have checked the contents of this manual for agreement with the hardware and software described. Since deviations cannot be precluded entirely, we cannot guarantee full agreement.

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# 1 Introduction

The VEGA 3 series is a family of modern, fully PC-controlled scanning electron microscopes with a tungsten heated filament.

Specific Features of the VEGA 3 SEM:

- An innovative and powerful four lens Wide Field Optics™ design, offering a variety of working and displaying modes.
- A range of chambers to suit all applications and a wide choice of supplementary accessories.
- Fast and precise motorized specimen stages.
- Excellent analytical qualities with optimized ports geometry.
- Unique live stereoscopic imaging using the 3D Beam technology.
- Turbomolecular and rotary pumps ensure quick and easy sample exchange and short times to reach a working vacuum.
- Sophisticated and easy-to-use software for microscope control using a Windows™ platform.
- Fully automated microscope set-up.
- Comprehensive software for image archiving, processing, evaluation and network operations comes as standard.
- Minimal requirements on space, power supply and environment.

Currently the VEGA 3 family includes several models of microscope fitted with various chambers according to the user's requirements for chamber size, stage movements precision and/or operation comfort. The abundant control software included in the standard scope of delivery is one of the valued assets of the Vega microscopes.

Since the VEGA 3 SEM is installed and maintained by trained specialists, technical details and installation procedures are limited to a short overview. In the case of necessary maintenance, reinstallation, hardware changes, etc. the appropriate service authorities or your local supplier have to be contacted for further assistance and instructions.

## 2 Safety Information

The user is liable to make himself familiar with the care of the device and with the safety rules valid in the country of the user. The microscope works with electric voltages that can be dangerous to life.

Any operations with the device which are not mentioned in these instructions, especially the removal of the housing and manipulation of the electric parts of the microscope, may be carried out only by an authorized person. It is also forbidden to substitute a part of the microscope for any other part that is not original and is not delivered by the microscope producer (e.g. the substitution of the original steel blinds on the flanges of the microscope chamber for light alloy blinds can cause an emission of dangerous ionizing radiation!)

The microscope is provided with a number of automatic protections making unsuitable usage impossible (e.g. it is not possible to switch on high voltage sources if the specimen chamber or electron gun space are open or are not evacuated to the working vacuum). The deactivation of these protections can cause destruction of the machine and endanger the health of the operating staff. It is strictly forbidden.

The symbols used meet the regulation standard ČSN EN 61010-1, except the symbol:



that marks the connectors with high voltage which are not dangerous in the aspect of the mentioned regulation standard (accidental touch can only cause electrical shock).

In the documentation there are two types of additional information given: Notes and Warnings,

Notes are designated thus:

*Note:*

In Italics and Blue print.

Warnings are designated thus:

***WARNING:***

In Italics and Red print.

## **3 Installation and Microscope Repairs**

### **3.1 Transport and Storage**

The method of delivery is defined in the contract and is determined individually according to the destination territory. The method of delivery must be approved by the manufacturer. The instrument is delivered partially disassembled and packed. The purchaser is obliged to check the status of the boxes after the delivery company handover. In the case of any damage it is necessary to catalogue the damage and inform the manufacturer of the situation. The packed instrument must be stored in a dry and clean place with a temperature range from  $-20^{\circ}\text{C}$  to  $+40^{\circ}\text{C}$  and must not be exposed to corrosive substances which can cause oxidation (acid vapours etc.).

### **3.2 Installation Instructions**

The microscope is delivered including installation. The installation must be ordered from the seller. The customer shall inform the seller of the readiness of the laboratory for the installation. Once the laboratory is ready, technicians of the manufacturer or technicians of an approved company will carry out the installation, connection to the mains and user training. The customer is not allowed to connect the microscope to the mains or do any other manipulation, except moving the microscope to the storage place. The installation company will fill in the installation protocol. The warranty period will start from this date and the user can start using the instrument normally as described in this manual.

### **3.3 Fuse Replacement**

The instrument does not contain any fuses which can be replaced by the user. All fuses are located under the covers which can be removed only by the service technician from the manufacturer or the service technician of an approved company. The fuses can be replaced only by exactly the same type; the type is described in the documentation or on the fuse holder.

### **3.4 Instrument Repair and the Spare Parts Usage**

It is only permitted to use original spare parts delivered by the manufacturer. Repair and maintenance which exceed the procedures mentioned in this manual can be performed only by the manufacturer's service technician or a service technician from an approved company.

## 4 Description of the Microscope

### 4.1 Electron Column

The scanning electron microscope displays the examined object by means of a thin electron probe. The column forms the electron probe (beam) and sweeps the beam over the examined specimen located in the microscope chamber. The imaging qualities of the microscope depend on the parameters of this electron beam: *spot size*, *aperture angle* and *beam intensity*.

**The spot size** determines the resolution of the microscope as well as usable magnification at stable picture sharpness. It is mainly considered that the spot is circular and has a Gaussian intensity profile. We can specify its size for example with half the width of the intensity distribution. The spot size is determined by the demagnification of the primary electron source, optical aberrations of the final lens (objective) and the diffraction aberration on the final aperture. The spot size is smaller at shorter working distances.

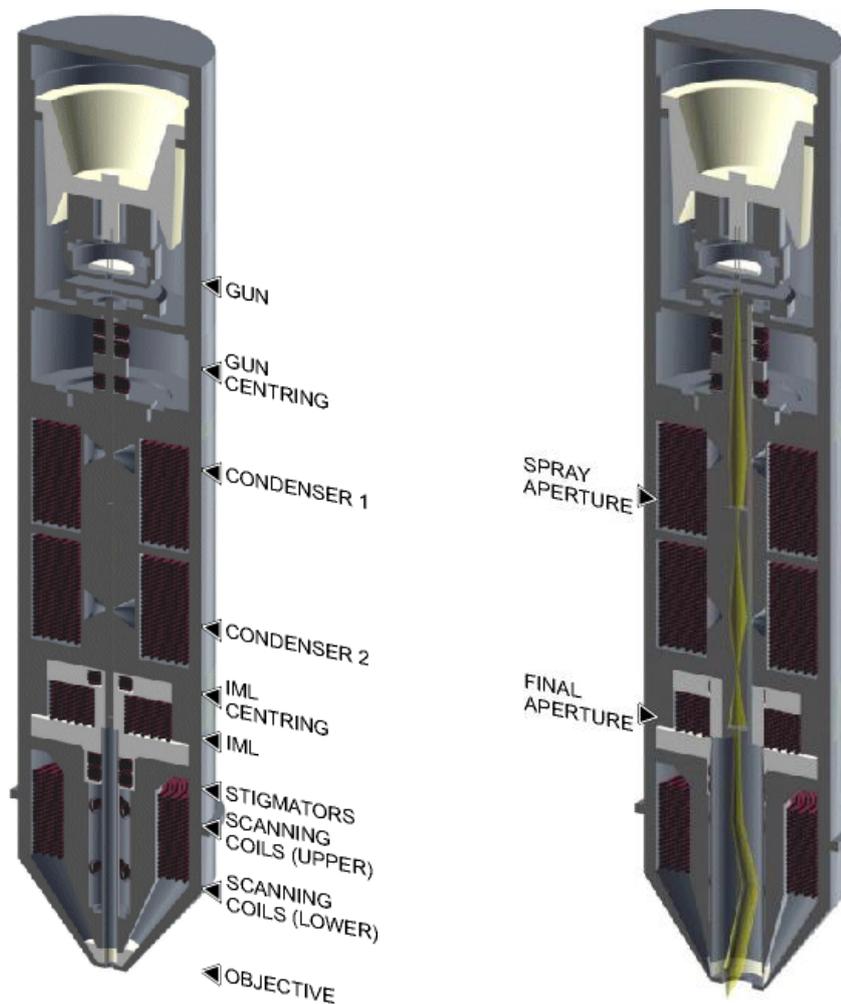
The incident electron beam is cone-shaped. The vertex angle of the cone is called **the aperture angle**. The wider the cone, the lower the depth of focus.

**The beam intensity** (BI) is the number of electrons passing through the probe in a defined time. The image noise of the electron microscope depends on the number of electrons used for the information collected from each picture element. It is necessary to use more time for image scanning at low beam intensity and vice versa.

It is evident that the incident beam parameters influence each other. The optical system of the microscope allows operation in different modes when some parameters of the beam can be preferred and the others can be kept down. Here are some typical examples:

- *Work on high magnification.* It is necessary to reach a high resolution, therefore low beam intensity, short working distance and slow scanning speed should be used. We recommend choosing RESOLUTION mode, working distance not more than 7 mm and scanning speed 7 or slower. See chapter 4.1.1.
- *Work with high intensity.* The spot size and the aperture angle are big; resolution is small. Useful magnification is low but fast scanning can be used because the signal to noise ratio is better. The higher the BI index, the higher the intensity.
- *Work with high depth of focus.* The aperture angle must be small. Use Depth mode.

### The VEGA 3 SEM cross section and schematic representation of the optical elements



The column of the microscope consists of the following main parts:

- **The electron gun** is a source of accelerated electrons. It consists of a cathode, Wehnelt cylinder and anode. The cathode and Wehnelt cylinder are connected to the negative electric potential; the anode and the remaining part of the column are on the earth potential. The cathode is a tungsten filament, heated to such a high temperature that it causes emission of free electrons. The voltage between the Wehnelt cylinder and the anode determines the *accelerating voltage* of electrons and thus their energy. The electron flow from the gun is specified with the *emission current*. The emission current can be changed by applying negative potential between the Wehnelt cylinder and the cathode (*bias*). The whole gun system works as a “virtual source” of electrons with the following specifications: the dimension 25 – 50  $\mu\text{m}$ , the electrons energy from 200 eV up to 30 keV, the emission current up to 300  $\mu\text{A}$  and its brightness  $10^6 \text{ A/cm}^2\text{sr}$ .
- **The gun centering** is formed by a system of electromagnetic deflection coils under the gun. It is designed for the tilting of the electron beam emitted from the gun so that it enters the axis of the optical system of the column. It is controlled by the

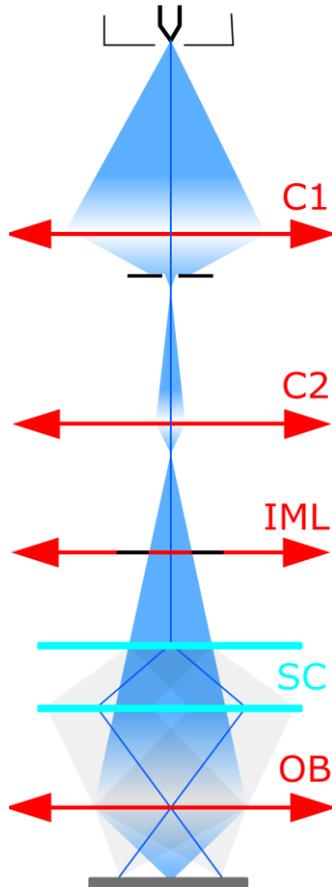
function gun alignment. The gun is correctly centered if the most intensive part of the electron beam is selected and the brightness of the image is the highest.

- **The spray aperture** is placed under the centering coils of the gun. It is intended for retaining the marginal parts of the electron beam emitted by the gun.
- The pair of **condensers C1 and C2** are strong magnetic lenses for the demagnification of the virtual source. The higher the excitation of the condenser, the shorter its focal length and the higher its demagnification.
- The **final aperture** cuts the size of the final incident beam. It is placed in the holder at the end of the central vacuum pipe of the column, about 60 mm under condenser C2. The optimum size of the aperture hole is 50  $\mu\text{m}$ .
- The auxiliary **lens IML** is a magnetic lens used for the aperture change of the beam entering the lens OBJ or for displaying if the OBJ is off. The change of the IML excitation causes the shifting of the electron beam across the optical axis and therefore it is necessary to compensate this shifting by means of the centering coils IML Centering.
- **The Stigmator** is an electromagnetic octupole. It is intended to compensate for astigmatism in all displaying modes.
- **The scanning coils** are formed by two stages of the deflection coils. A scanning ramp is connected to the coils. The ramp frequency determines the scanning speed of the electron beam; the amplitude determines the microscope's field of view and the magnification.
- **Objective OBJ** is the last magnetic lens of the column that forms the resulting electron beam. In the usual modes the excitation of the OBJ is determined by the working distance – the distance between the lower objective pole piece and the focused specimen surface.

### 4.1.1 Electron Column Displaying Modes

#### RESOLUTION Mode

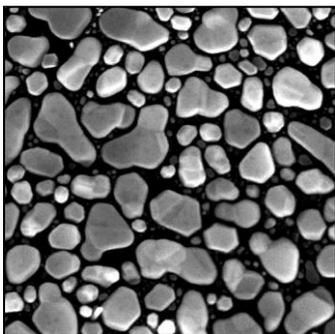
This is the basic and most common displaying mode. The IML lens is switched off, the OBJ lens is excited and it focuses the final electron beam.



#### Characteristics:

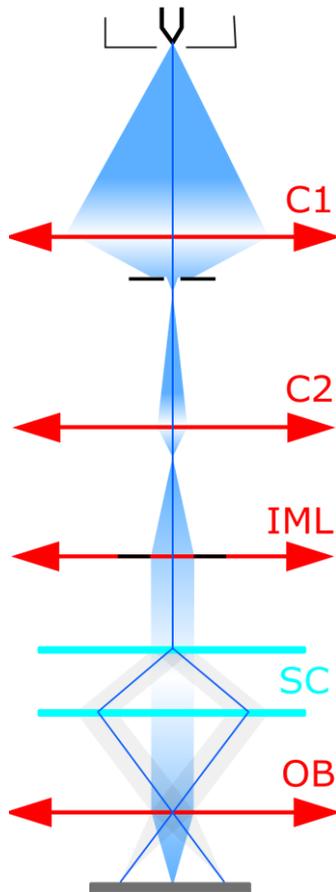
- high resolution
- low depth of focus

In this mode, the VEGA 3 works like other common three lens microscopes without IML lens. The aperture is nearly optimal for lower BI values (small spot size, low beam current), short working distances (4 – 5 mm) and for the accelerating voltage 30 kV. The pivot point of the scanning and the electric image shifts are close to the principal plane of the objective OBJ, so that the curvature of the field, distortion and field of view are as good as possible. The centering of the objective OBJ is performed by defined beam tilt of the central electron beam, which does not cause image shift. This mode is intended for displaying with the highest resolution.



## DEPTH Mode

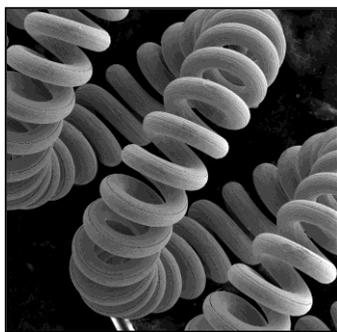
The DEPTH mode differs from the previous mode by the auxiliary lens IML being switched on.



### Characteristics:

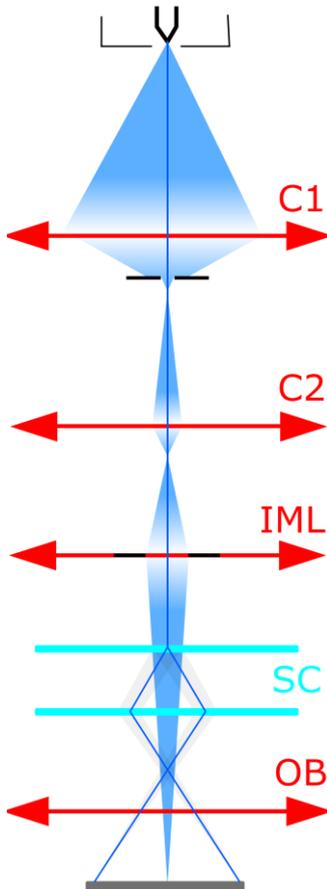
- good resolution
- increased depth of focus

The aperture of the final beam is lower, but the spot size is bigger in comparison with the RESOLUTION mode. The beam in the probe stays unchanged. This mode is used if it is necessary to have a greater depth of focus.



## FIELD Mode

The FIELD mode utilizes the intermediate lens IML for the electron beam focusing while the objective OBJ is off.



### Characteristics:

- large field of view
- high depth of focus
- worse resolution

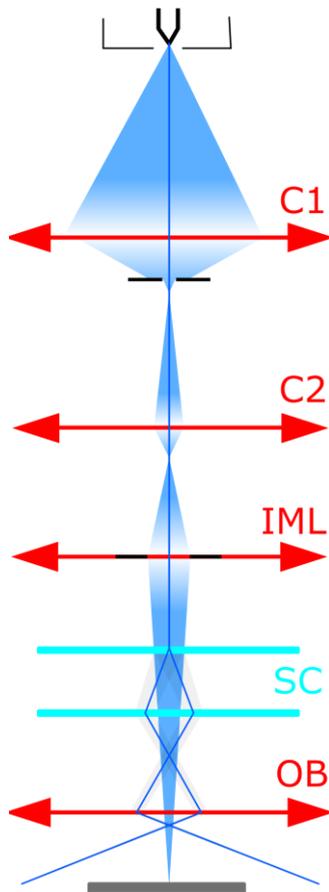
The beam aperture is very small and the depth of focus is usually higher than the field of view. As the objective OBJ is off in this case, it does not affect the middle beam and thus does not need to pass near the centre of the objective OBJ. The position of the pivot point of scanning is optimized according to the field of view. The centering coils IML center the supplemental intermediate lens IML to avoid image movement during focusing. The DC component of the scanning coils is set up so that no image shift occurs if switched from the RESOLUTION mode to the FIELD mode.

The characteristic of this mode is a bigger spot size. The maximum magnification used is therefore a few thousand. The mode is used for the searching of the parts of the specimen to be examined.



## WIDE FIELD Mode

The WIDE FIELD mode uses the intermediate lens IML for focusing the electron beam, while the objective OBJ is excited to a high value.

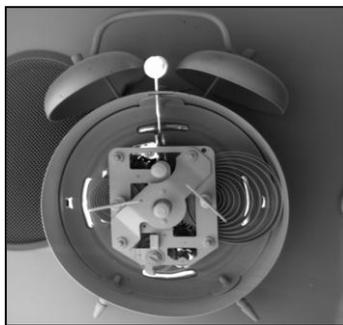


### Characteristics:

- extra large field of view
- image distortion is corrected and minimized
- only available for post-2007 devices

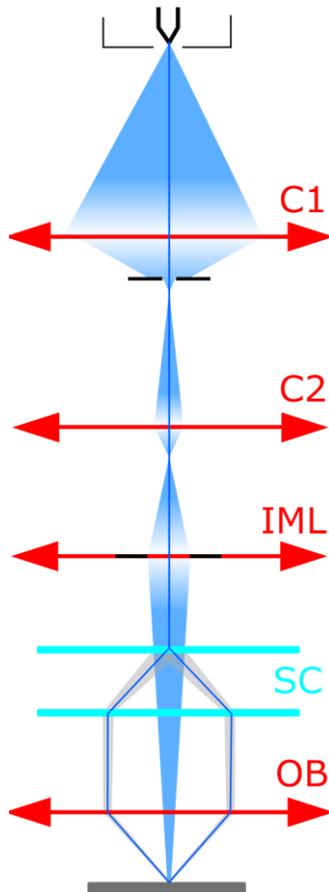
Highly excited objective multiplies the deflection of the beam. The aperture of the beam is very small and the depth of focus is very high. The IML Centering coil serves for minimizing the image shift when focusing.

The mode is used to search for the part of the specimen to be examined. To know the proper magnification value, the objective must be well focused. This might be a little difficult due to the high depth of focus.



## CHANNELING Mode

In the CHANNELING mode, the scanning and lens focusing is controlled so that the electron beam touches the same point of the specimen surface all the time. By means of scanning the beam, only the angle of incidence of the electron beam is changed, i.e. the rocking beam.



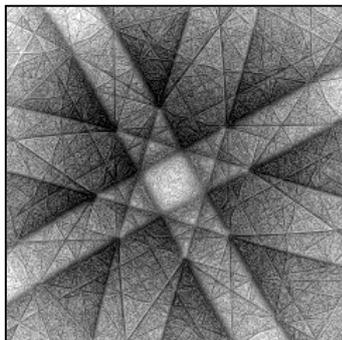
### Characteristics:

- the position of the specified point in the image depends on the beam tilt
- it is the mode for ECP acquisition – Electron Channeling Pattern

The resulting image is the amount of electrons dependent on the impacting beam angle. The excitation ratio of the scanning coils is set up so that the beam utilizes the whole area of the objective lens bore and enters the lens parallel to the optical axis.

All electron beams parallel to the optic axis are focused by the lens into a single point on the specimen surface. As a consequence, the scanning is transformed into beam tilting, i.e. the resulting pivot point of the scanning lies on the specimen surface plane.

The intermediate lens focuses the beam into the upper focal point of the objective lens. The result is that the beam, after passing through the objective lens, is parallel and the angular resolution of ECP (Electron Channeling Pattern) images is at its maximum.



The mode is intended for the examination of crystallographic materials. The minimum size of crystals should be 150  $\mu\text{m}$ .

*Note: ECP patterns are produced by back scattered electrons, it is preferable to use a BSE detector for imaging if available.*

### 4.1.2 Electron Column Microscope Centering

It is necessary to centre the electron optics of the column to reach high quality images. The goal is to ensure that the beam is as close as possible to the optical axis of the column and thus minimize optical aberrations. The centering is electronic; it is fully controlled by the PC.

It is necessary to adjust every displaying mode and every high voltage range you intend to use. The whole HV range from 200 V up to 30 kV is divided in to four HV indices (200 V – 5 kV, 5 – 10 kV, 10 – 20 kV, 20 – 30 kV). This means that once you work in the RESOLUTION mode and you work on 10 kV and 30 kV, it is necessary to centre the microscope for 10 kV as well as for 30 kV. With further switching among HV indices the VegaTC software remembers all settings, so the user does not need to carry out any further centering.

Each microscope is factory centered at 5, 10, 20 and 30 kV and this setup is loaded for standard user's accounts (guest, supervisor).

#### Recommended centering conditions

The centering is done by means of a special centering specimen, which is included in the microscope accessories and is marked as ADJ. The surface of this specimen has a fine structure, making the centering easier. If this specimen is not available, it is possible to use a common specimen stub. Once you start centering, the image must be focused perfectly.

Mode	Working Distance (WD)	Beam Intensity (BI)	Magnification (Mag)
RESOLUTION	10 – 15 mm	11	2000 – 5000 x
DEPTH	10 – 15 mm	11	2000 x
FIELD	10 – 15 mm	11	500 x
WIDE FIELD	10 – 15 mm	11	max. Mag

It is possible to do the centering either *automatically*, or *manually*. Manual centering is suitable for situations where it is necessary to set up special working conditions.

#### Centering of the Electron Gun

The centering is done by automatic procedure. It is always necessary to perform this auto centering after high voltage value changes inside a specified range with the item High Voltage on the Pad panel.

1. Insert the centering specimen.
2. Set up the recommended working conditions.
3. Use the function Adjustment >>> **Auto Gun Centering** in the Electron Beam panel (see **Figure 6**).

## Automatic Centering

The automatic procedure of column centering is very fast and suitable for low magnifications. For very precise work at high magnifications manual centering is more suitable.

1. Insert the centering specimen.
2. Set up the recommended working conditions to start.
3. Use the function Adjustment >>> **Auto Column Centering** in the Electron Beam panel.

## Manual Centering

1. Insert the centering specimen.
2. Set up the working conditions to start.

### RESOLUTION mode

3. Use the function Adjustment >>> **Manual Column Centering** in the Electron Beam panel. The image starts wobbling, that is, periodically changing the working distance. Press **Next>>** button.
4. Minimize the image movement by changing the OBJ Centering using the trackball and keys F11 and F12.

### DEPTH mode

1. Set the same magnification for both RESOLUTION and DEPTH modes. Use the trackball.
2. Set the same field of view by means of changing the IML Centering parameters using the trackball and keys F11 and F12.
3. Minimize the image movement by means of changing the OBJ Centering.

### FIELD mode

1. Set the same magnification for the RESOLUTION and FIELD modes. Use the trackball.
2. Minimize the image movement by means of changing the IML Centering using the trackball and keys F11 and F12.
3. Set the same field of view by means of changing the OBJ Centering.

### WIDE FIELD mode

1. Set the same magnification for the RESOLUTION and WIDE FIELD modes.
2. Set the same field of view by means of changing the IML Centering.

*Note: It is necessary to keep to the described sequence for each procedure. The mode RESOLUTION must always be adjusted first.*

## 4.2 Chamber and Sample Stage

The chamber is a sealed space under the column where specimens are placed for examination. The specimen is fixed on the sample stage which allows movement of the sample during the examination process. The chamber must be evacuated during examination.

The sample stages are divided into two basic types:

- motorized
- manual

Manipulators have electrically *isolated specimen holders*. The specimen holder is connected to a pA-meter. The pA-meter also works as an acoustic contact indicator of the specimen to the chamber. If contact between the specimen holder and the chamber body occurs, all motorized axes will stop and an audible sound will indicate the contact (touch alarm).

### The chamber and sample stage types

Type	Motorized axes	Manual axes	Eucentricity
SB	X, Y, Rotation	Z, Tilt	–
LM	X, Y, Z, Rotation, Tilt	–	automatic
XM	X, Y, Z, Rotation, Tilt	–	automatic
GMH	X, Y, Z, Rotation, Tilt	–	automatic
GMU	X, Y, Z, Rotation, Tilt	–	automatic

**The eucentric position** is such a position of the specimen that the observed area of the sample does not move when the sample itself is tilted. For the motorized stages the auto-eucentric function can be activated by checking the box Keep View Field on the Stage Control panel.

## 5 Vacuum Modes

The microscope allows the investigation of specimens in a pressure range of 0.005 Pa to 2000 Pa. It is necessary to use the medium or the low vacuum mode to investigate non-conductive samples.

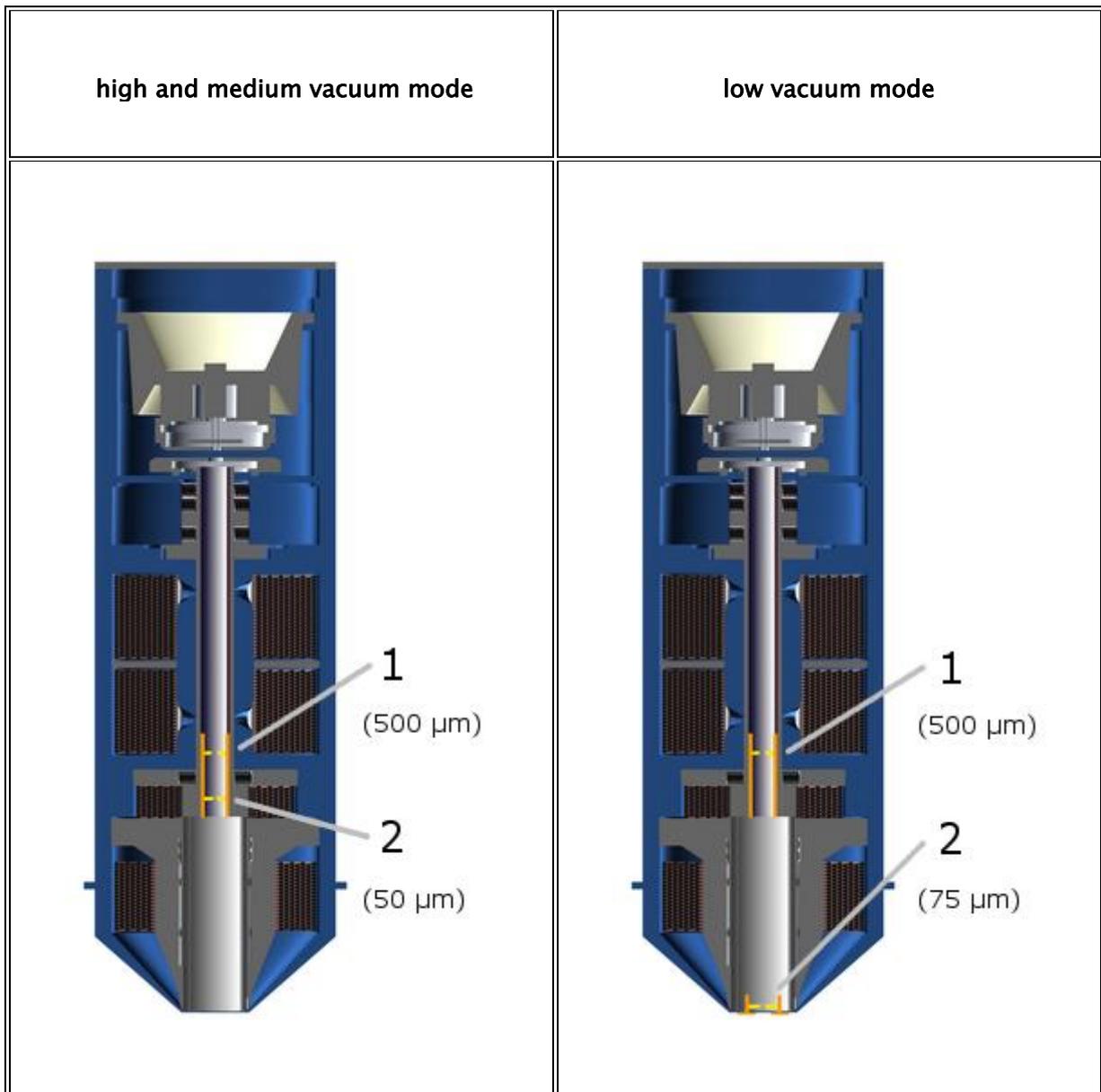
Mode	Pressure [Pa]	Microscope type	Note
high vacuum	0.005	SBH, LMH, XMH, GMH SBU, LMU, XMU, GMU	
medium vacuum	3 – 150	SBU, LMU, XMU, GMU	
low vacuum	3 – 500	SBU, LMU, XMU	1x rotary pump aperture in the objective
extended low vacuum	3 – 2000	SBU, LMU, XMU	2x rotary pump aperture in the objective

**High and medium vacuum modes:** the upper spray aperture (500  $\mu\text{m}$ ) is located just below the C2 condenser and the final aperture diaphragm (50  $\mu\text{m}$ ) at the end of the central vacuum tube approximately in the middle of the IML lens (see chapter 4.1). Both apertures are located in the one aperture holder which is inserted in the central vacuum tube all the way down to the mechanical stop. The microscope is delivered with this aperture holder inside the microscope column.

**Low and extended low vacuum modes:** the same aperture holder is used as for high and medium vacuum modes, but only the 500  $\mu\text{m}$  spray aperture is used, which is located just below the C2 condenser (the same as with the high and the medium vacuum modes). The aperture diaphragm (75  $\mu\text{m}$ ) is located in the special low vacuum aperture holder, which is then inserted into the objective.

*Note: The microscope is delivered configured for high and medium vacuum mode. The aperture holder for low and extended low vacuum mode is part of the microscope accessories, see chapter 9.1.*

## Configuration of the apertures in the electron column



### 5.1 High Vacuum Mode

In high vacuum mode, it is possible to investigate both conductive and non-conductive samples; however non-conductive samples require previous metal coating (Cr, Au, Au-Pd, Pt). All displaying modes are available.

### 5.2 Medium Vacuum Mode

In the medium vacuum mode – up to 150 Pa, it is possible to examine samples using all the displaying modes, because the differential pumping aperture is located in the upper position.

1. Press the UniVac button on the Low Vacuum Mode panel.
2. Only SBU models: Close the manual valve, which divides the specimen chamber and the pumping line. The valve can be closed by turning the handle clockwise and pushing it towards the specimen chamber.
3. Enter the desired chamber pressure value on the Low Vacuum Mode panel.
4. To return to the high vacuum mode, press the UniVac button again. Open the dividing valve of the SBU microscope types manually.

### 5.3 Low Vacuum Mode

In the low vacuum mode – up to 500 Pa (up to 2000 Pa, if the microscope is equipped with a secondary rotary pump), it is possible to examine samples using only the RESOLUTION and DEPTH modes, because the differential pumping aperture is located in the lower position.

1. Put the low vacuum aperture (75  $\mu\text{m}$ ) into the objective and change the aperture holder according to the description (see chapter 9.5.2).
2. Confirm the aperture exchange in the SEM -> Change UNI mode menu.
3. Switch the microscope to Low vacuum mode (pressure range 1 Pa – 500 Pa) using the UniVac button on the Low Vacuum Mode panel.
4. SBU models only: Close the manual valve dividing the specimen chamber and the pumping line. The valve can be closed by turning the handle clockwise and pushing it towards the specimen chamber.
5. Enter the requested pressure value in the field next to the UniVac button and click on the OK button.
6. To return to the high vacuum mode, press the UniVac button. Open the SBU and valve manually.
7. It is necessary to remove the aperture from the objective and replace the final aperture to use the microscope in all the working modes. It is also necessary to confirm the replacement of the final apertures in the SEM -> Change UNI mode menu.

## 6 Detectors

The detection system may contain a set of detectors designed for detecting various signals resulting from electron beam interaction with the sample surface. The microscope is always delivered with the SE detector.

### Switching on

- In the case of adjustment of the required detector, select the appropriate one from the list box in the Detectors & Mixer panel (see **Figure 2** in chapter 8.3). This procedure is valid for all detectors, except the LVSTD, where further procedures are needed (see chapter 6.2).

### 6.1 SE Detector

*The detector works in high vacuum only.*

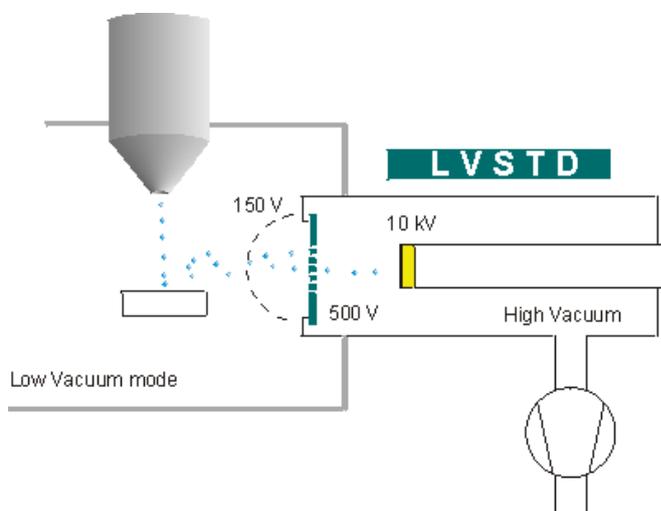
Secondary electrons enhance topographic contrast contrary to material contrast of back-scattered electrons. The secondary electron (SE) detector is a basic standard detector always present in the microscope.

The SE detector is of Everhart–Thornley type. The grid on the front part of the detector has positive potential. This attracts and accelerates the low-energy secondary electrons arising on the specimen surface and focuses them onto the scintillator. The light flashes, which result from the impingement of the electrons on the scintillator, are transferred through the light guide to the photo-multiplier outside the chamber of the microscope.

### 6.2 LVSTD Detector

*The detector works in low vacuum only.*

The LVSTD detector (*Low Vacuum Secondary Tescan Detector*) is a detector of secondary electrons, specially designed for low vacuum mode. It is suitable for the investigation of non-conductive samples.



The LVSTD consists of a standard Everhart–Thornley detector situated in a separated detector chamber. This detector chamber is pumped by a small turbo molecular pump.

### Switching on

1. Check if the UniVac mode is switched on and check if the required value of the pressure in the chamber has been set lower than ~500 Pa. If not, set the pressure on the panel to a value lower than 500 Pa.
2. To switch on the detector click on the LVSTD button on the **Low Vacuum Mode** panel (see **Figure 11**; chapter 8.4).
3. Now the detector chamber is automatically pumped down. This may take about 2 minutes. The blinking message "LVSTD detector not ready yet" appears in the panel. Wait until this message disappears.
4. In the **Detectors & Mixer** panel select LVSTD detector from the list box (**Figure 2**; chapter 8.3).

### Switching off

The detector can be switched off by simply clicking on the LVSTD button on the **Low Vacuum Mode** panel.

The detector is automatically switched off:

- if the pressure in the chamber exceeds value higher than 500 Pa.
- if the UniVac mode is switched off.

The detector needs to be switched on manually if automatic detector switch-off occurs.

*Note: The stability of the signal from the LVSTD depends strongly on the pressure inside the chamber. In order to obtain an image with stable brightness, it is necessary to have stable pressure in the chamber. Therefore, after a change of the required pressure value, it might be necessary to wait for a while until the pressure reaches the new level and becomes stable.*

*Note: The secondary electrons, in contrast with backscattered electrons, are much more sensitive to specimen surface charging, as they are of very low energy. There are several ways how to eliminate charging: using a higher pressure in the chamber, using a lower accelerating voltage of primary electrons or using lower electron beam current.*

## 6.3 BSE Detector

*The detector works in high and low vacuum.*

Back-scattered electrons (BSE) enhance material contrast of the sample. The BSE detector is of the scintillation type. An annular (YAG) mono-crystal scintillator with a conductive surface is placed in the optical axis directly under the lower pole extension of the objective. The high energy back-scattered electrons, impinging the scintillator without any additional acceleration, excite the scintillator atoms that emit visible radiation photons successively. The photons are carried, by means of the light guide, through the side outlet of the

scintillator to the cathode of the photo-multiplier. They are then processed in the same way as the signal coming from the secondary electrons.

The BSE detector is manufactured in an R-BSE (Retractable BSE) version. This modification allows the retraction of the detector from under the pole piece position if the detector is not used. This enables the specimens to be moved as close as possible to the objective when viewed by other detectors.

## 6.4 CL detector

*The detector works in high as well as low vacuum.*

The cathodoluminescence detector is available in two versions depending on the wavelength range of the detected light: 350 – 650 nm range (mainly visible and near UV light) or 185 – 850 nm range (UV, visible and near IR light). The first version is made either as a stand-alone detector or exchange CL / BSE detector.

The IR camera (Chamber View) must be switched off during operation of the CL detector.

### 6.4.1 Exchange of CL for BSE lightguide

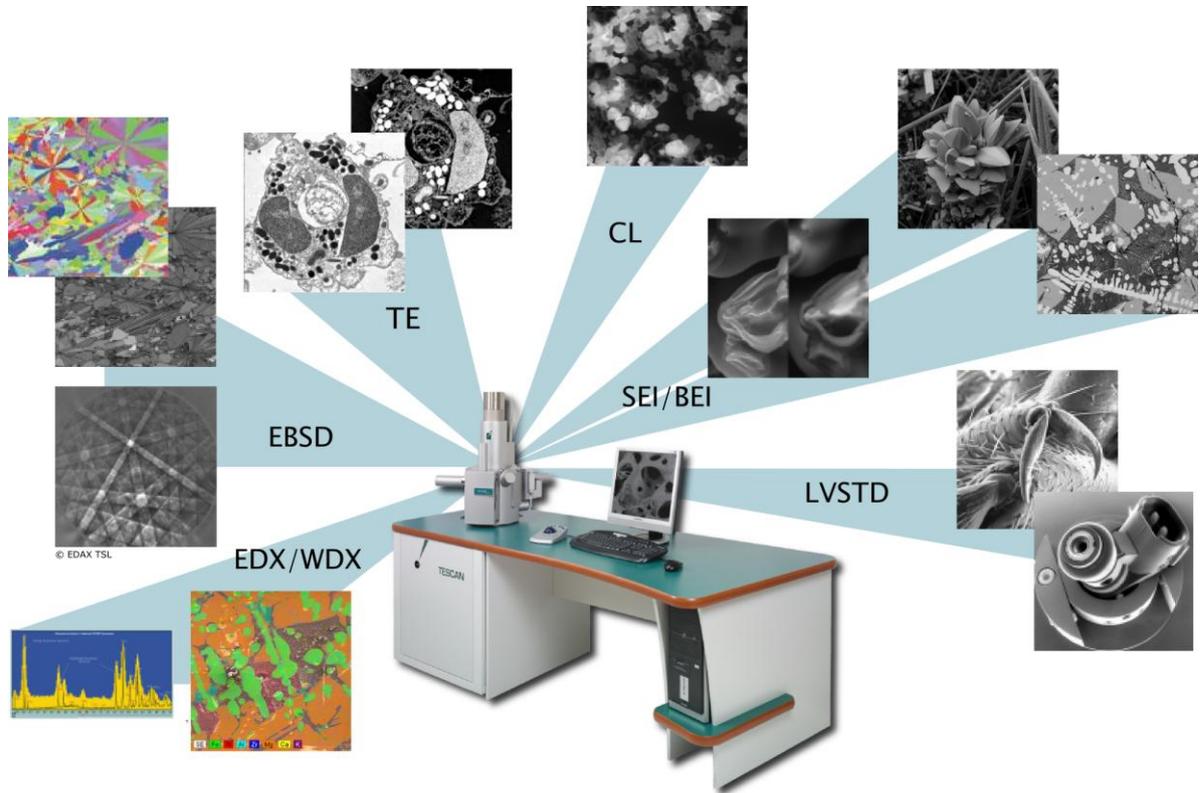
(Only available in exchange CL / BSE of 350 – 650 nm range version)

1. Fully retract the current detector (i.e. it is close to the chamber wall, not under the column).
2. Put on gloves and open the chamber. Rotate the light guide by hand around its axis by about 30 degrees.
3. Move the current lightguide horizontally in the direction of its axis towards the objective until it is released.
4. Insert the new lightguide in exactly the opposite way: rotated by about 30 degrees from its working position, move it in the direction of its axis horizontally towards the photomultiplier until the stop.
5. Rotate the new lightguide by hand to its fixed position.
6. Return the detector carefully to its working position using the retraction mechanism and observe whether the new lightguide sits well and does not hit the objective.



### 6.5 Other Detectors

TESCAN provides other special detectors which can be attached to the microscope. It is possible to obtain a list from the manufacturer.



## 7 Control Elements

### 7.1 Keyboard

The keyboard is used for text and numeric input. Its usage does not differ from the Windows system practice.

Keyboard shortcut	Command
Ctrl + O	Open...
Ctrl + S	Save As...
Ctrl + P	Print...
Alt + X	Exit
Ctrl + H	View Header...
Ctrl + C	Copy to Clipboard...
Ctrl + V	Paste from Clipboard...
Ctrl + Alt + PgUp	Zoom All In
Ctrl + Alt + PgDn	Zoom All Out
Ctrl + PgUp	Zoom In
Ctrl + PgDn	Zoom Out
F1	Help – Contents
F11 hold down	Blocks the changing of the right parameter of the active function.
F12 hold down	Blocks the changing of the left parameter of the active function.

### 7.2 Mouse

The mouse usage follows the Windows system practice.

Mouse functions during normal scanning:

- Double clicking on the left mouse button on the scanning window switches the focus window on/off.
- Turning the mouse wheel changes the scan speed (the scanning window needs to be active).
- If the microscope is scanning over the whole scanning window, then
  - clicking on the right mouse button opens the context menu for simple program control.
- If the microscope is scanning only in the focus window, then
  - holding down the right mouse button and dragging the mouse cursor in the scanning window changes the dimensions of the focus window.

- holding down the left mouse button and dragging the mouse cursor in the scanning window moves the focus window.
  - double clicking on the right mouse button on the focus window moves this window to the centre of the image.
  - clicking on the right mouse button out of the focus window opens the context menu.
- Clicking the mouse wheel on a selected object in the scanning window moves the stage so that the object lies in the centre of the scanning window.
  - Holding down the mouse wheel on a selected object and dragging the cursor to any position in the scanning window moves the object to the selected position in the scanning window.
  - Holding down the mouse wheel on a selected object in the scanning window for longer than 0.8 seconds moves the stage so that the object lies in the centre of the scanning window and the magnification is increased by the factor set in the SEM -> Options -> Center Zoom.

*Note: If an additional software module is active, the functions of the buttons can be different.*

### 7.3 Trackball

The trackball is often used with the Pad panel.



Turning the trackball in the direction of the axis X changes the first parameter of the active function; turning the trackball in the direction of the axis Y changes the second parameter of the active function. Holding the F11 key locks the first parameter of the active function; using the F12 key locks the second parameter of the active function.

### 7.4 Control Panel

The Control Panel has several knobs and a colour touch screen. It was developed by TESCAN exclusively for SEM control. It is not a standard SEM part.



The manual knob set provides the user with a simple and straightforward way of operating the microscope. It can control stage, magnification, focus, beam intensity, scanning speed and other parameters.

Most common functions have dedicated knobs. The three upper knobs have variable function; their actual function is shown at the bottom of the touch screen. Several important parameters are shown in the middle of the display. There are also shortcuts to the automatic functions (focus, brightness/contrast, image acquisition) in the header.

## 8 Getting Started

Only conductive samples can be explored in a high vacuum, so the specimen must be conductive or must be made conductive using one of the methods described in the technical information. Furthermore, the conductive surface of the specimen must have a conductive contact to the stub. Non-conductive samples can be investigated only in a low vacuum.

### 8.1 Starting the Microscope

1. Turn the main switch key to the right (ON position). Wait for the computer to boot.
2. Click on the VegaTC icon  on the Windows desktop. The **VegaTC – Log in** screen is displayed prompting for user name and password.
3. After logging in, the latest configuration will be loaded from the user profile. If a new user profile is created, load the supervisor configuration using Configuration ► Load function from the Options menu.

### 8.2 Specimen Exchange

The specimen should somehow be fixed or glued to the specimen stub before it is inserted into the chamber. It is possible to use 12.5 mm specimen stubs or any other specimen holders, delivered as microscope accessories (see chapter 9.1).

If the specimen is examined in the high vacuum mode, it must be conductive or must be made conductive using one of the methods described in the technical information. The conductive surface of the specimen must be conductive contacted to the stub.

Non-conductive samples can be investigated in the low vacuum mode.

1. Vent the microscope by using the **VENT** button on the **Vacuum** panel. Wait until the pressure is at atmospheric level.
2. Set the tilt of the specimen stage to zero.
3. Open the chamber door by gently pulling it.
4. The automatic positions set up in the **Stage Control** panel can be used, which are intended for specimen position exchange. To select the sample position click on the appropriate number button on the carousel. At this time the button background is red to indicate the specimen exchange mode.

***WARNING:** If the specimen stage is moving, do not touch any of its parts. The moving manipulator can cause health injuries. During the changing of the specimen use the suitable gloves for prevention of pollution of inner microscope parts.*

5. Loosen the screw holding the specimen stub on the specimen stage. Remove the specimen stub by lifting the stub upwards. It is recommended that suitable tweezers be used.
6. Use the previous steps in reverse order to place a new specimen in position. Once the specimen stub is fastened with the specimen, make sure that it will not touch any

interior part of the chamber. Contact between the specimen and the chamber will be indicated by an acoustic buzzer.

**WARNING:** Before closing the chamber, make sure that the specimen inside does not touch the chamber, objective pole piece or any of the detectors. The collision of the specimen with any of the parts of the chamber interior can cause damage to the microscope.

**Note:** Contact between the specimen and any part of the chamber is indicated by a special electric circuit. This circuit is based on measuring the electric current. It works only if the specimen is conductive.

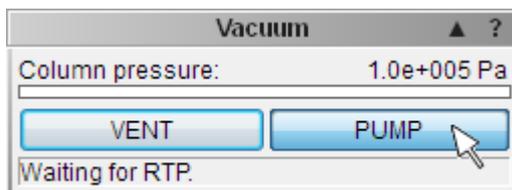
7. Close the chamber door by pushing it towards the chamber.
8. Start the pumping procedure by clicking on the **PUMP** button on the **Vacuum** panel, where the actual pressure and pumping progress are also displayed. Check that the chamber door is tightly closed.

### 8.3 Images at Low Magnification

There are four factory presets for the accelerating voltage (5, 10, 20, 30 kV), one for each HV index. The user does not need to make any further adjustments by switching among them and using magnification up to 4000x.

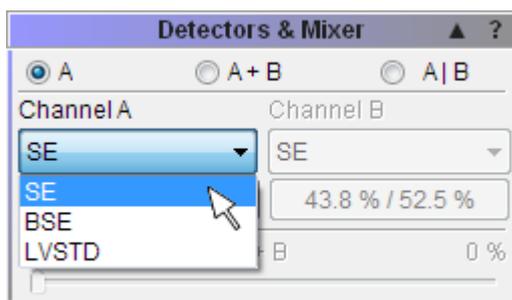
1. Click on the **PUMP** button on the **Vacuum** panel to start the pumping procedure (**Figure 1**). It usually takes around 3 minutes to reach vacuum ready – status which means that the microscope is ready to use. If there is a need to exchange the specimen, follow the instructions in chapter 8.2.

Figure 1



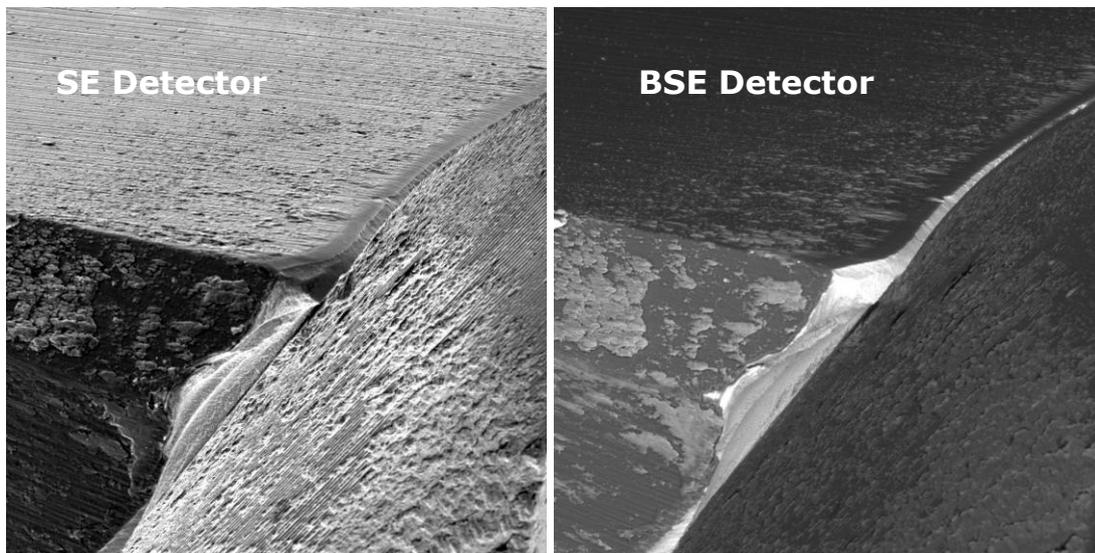
2. In the **Detectors & Mixer** panel select the appropriate detector from the list box (**Figure 2**). We recommend using the SE or BSE detector. When the BSE detector is used, make sure that the detector is not retracted! See chapter 6 for detailed information.

Figure 2



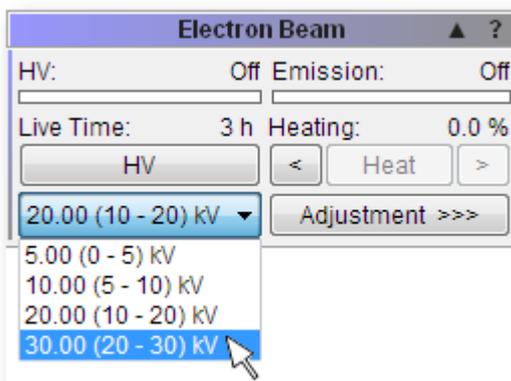
*Note: Note the difference between SE and BSE images below (Figure 3).*

Figure 3



3. Select the accelerating voltage (30 kV recommended) using the combo box on the **Electron Beam** panel (Figure 4).

Figure 4



4. Clicking on the **HV** button on the **Electron Beam** panel turns the high voltage on and starts the heating of the tungsten filament (see Figure 4).
5. Right-click in the SEM Scanning window to open the menu and select the **Minimum magnification** function (Figure 5).
6. Right-click in the SEM Scanning window to select the Auto signal function to set brightness and contrast (see Figure 5).

*Note: If the Scanning window remains black, select the Auto Gun Heating function using the combo box on the Electron beam panel after clicking on the Adjustment button (Figure 6).*

Figure 5

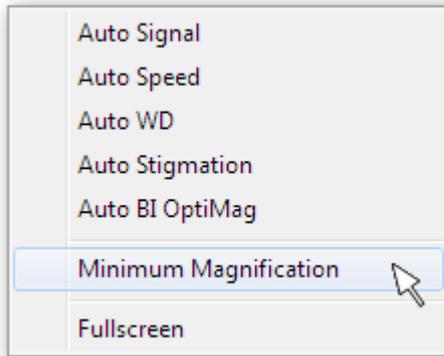
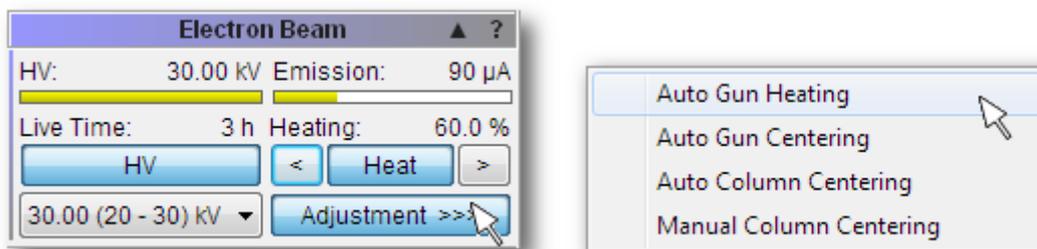


Figure 6



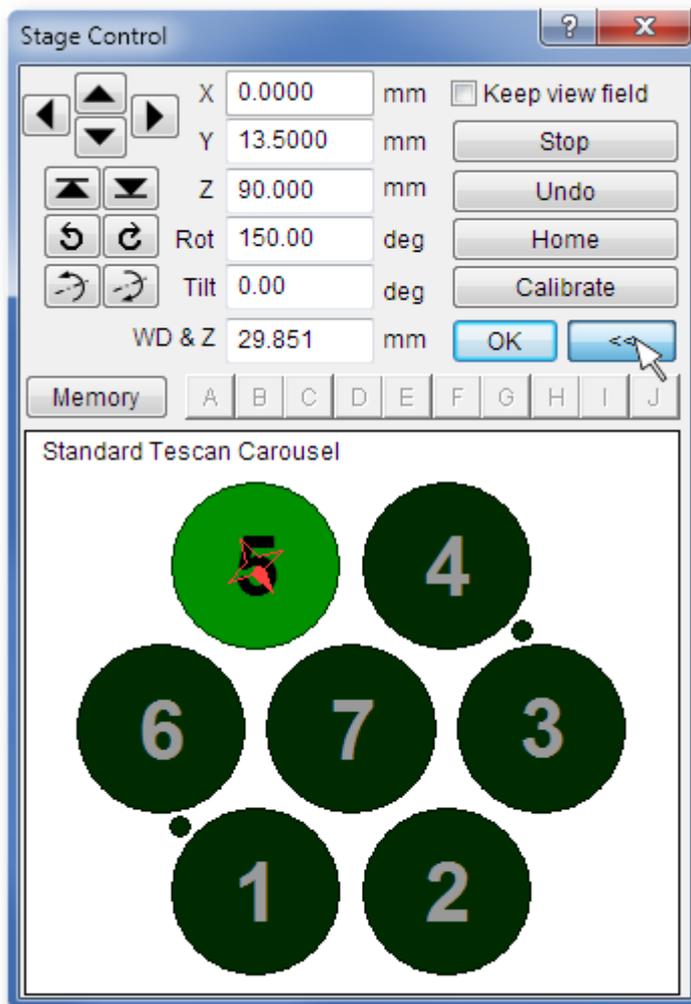
7. Clicking on the WD icon  on the Toolbar and turning the Trackball from left to right (or vice versa) focus the image (alternatively use the **Auto WD** function for focusing (see **Figure 5**)). Double-clicking in the SEM Scanning window opens the Focus window. To remove the Focus window double-click anywhere in the SEM Scanning window.
8. Focus in the Resolution mode (click on the **Scan Mode** function in the **Info Panel** and select **RESOLUTION** or use the **Continual Wide Field** function).
9. To select beam intensity (BI 10 recommended), first left-click on the BI icon  on the Toolbar and then use the arrows on the **Pad** panel (**Figure 7**).

Figure 7



10. To select the sample position on the **Stage Control** panel, click on the appropriate number button on the carousel (**Figure 8**) or use the manual knobs in the case of the SB microscope type.

Figure 8



11. Placing the cursor over the SEM Scanning window and clicking the mouse wheel moves that area on the stage into the centre of the image. See chapter 7.2 for other mouse actions.

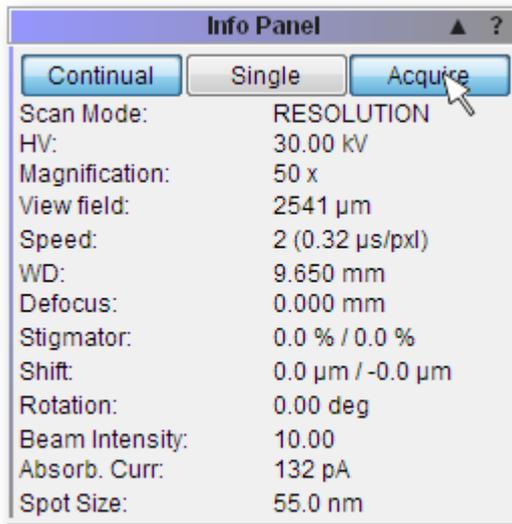
12. To magnify the image click on the Magnification icon  on the Toolbar and turn the Trackball from left to right.

13. Once the area of interest is magnified and focused as desired, right-click on the Speed icon  on the Toolbar and select the appropriate scanning speed.

14. Clicking on the **Acquire** button on the **Info Panel (Figure 9)** or on the icon  on the Toolbar saves the image. Fill in the note, sign and description field if necessary. Choose a folder in which to store the image. To change the parameters of the image use the **Image Parameters** function in the SEM menu.

15. Clicking on the icon  opens the dialogue for saving the current adjustment of the microscope. It is possible to restore the saved adjustment of the microscope later.

Figure 9



## 8.4 Imaging of non-conductive samples without coating

An ordinary SE detector is not available in low vacuum operations (see chapter 6), therefore Tescan have developed the LVSTD detector (Low Vacuum Secondary Tescan Detector), which gives topographical information from the sample in low vacuum. The BSE detector is available for both modes (LowVac, HiVac) and gives compositional information.

1. Switch the microscope to Medium vacuum mode (pressure range 3 Pa – 150 Pa) by clicking on the **UniVac** button on the **Low Vacuum Mode** panel (Figure 10). In the case that even lower vacuum is needed (pressure range 150 – 2000 Pa) follow the instructions for aperture exchange in chapter 9.5.
2. Enter the desired pressure value in the field next to **UniVac** button and click on the **OK** button.
3. If the LVSTD is attached to the chamber, the **LVSTD** button is present (Figure 11).

Figure 10

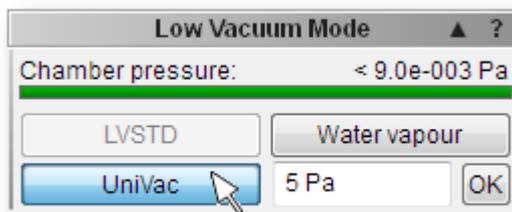
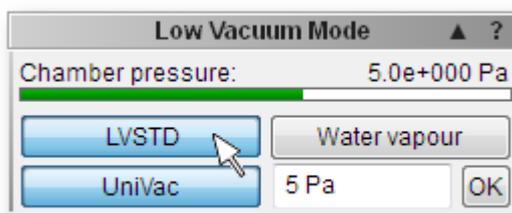
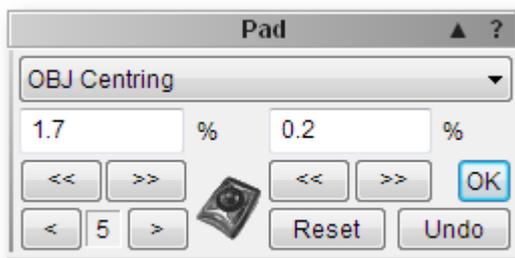


Figure 11



4. To switch between detectors (BSE or LVSTD) use the list box in the **Detectors & Mixer** panel (see **Figure 2**).
5. Turn on high voltage by clicking on the **HV** button on the **Electron Beam** panel (see **Figure 4**).
6. Set minimum magnification.
7. To select beam intensity (BI 10 recommended), first left-click the BI icon  and then use the arrows on the **Pad** panel (**Figure 7**).
8. Use the **Auto Signal** function to set suitable brightness and contrast.
9. Select the **OBJ Centering** function from the combo box on the **Pad** panel (**Figure 12**) and turn the Trackball to set the brightest area into the centre of the Scanning window.

Figure 12

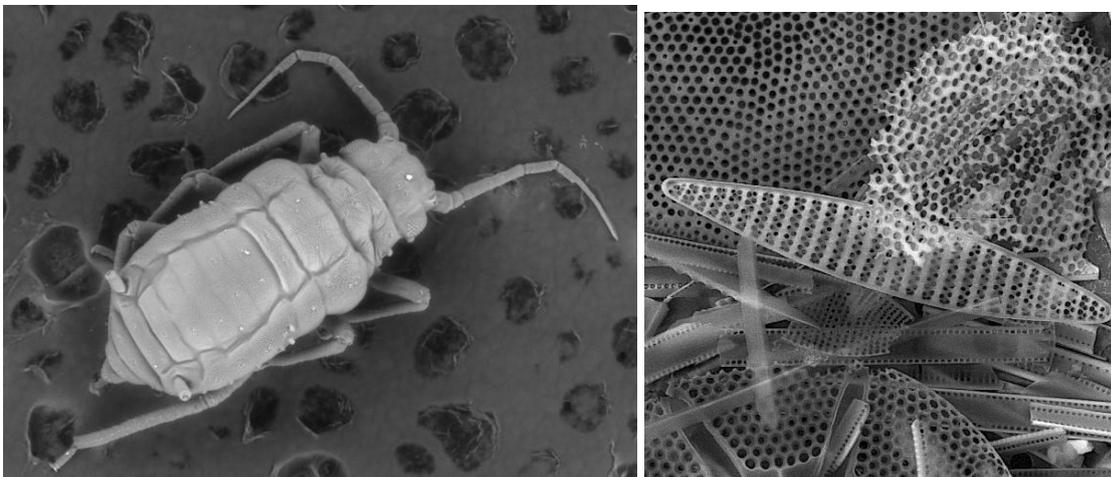


10. Follow the instructions 10. – 15. in chapter 8.3.

*Note: Some non-conductive samples, which are not too sensitive to the beam, can be handled at lower voltages in high vacuum mode. Different high voltages can be selected from the Electron Beam panel.*

*Note: See LVSTD images obtained at low vacuum mode of an organic sample without coating (Figure 13).*

Figure 13

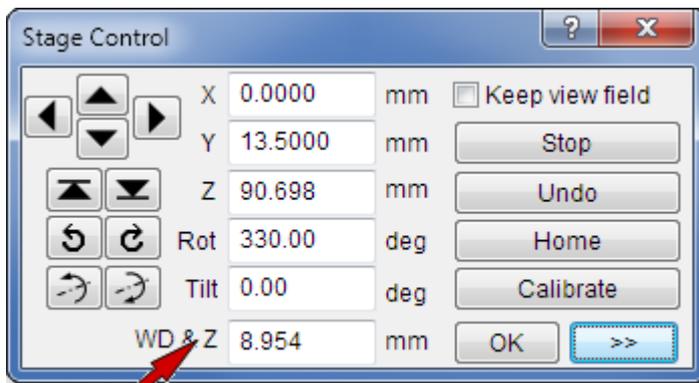


## 8.5 Images at High Magnification

1. Insert an appropriate sample for high magnification images (e.g. tin on carbon sample, **Figure 17**).
2. The best resolution is available with the highest accelerating voltage (30 kV) of the primary electrons. Select the fourth HV index using the combo box on the **Electron Beam** panel.
3. Turn on the high voltage.
4. Focus in the Resolution mode (click on the Scan Mode function in the **Info Panel** and select RESOLUTION or use the **Continual Wide Field** option – switches automatically between the Wild Field and Resolution Mode and vice versa when increasing/decreasing magnification).
5. Check the spot size, which is determined by the BI value. Right-click in the Scanning window to select the optimum BI value – **Auto BI OptiMag**.
6. For the best resolution images it is necessary to have as short a working distance (WD) as possible. For the SE detector the optimum WD is about 5 mm (in the case that the BSE is not mounted underneath the objective lens). For BSE images the optimum WD is about 8.5 mm. To change the working distance together with Z-axis, without defocusing the image, use the **WD&Z** function on the **Stage Control** panel (**Figure 14**).

*Note:* Before changing WD&Z use the degauss function by means of the  icon. The image should remain in focus.

**Figure 14**



7. Gradually magnify and focus the image to achieve 10 kx magnifications. In the case that the image is moving during focusing, it is necessary to check the centering of the objective. Select the **Manual column centering** function using the combo box on the **Electron beam** panel after clicking on the **Adjustment** button (**Figure 15**). The Manual Centering Wizard window will appear (**Figure 16**). Clicking on the **WOB** button opens the Focus window in the SEM Scanning window. Click on the **Next>>** button to obtain the next instructions. The function of the centering has two adjustable values. To be sure just one value is changing, hold down F12 to change only X movement at the Trackball, and F11 to change only Y movement.

Figure 15

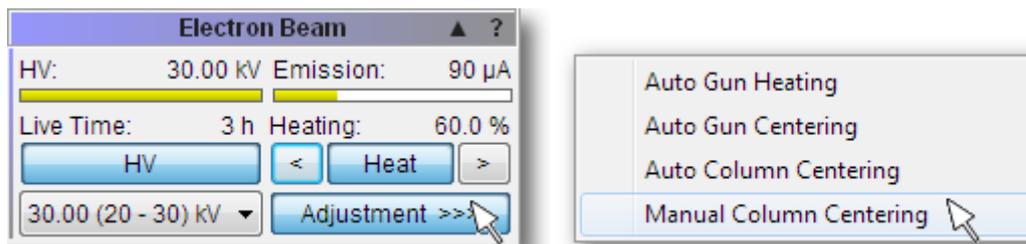
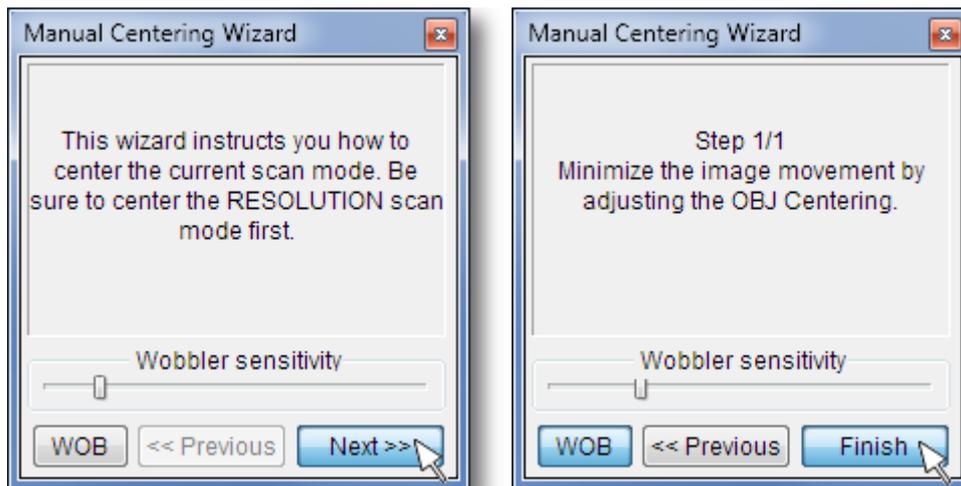
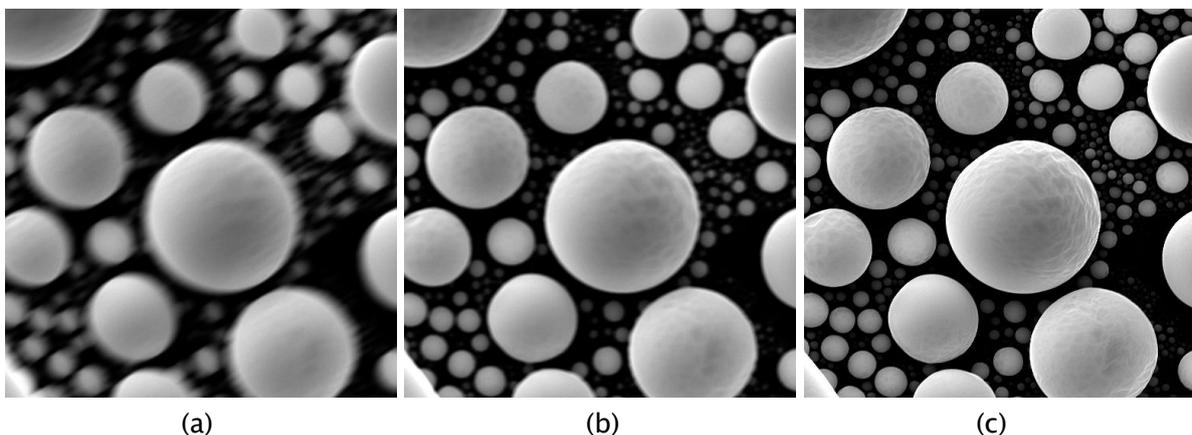


Figure 16

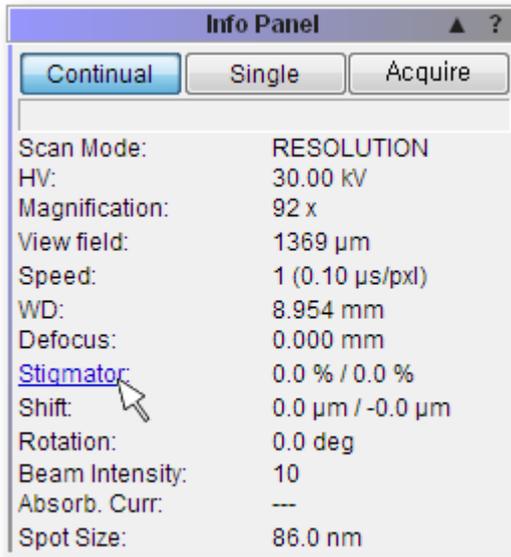


8. Each time that the image is too dark or light it is necessary to use the **Auto Signal** function (see **Figure 5** or use the icon ). To set the contrast and brightness manually, click on the icon  and use the Trackball.
9. At higher magnifications ( $>10$  kx) it is necessary to check if astigmatism (**Figure 17 (a), (b)**) is precisely corrected (**Figure 17 (c)**). To correct astigmatism click on the **Stigmator** function on the **Info Panel (Figure 18)**. For precise correction use the F11 and F12 buttons in the same way as in point 7.
10. Select the appropriate scanning speed and save the image.

Figure 17



11. Clicking on the icon  opens the dialogue for saving the current adjustment of the microscope. It is possible to restore the saved adjustment of the microscope later.

**Figure 18**

## 8.6 Stopping the Microscope

1. Switch off the high voltage by clicking on the HV button in the Electron Beam panel.
2. Close the program (use Exit from the File menu) select the Switch off the microscope option and exit the application.
3. Wait until the VegaTC program closes itself. The microscope configuration will be automatically saved on the hard drive.
4. Shut down OS Windows in the usual way.
5. Turn the main switch to the left (OFF position).

## 9 Microscope Maintenance

### 9.1 Basic Microscope Accessories

This document describes the use of the most important tools included in the microscope accessories. The exact list is attached to the packaging list of the microscope.



1. Hexagonal screwdriver, size 3.0 mm – general use, mainly various flange screws, the most common size used for screws.
2. Flat screwdriver, size 3.2 mm – general use.
3. Low vacuum aperture holder with screw, size M3x25 – used for the removal of the low vacuum aperture holder.
4. Basic specimen stubs.
5. Hexagonal screwdriver, size 2.5 mm – used for mounting / dismounting sample stage Z extensions (LS, LM chambers) and the stub holders (XM chamber).
6. The distance washers.
7. Aperture holder.
8. Hexagonal screwdriver, size 1.5 mm – used for fixing the screws in the sample stage and securing the screws of the cathode.
9. Aperture 50  $\mu\text{m}$ .
10. Aperture 500  $\mu\text{m}$ .
11. Vacuum grease – used for sealing the O-Rings.
12. The base for centering the Wehnelt cylinder.

13. Tungsten cathode.
14. Bent tweezers – used for the aperture holder disassembly and the titanium tube removal.
15. Flat tweezers – general use.
16. Setting rod for the aperture holder.

*Note: This document contains only the special and the most important types of accessories to show which kind to use. The exact list is included as a packaging list for accessories.*

## 9.2 Filament Exchange

The microscope uses an electron gun with a direct heated tungsten cathode filament. The cathode filament will be consumed during microscope usage and will be burnt after a certain period of time. The filament life depends above all on the proper heating level, emission current and on the vacuum conditions. This is about 200 – 300 hours of usage. The cathode exchange is an operation performed by a trained user.

*Note: Check the cleanliness of the Wehnelt cylinder. Maintain the principles of vacuum hygiene during the filament exchange. Dismantling and mounting of the gun is to be performed in a clean, dust-free environment, if possible, and always wearing gloves.*

*Warning: Never touch the ceramic parts of the gun! They function as a high voltage isolator and their surface must not become dirty; it is not possible to clean the ceramic parts in any way.*

1. Make sure that the cathode filament is really burnt. For example, the voltage is 30 kV, heating 60% and the emission current less than 10  $\mu\text{A}$  (see Electron Beam panel), the filament is burnt.

Test it while the high voltage is on and with the usual level of heating current (Electron Beam panel), for example for high voltage 30 kV, heating 60% and the emission current less than 10  $\mu\text{A}$ .

2. Switch off the high voltage (click on the HV button).
3. Vent the microscope (VENT button).
4. Pull the electron gun upwards, remove it and place it down with the cathode upwards.



5. Protect the open part of the column against dust by using, for example, polyethylene or aluminum foil.
6. If the electron gun body is hot after the previous usage, allow it cool down for a few minutes.

7. Screw off the polished stainless cap nut.



8. Remove the removable part of the electron gun. If you have a new pre-centered filament skip to step 15 - inserting a new pre-centered filament. If you exchange the filament and you do not have a pre-centered gun go to the next point.



9. Place the Wehnelt cylinder with the filament as shown in the picture. Loosen the 4 screws on the side of the Wehnelt cylinder by approximately 2 turns. Use the 1.5 mm hexagonal screwdriver.



10. Remove the filament with the centering ring. Hold the filament by the contacts.



11. If necessary, clean the Wehnelt cylinder. Do not forget to remove the distance washers and then put them back before cleaning the Wehnelt cylinder.
12. Carefully insert the new filament with the centering ring and lightly screw in the 4 centering screws to hold the filament approximately in the centre of the Wehnelt cylinder. The filament contacts must be in line with the position pin on the Wehnelt cylinder. The screws should not be fixed at this point; there should be about 0.5 mm (0.02") play.

*Note: Leave the same amount of distance washers under the filament as with the previous filament. In the case of using a new Wehnelt cylinder or the amount of washers used is unknown, use 2 distance washers 0.05 mm (0.002").*



13. Turn the Wehnelt cylinder with the inserted filament and place it into the centering holder. The orientation pin and the filament contact must fit into the holes in the holder.



14. Centre the filament tip inside the Wehnelt cylinder by tightening and loosening the opposite centering screws in both directions.



15. Place the completed gun back onto the gun body. Ensure that the filament contacts and the centering pin fit into the appropriate holes on the gun.



16. Fix the gun to the gun body with the polished nut.
17. Blow the completed gun with compressed dry air or nitrogen and place the gun body back onto the column.
18. Evacuate the microscope (PUMP button).
19. Confirm the filament exchange in the menu SEM -> Maintenance ▶ Confirm Filament Change. This causes the reset of the filament lifetime and reset of the heating values.

*Note: Filament exchange is only allowed for Expert and higher users.*

### 9.3 Starting up the Microscope after a Filament Exchange

It is necessary to perform the following procedure after a filament exchange:

1. Put the basic specimen stub into position 7 on the sample stage and calibrate the sample stage. The aim is that the electron beam will be directed onto the flat aluminum surface.

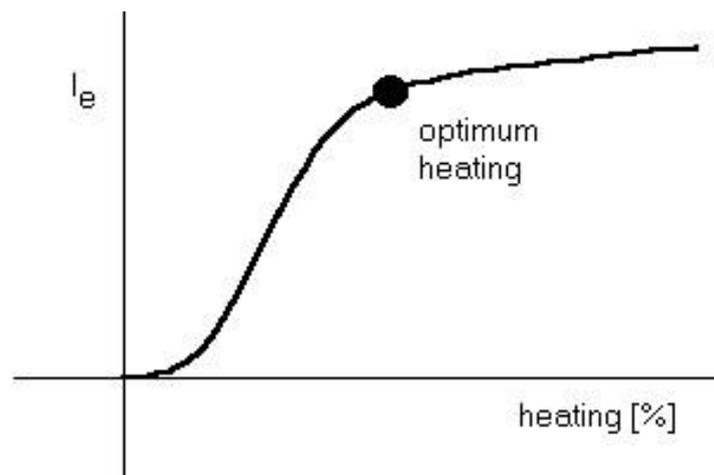
2. Set up 30 kV and wait for high voltage stability. Wait until the discharging of the high voltage ceases; it should be no longer than 10 minutes.
3. Use the **Auto Gun Heating** function (see **Figure 6**; chapter 8.3). An automatic procedure will set up the filament saturation and filament centering. It sets up automatic brightness and contrast adjustment.
4. Typical new filament saturation heating is from 48 % to 53 % for 30 kV accelerating voltage. A worn filament has a lower heating level, usually 43 % to 47 %. The emission current for the saturated filament should be in the range of 60 – 90  $\mu\text{A}$ . The typical absorbed current is listed in the table below. The typical values reached are listed in the first column, but the suitable ranges for the currents are listed in the second column. In general we try to obtain as high an absorbed current as possible since the absorbed current gives us information how many electrons are passing through the column, the more electrons, the better the signal from the specimen.

BI	Typical Absorbed current	Suitable range
11	230 $\mu\text{A}$	150 ~ 300 $\mu\text{A}$
20	45 nA	35 ~ 50 nA

5. If the emission current is not in the range of 60 to 90  $\mu\text{A}$ , it is necessary to repeat steps 1 to 10 in chapter 9.2 "Filament exchange". The distance washers must be removed or added and the filament centred according to steps 12 to 19. Adding one distance washer size 0.05 mm (0.002") decreases the emission current by 13  $\mu\text{A}$ , removing the washer increases the emission current by the same amount.

Example: The emission current for the saturated filament is 105  $\mu\text{A}$ , by adding 2 distance washers an emission current in the desired range of  $75 \pm 15 \mu\text{A}$  is achieved.

6. It is possible to check the filament saturation point setting by means of the arrows on the Electron Beam panel.



7. Repeat the previous procedure for the HV range (HV index) if you need to work on the other HV range.

**Warning:** The filament wire becomes thinner during the operation. To increase its lifetime, check its saturation point after every 15 hours of work. The thinner the filament, the lower the heating level (saturation).

## 9.4 Mechanical Gun Centering

In the case that the mentioned absorbed current cannot be reached, or the value Gun Shift or Gun Tilt (use the combo box in the Pad panel) is higher than 60 %, it is necessary to carry out mechanical gun centering.

*Note: The filament itself needs to be perfectly centred inside the Wehnelt cylinder; otherwise mechanical gun centering will not be possible!*

1. Ensure that the microscope is scanning over the conductive surface. The best is to place the standard stub into position 7 of the sample stage and perform the stage calibration. The sample stage will be under the objective after the calibration.
2. Set: HV = 30 kV, BI = 11, Scan Speed 1.
3. Reset the parameters: Gun Shift and Gun Tilt.

*Note: The reset of the values can cause a drop of the absorbed current or a total loss of the signal. This is not a defect; by following centering the same or most probably an even better level will be achieved.*

4. Set up a suitable level of the signal by means of the automatic brightness and contrast (**Auto Signal** function).
5. Loosen all 4 screws by about  $\frac{1}{2}$  – 1 revolution of the screw.
6. Try to maximize brightness and contrast by means of tightening and loosening opposite corresponding screws. If the image becomes saturated (the whole image is white) adjust **Auto Signal** again to set the suitable level. Try to adjust the gun in alternating directions. Never tighten the screws using brute force. Opposite screws work against each other, so in the case that one screw is fixed, it is necessary to loosen the respective one.
7. Once the maximum signal (brightness and absorbed current) is obtained, fix all 4 screws uniformly to fix the gun into its position. The slight drop of the signal is not a problem; optimization will be performed by electric gun centering.
8. To perform the automatic gun centering procedure, use the **Auto Gun Centering** function (see **Figure 6**) in the VegaTC program. Once the automatic gun centering has finished, it is recommended that the values of the Gun Shift and Gun Tilt are checked. They should not exceed the value of  $\pm 30$  %.

*Note: In the case that no signal is found during the mechanical centering, the gun can be mechanically extremely misaligned. In this case the gun should be placed in the centre of the system. Try to tighten the screws equally to the same position. Then try to find the signal around this position, the correct position is normally in a range of no longer than  $\pm 1$ mm (2 full turns of the screw).*

## 9.5 Aperture Exchange

The column of the microscope is fitted with two apertures in all vacuum modes. Exchange of the Aperture is performed in two cases. Firstly, when switching between high/medium vacuum mode and low vacuum mode, follow the instructions in chapters 9.5.1 and 9.5.2. Secondly, when the apertures themselves need to be exchanged for a new set or need to be

removed from the holder for cleaning, see the instructions in chapter 9.6.

During any exchange it is necessary to maintain the principles of vacuum hygiene. Dismantling and mounting operations must be performed in a clean and dust-free environment – if possible, and by wearing gloves.

### 9.5.1 Exchange of the Aperture Holder

1. Vent the microscope (**Vacuum** panel, **VENT** button).
2. Pull the electron gun upwards, remove it and place it down with the cathode upwards.
3. Screw off the anode (anticlockwise).
4. Insert the setting rod from the delivered accessories into the central vacuum tube and lower it carefully to the aperture holder. Turn the setting rod clockwise (approximately one turn) to screw the thread at the end of the setting rod into the aperture holder and pull it upwards to remove the aperture holder.



5. Screw the aperture holder from the accessories onto the setting rod and insert it in the central vacuum tube all the way down to the mechanical stop inside the central vacuum tube.
6. Screw on the anode and tighten it slightly.
7. Clean the gun body and the gun chamber using compressed dry air or nitrogen. Place the gun on the column.
8. Pump the microscope down.
9. Confirm the exchange of the final aperture in the SEM -> Options menu (check the aperture hole diameter).

### 9.5.2 Insertion of the Low Vacuum Aperture Holder

This aperture is inserted into the objective and is accessible from the bottom – from the microscope chamber.

1. Place the aperture holder body onto the pad with the wider part down.
2. Drop the new or cleaned aperture (75 µm) into the aperture holder.
3. Check that the aperture is placed with the bigger hole upwards. Contrariwise, turn the aperture; tap the holder at the pad if the aperture is not placed correctly inside the holder.
4. Take the collet with the tweezers, with the collet thread upwards and screw it into the aperture holder body to lock and secure the aperture.
5. Check the cleanliness of both sides of the aperture surface (preferably using

an optical microscope). If necessary clean the aperture using compressed dry air or nitrogen.



6. Fit the sealing ring in the groove of the aperture holder body.
7. Fit the contact spring in the groove of the aperture holder body.
8. Before inserting the aperture into the objective, move out the BSE detector.
9. Open the chamber door and insert the aperture holder into the objective with the wider part downwards.
10. To remove the aperture holder – use the screw included in the microscope accessories. Place the screw in the aperture holder and by pulling down the screw, remove the aperture holder.

For the low vacuum mode, it is necessary to confirm the change in the menu SEM -> Change UNI mode.

*Note: If you change any of the apertures, it is necessary to centre the whole optical system again.*

The apertures become contaminated during microscope usage, which can cause a decrease in the optical qualities of the column. It is necessary to clean them from time to time or exchange them.

## 9.6 Cleaning the Column

Contamination on the inner vacuum surfaces of the column appears during microscope operation, decreasing the optical qualities of the microscope. That is why it is necessary to clean the vacuum surfaces from time to time.

### 9.6.1 Types of Contamination or Impurities

- Organic, badly conductive covers, arising from the interaction of the organic residual gases in the vacuum with the electrons. These coatings appear along the whole length of the primary electrons. They cause poor electrical conductivity and therefore charging of the internal parts and the specimen surface.
- Tungsten coating arises through the steaming of the filament and the de-dusting of the tungsten from the tungsten cathode filament. It impairs the electrostatic strength of the system (cathode – Wehnelt cylinder – anode) and causes leakage of the heating current and micro-discharges in the electron gun.

- Dust particles retained on the internal surfaces. These enter into the microscope with each venting during the exchange of specimens, apertures or cathode. Dust particles retained on the apertures worsen the optical qualities.
- Impurities taken into the microscope through incorrect procedure during the exchange of apertures, cathodes or specimens.

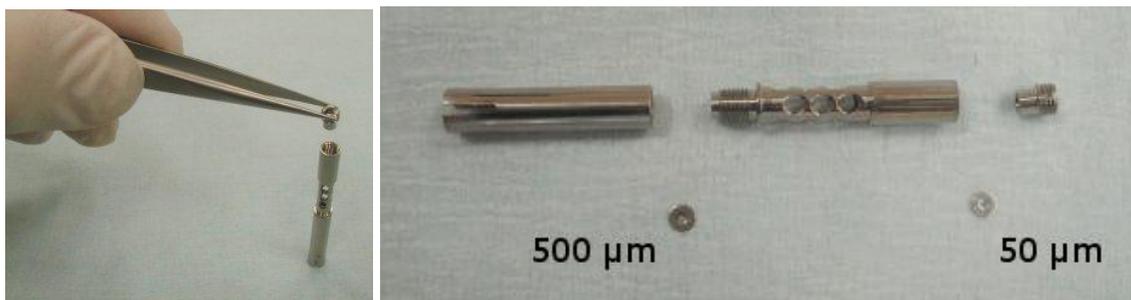
### 9.6.2 Cleaning the Column Parts

By cleaning the column is meant: cleaning of the aperture holders including the spring collets, the Wehnelt cylinder, anode and apertures. The apertures themselves are made of platinum and therefore they need special treatment and it is necessary to clean them separately. To remove all mentioned parts from the column, follow the instructions below.

1. Vent the microscope (**Vacuum** panel, **VENT** button).
2. Pull the electron gun upwards, remove it and place it down with the cathode upwards.
3. Screw off the anode (anticlockwise).
4. Insert the setting rod from the delivered accessories into the central vacuum tube and lower it carefully to the aperture holder. Turn the setting rod clockwise (approximately one turn) to screw the thread at the end of the setting rod into the aperture holder and pull it upwards to remove the aperture holder.



5. Dismantle the bottom part of the holder with a screwdriver or tweezers and shake out the aperture (50  $\mu\text{m}$ ).



6. Split the medium and upper part of the holder by unscrewing and shake out the spray aperture (500  $\mu\text{m}$ ).
7. Clean the mentioned parts of the column.

#### Recommended cleaning steps

Cleaning the Apertures:

- Place the aperture in a beaker filled with isopropyl alcohol, ethanol or coleman fuel. Wash the aperture in an ultrasonic bath for about 10 minutes.

- Anneal the clean aperture in an alcohol burner. Use only clean ethanol for the burner to prevent the combustion products from polluting the aperture.

Cleaning the other parts of the column:

- Clean very dirty parts with a piece of cotton wool and fine abrasive powder. Liquid cleanser with fine abrasive material is suitable. (Don't use for apertures).
  - Put the parts into a beaker, dilute the fine abrasive material (liquid cleanser with fine abrasive material) in the distilled water. Put the beaker with the parts into an ultrasonic bath for about 20 minutes. (Do not use for apertures).
  - Rinse the parts with distilled water and place them in isopropyl alcohol, ethanol or coleman fuel and place them into the ultrasonic bath for another 10 minutes.
  - Dry the parts properly with clean compressed air or nitrogen after cleaning.
8. Drop the cleaned or new spray aperture into the upper part of the aperture holder. Check whether the aperture is oriented upwards by the bigger opening (once the holder is inserted into the column the aperture will be oriented correctly – with the small opening up). If the aperture is not correctly oriented, try to turn it by tapping the holder against the pad or the table.



9. Fix the aperture by screwing on the middle part of the aperture holder. Check the cleanness of both sides of the aperture – best under an optical microscope. If necessary blow the aperture with compressed dry air or nitrogen.
10. *This point is applicable only for the high and medium aperture holder configuration.* Drop the clean or new final aperture (50  $\mu\text{m}$ ) into the lower end of the middle part of the aperture holder. Once the assembled holder is in the column, the aperture will be oriented upwards with the smaller opening. If the aperture is not correctly

oriented, try to turn it by tapping the holder against the pad or the table.

11. Fix the aperture by screwing on the third (bottom) part of the aperture holder. Use a small screwdriver or tweezers.
12. Blow the assembled holder with the aperture with clean compressed air or nitrogen.
13. Screw the aperture holder onto the setting rod and insert it in the central vacuum tube all the way down to the mechanical stop inside the central vacuum tube.
14. Screw on the anode and tighten it slightly.
15. Clean the gun body and the gun chamber using compressed dry air or nitrogen. Place the gun onto the column.
16. Pump the microscope down.

### 9.6.3 The Frequency of Cleaning

The frequency and the method of cleaning depend on the specific part of the optical system, the kind of the impurities and on the operation conditions. The following frequency of cleaning is recommended for usual operation:

- Wehnelt cylinder, anode – according to necessity, if the emission current is unstable, if there is an emission current without filament heating, if there are discharges of high voltage in the gun.
- Aperture – at worsened optical qualities i.e. if high astigmatism appears, if there are major changes of the values for lens centering and for different accelerating voltage, etc.
- Spray aperture, aperture holders and vacuum tubes – once every 3 to 6 months.
- Other parts – at the service examination.

## 9.7 Specimen Holders

The specimen holders differ according to the microscope type delivered; here is only an overview of all available types.



### Standard specimen holder

∅ 12.5 mm, height 3 mm: the most common holder suitable for smaller specimens. The specimen is normally glued with conductive glue or stuck on with double-sided sealing tape.



### Specimen holder GM163-A,

∅ 14 mm, height 20 mm: extension for small specimen holders for work at very short working distances.

**Specimen holder HM113:**

for small round-shaped samples up to a max. diameter of  $\varnothing$  12 mm.

**Specimen holder HM116:**

for round-shaped samples up to a max. diameter of  $\varnothing$  20 mm.

**Specimen holder TE0038B:**

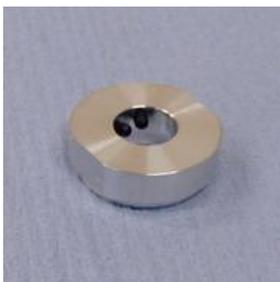
designed for standard  $\varnothing$  30 mm samples.

**Specimen holder HM114:**

for flat samples up to a width of 20 mm.

**Specimen holder GM153:**

replacement of the standard seven position specimen holder (the seven position holder must be removed). It is designed for rod-shaped samples of a diameter up to 26 mm.

**Specimen holder HM154-A:**

CAMSCAN  $\varnothing$  12.5 mm specimen holder adaptor.