



Document version 1.13, Original Instructions

The reproduction, transmission or use of this document or its contents is not permitted without express written authority.

Violators are liable for damages. All rights reserved.

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

© 2023 TESCAN ORSAY HOLDING, a.s., Brno, Czech Republic

# Table of Contents

<b>1 Introduction</b> .....	7
<b>2 Safety Instructions</b> .....	8
2.1 Emergency Contact .....	8
2.2 Microscope Supervisor Contact .....	8
2.3 Limitations of Use .....	8
2.4 Clothing and Personal Safety .....	9
2.5 Reading the Manual .....	10
2.6 Levels of Hazards .....	11
2.7 Proper Use .....	12
2.8 Radiation Safety .....	15
2.8.1 Ionizing Radiation .....	15
2.8.2 Magnetic Field .....	15
2.9 EMO (EMergency Off) Button .....	16
2.10 Chemicals .....	17
2.11 Dismounting and Disposal .....	18
<b>3 Installation and Repair</b> .....	19
3.1 Transport and Storage .....	19
3.2 Moving the Microscope .....	19
3.3 Installation Instructions .....	19
3.4 Fuse Replacement .....	19
3.5 Instrument Repair and Spare Parts Usage .....	19
<b>4 System Description</b> .....	20
4.1 Electron Column (SEM) .....	21
4.2 SEM Scan Modes .....	23
4.2.1 UH-RESOLUTION Scan Mode .....	23
4.2.2 DEPTH Scan Mode .....	24
4.2.3 ANALYSIS Scan Mode .....	24
4.2.4 OVERVIEW Scan Mode .....	25
4.2.5 WIDE FIELD Scan Mode .....	25

4.3 SEM Potential Tube Modes .....	26
4.4 Chamber .....	27
4.5 Vacuum Modes .....	28
4.6 Sample Stage .....	29
4.6.1 Description of Stage Movements .....	29
4.6.1.1 Movement along XYZ axes .....	30
4.6.1.2 Rotation .....	30
4.6.1.3 Tilt .....	31
4.7 Detectors .....	33
4.7.1 Electron Beam-Sample Interaction .....	33
4.7.2 In-Beam Axial Detector .....	35
4.7.3 In-Beam Multidetector (MD) .....	35
4.7.4 Everhart-Thornley (E-T) Detector .....	36
4.7.5 Retractable BSE (R-BSE) Detector (Optional) .....	36
4.7.6 Low Energy BSE (LE BSE) Detector (Optional) .....	36
4.7.7 Low Energy 4Q BSE (LE 4Q BSE) Detector (Optional) .....	37
4.7.8 Water Cooled BSE Detector (Optional) .....	37
4.7.9 Aluminum-Coated BSE Detector (Optional) .....	38
4.7.10 Retractable HADF STEM (R-STEM) Detector (Optional) .....	39
4.7.11 Cathodoluminescence (CL) Detectors (Optional) .....	40
4.7.12 Low Vacuum Secondary TESCAN (LVSTD) Detector (Optional) .....	41
4.7.13 Gaseous Secondary Electron (GSD) Detector (Optional) .....	41
4.7.14 TESCAN EDS Detector (Optional) .....	42
4.8 Control Devices .....	43
4.8.1 Mouse .....	43
4.8.2 Trackball .....	44
4.8.3 Control Panel .....	45
<b>5 Starting the Microscope .....</b>	<b>47</b>
5.1 User Access Levels .....	48
5.2 Licences .....	48
5.3 System Saving Modes .....	49

<b>6 Working with the SEM .....</b>	<b>50</b>
6.1 SEM Basics Step-by-Step .....	52
6.2 SEM Imaging of Non-conductive Samples .....	58
6.2.1 Low Energy Imaging .....	59
6.2.2 Ultra-Low Energy Imaging in BDM .....	61
6.2.3 Imaging in the LowVac Mode .....	64
6.2.4 Advanced Scanning Strategies .....	68
6.2.5 Conductive Coating of Sample Surface .....	68
6.3 Simultaneous Signal Acquisition & Signal Mixing .....	69
6.4 Presets .....	70
6.4.1 Creating a Preset .....	71
6.4.2 Activating a Preset .....	71
6.4.3 Editing a Preset .....	72
6.4.4 Removing a Preset .....	72
<b>7 Finishing Up Work with Microscope .....</b>	<b>73</b>
<b>8 Microscope Maintenance .....</b>	<b>74</b>
8.1 Safety Precautions .....	74
8.2 Maintenance Schedule for Customers - Overview .....	75
8.3 Stage Center Adjustment .....	78
8.4 Field of View Fine Adjustment .....	79
8.5 SEM Centering Overview .....	80
8.5.1 (Intro) Centering Background .....	80
8.5.2 Quick Overview (Recommended Auto Procedures) .....	81
8.5.3 Semi-Automatic Centering - Centering Wizards .....	81
8.5.3.1 SEM Gun Centering Wizard .....	82
8.5.3.2 SEM Objective Centering Wizard .....	84
8.5.3.3 SEM Stigmators Centering Wizard .....	85
8.5.3.4 SEM User Alignment Wizard .....	86
8.5.3.5 Astigmatism Correction (Stigmators "Adjustment") .....	87
8.5.3.6 Image Alignment .....	88
8.5.4 Automatic Centering (Recommended) .....	89

8.5.4.1 Auto Gun Centering .....	89
8.5.4.2 Auto Gun Fine Centering .....	90
8.5.4.3 Auto Objective Centering .....	90
8.5.4.4 Auto Stigmators Centering .....	91
8.5.4.5 Auto Stigmators Precentering .....	91
8.5.5 Auto Image Adjustments .....	92
8.5.5.1 Auto Focus .....	92
8.5.5.2 Auto Fine Focus .....	92
8.5.5.3 Auto Brightness / Contrast .....	93
8.5.5.4 In-Flight Brightness / Contrast .....	94
8.5.5.5 Auto Stigmators .....	95
8.5.6 Saving Your Centering .....	95
8.5.7 Restoring Default Centering .....	95
8.6 SEM Centering Tutorials .....	96
8.6.1 Common Centering Procedure (Regular Work) .....	96
8.6.1.1 SEM Centering in UH-RESOLUTION .....	96
8.6.1.2 SEM Centering in DEPTH, ANALYSIS and OVERVIEW .....	96
8.6.1.3 SEM Centering in WIDE FIELD .....	96
8.6.2 Centering of Multiple Conditions .....	97
8.7 Switching the Electron Source OFF / ON .....	98
8.7.1 Switching the Electron Source OFF .....	98
8.7.2 Switching the Electron Source ON .....	99
8.8 Changing the R-STEM Aperture .....	100
8.9 Centering the R-STEM Detector .....	101
8.10 Inserting / Removing the LowVac Aperture .....	104
8.11 Cleaning the LowVac Aperture .....	106
8.12 Exchanging the LowVac Aperture Sealing O-Ring .....	107
8.13 Refilling LowVac Water Reservoir .....	108
<b>9 Troubleshooting .....</b>	<b>110</b>
9.1 ... Health Status Reports A Problem? .....	112
9.2 ... Non-Standard System Settings Status Reports A Problem? .....	113

9.3 ... You Crashed with Your Sample? .....	114
9.4 ... You Lost Signal? .....	115
9.5 ... Maximum View Field Is Limited? .....	116
9.6 ... You Need To Restart Load Lock? .....	117
<b>10 Appendix .....</b>	<b>119</b>
10.1 Accessories Box .....	120
10.2 Sample Holders .....	121
10.2.1 Standard & Most Common Sample Holders .....	121
10.2.2 R-STEM Sample Holders .....	123
10.2.2.1 APG-32 .....	123
10.2.2.1.1 APG & Sample Loading .....	123
10.2.2.1.2 APG & Standard Automated Load Lock .....	125
10.3 Standard Automated Load Lock .....	127
10.3.1 Loading a Sample .....	128
10.3.2 Unloading a Sample .....	131
10.4 Manual Load Lock .....	134
10.4.1 Loading a Sample .....	135
10.4.2 Unloading a Sample .....	139
10.5 Keyboard Shortcuts .....	143

## 1 Introduction

The TESCAN CLARA microscope is a Scanning Electron Microscope (SEM) equipped with a BrightBeam™ electron optics column offering an excellent resolution at low beam energies for beam sensitive and non-conductive samples imaging.

This manual provides an overview of the components, the operational principles and the directions for using the TESCAN CLARA scanning electron microscope. Not all parts of this manual may apply to a given installation nor should they be taken literally in all cases. Also, details of the TESCAN Essence software may vary according to the current settings and therefore differ slightly from what is shown in the figures here.

More information about software features can be found in the **Help** section in the microscope control TESCAN Essence software.

Since TESCAN CLARA is installed and maintained by trained specialists, the technical details and installation procedures here are limited to a short overview. In cases where maintenance, reinstallation, hardware changes, etc., become necessary, the appropriate service authorities or your local supplier must be contacted for further instructions and assistance.

## 2 Safety Instructions

The safety instructions in this manual are the result of risk evaluation and hazard analyses. Before using the microscope be sure to read and understand all the actions highlighted in this manual.

### 2.1 Emergency Contact

TESCAN Brno, Service dpt. Helpdesk

Libušina třída 816/1, 623 00 Brno, Czech Republic

Phone: **+420 530 353 353**

mailto: support@tescan.com

### 2.2 Microscope Supervisor Contact

*Dear microscope supervisors, please fill in your contact information below.*

**Supervisor:**

**Contact:**

### 2.3 Limitations of Use

The chapter is intended to specifically describe safety related issues in handling the microscope. Read this carefully before beginning work with the microscope.

- This equipment comprises a single beam microscope system containing the BrightBeam™ electron optics column (SEM). TESCAN ORSAY HOLDING, a.s. does not take any responsibility for any problems that may arise from using the microscope for purposes other than SEM analysis.
- **Notice of infringement of rights:** TESCAN ORSAY HOLDING, a.s. and its subsidiaries shall not be liable for infringement of third party industrial rights (particularly patents) arising from the use of this product in applications other than those described here or in combination with products other than those described here.
- This microscope is for indoor use only and is not to be used outdoors.
- This microscope is designed to be operated in a clean room.
- This microscope is operated at high voltages and contains components which become hot and rotate. If a component needs to be repaired or replaced, contact an authorized service engineer.
- All personnel who work with or around the equipment should read and understand the safety related information in this manual carefully before starting work.
- The supervisor is responsible for strict adherence to safety standards, but responsibility with respect to safety standards during day-to-day operations resides with each individual operator and maintenance personnel.
- This manual must be made available to operators whenever necessary.

## 2.4 Clothing and Personal Safety

- Always wear appropriate clothing (e.g. a lab coat, clean and safe shoes) when working with the microscope to avoid dust contamination.
- Always use powder-free gloves when handling vacuum parts to avoid chamber contamination, e.g. sample loading and unloading or mounting stage accessories.
- Always wear powder-free gloves whenever you need to put your hands inside the chamber or touch internal surfaces of any vacuum part to protect against skin contact with residual chemicals.
- When handling any chemicals, always wear a face shield, safety glasses with side-shields and safety gloves and **be aware of the particular Material Safety Data Sheet (MSDS)**. MSDSs are available on request.
- Personal Protective Equipment (PPE) should be used in accordance with the instructions provided by the PPE supplier.
- DO NOT operate the system while under the influence of non-prescription drugs or alcohol.
- DO NOT smoke when using the microscope.
- Be aware of the location of the nearest phone.
- Be aware of the location of the nearest fire-extinguisher suitable for use with an electron microscope.
- Be aware of the emergency services number.

## 2.5 Reading the Manual

This manual contains the following four symbols to help identify important actions when operating or maintaining the microscope.

Symbol	Definition
	Warning of hazardous electric source, disregarding this may result in serious injury or death.
	Prohibits an action or activity associated with a source of danger, disregarding this may result in serious injury.
	Warning of a source of danger associated with the operation of the unit or equipment.
	Command to perform an action or task associated with a source of danger, disregarding this may result in serious injury.

In addition, there is also one type of extra information given in this document - **Notes**. Notes do not contain any safety information.

**Note:** Notes help explain relations to other features, to clarify the background and / or principles relevant to the context and may point out workarounds and options for reaching the desired parameter.

These symbols and rules also apply for the Essence Help.

## 2.6 Levels of Hazards

The instructions given in this manual aim to ensure safe and correct operation of the product, and to prevent injury to operators or damage to the product. These instructions are grouped into four categories, Danger, Warning, Caution and Notice, which indicate the level of hazard, damage or the degree of emergency. All critical safety instructions must be carefully followed at all times.

“DANGER”, “WARNING”, “CAUTION” and “NOTICE” signs are in decreasing order of severity (DANGER > WARNING > CAUTION > NOTICE).

### DANGER

DANGER is used to indicate a hazardous situation that, if not avoided, will result in death or severe injury. This word is limited to the most extreme situations.

### WARNING

WARNING is used to indicate a hazardous situation that, if not avoided, could result in death or severe injury.

### CAUTION

CAUTION is used to indicate a hazardous situation that, if not avoided, could result in moderate or minor injury. It might be used without the safety alert symbol as an alternative to NOTICE.

### NOTICE

NOTICE is used to indicate a hazardous situation that, if not avoided, could result in property damage. The safety alert symbol should not be used with this word. As an alternative to NOTICE, the word CAUTION without the safety alert symbol may be used.

#### *Severe injury*

This term describes injuries whose consequences include loss of eyesight, burns, electrical shock, fracture, poisoning, etc. and / or requires long-term treatment or hospitalization.

#### *Moderate injury*

This term describes injuries that need short-term treatment (1 to 24 hours) and might need hospitalization.

#### *Minor injury*

This term describes injuries that do not need long-term treatment (less 1 hour) or hospitalization.

## 2.7 Proper Use

The system should only be operated by authorized personnel and may not be operated until all safety precautions have been thoroughly understood. DO NOT proceed with operating the system before completely understanding what is referred to in the user manual. The user is also responsible for familiarizing himself / herself with device upkeep and all applicable safety rules valid in the country of installation.



### NOTICE

**Keep the chamber pumped.** Never leave the microscope for long periods with air inside the chamber. Vent the chamber only when you need to change the sample or mount some accessory.



### NOTICE

**DO check the screen.** Standard error messages and warning signs appear on the computer screen whenever a system problem occurs (e.g. improper manipulation etc.). The user must be aware of the computer screen when working with the microscope.



### NOTICE

**Unauthorized manipulation.** Any manipulation of the device not mentioned in this manual, especially removal of the housing and manipulation of electrical components of the microscope including servicing procedures, may be carried out only by an authorized service engineer.



### CAUTION

**Crush hazard.** Moving parts of the microscope (chamber door, sample stage, Load Lock) have several pinch point hazards. Keep hands clear when operating them and always use the cover to avoid this hazard!



### CAUTION

**Do NOT lift any heavy microscope part.** Only an authorized service engineer are allowed to manipulate heavy microscope components.



### WARNING

**DO NOT install non-original parts in the microscope.** It is forbidden to substitute any part of the microscope with another part that is not original and not delivered by the microscope producer (e.g. the substitution of the original steel covers on the flanges of the microscope chamber with light alloy covers can lead to the emission of dangerous ionizing radiation!). Only original spare parts delivered by the manufacturer must be used in all cases.

**WARNING**

**DO NOT replace fuses.** All fuses in the system must be replaced by an authorized service engineer (all fuses are located under the covers, which can be removed only by an authorized service engineer). Fuses must be replaced only by those of the exact same type; the type is described in the documentation or on the fuse holder.

**WARNING**

**DO NOT override interlocks.** The system includes safety interlocks to minimize hazards. Safety interlock circuitry is designed to protect both the microscope and its users. Overriding interlocks or any other interlock modification is strictly forbidden.

**WARNING**

**DO NOT remove any covers.** Do not remove any covers from the system, especially when the microscope is in operation! Only an authorized service engineer is allowed to remove covers.

**WARNING**

**DO NOT remove the ferrite shielding from the ion pump.** Do not remove the ferrite shielding from the ion pump during the pumping or bake-out procedures. Only an authorized service engineer is allowed to remove covers. Bake-out procedure can be also done only by an authorized service engineer.

**WARNING**

**DO NOT remove ion pump cover.** The voltage of the equipment under the cover is lethal. Take necessary precautions when servicing the microscope. This label is meant for an authorized service engineer. **Users are forbidden from removing any covers!**

**DANGER**

**Danger to life!** The microscope works with electric voltages that can be lethal! Keep in mind that even in the *Power save mode* the microscope is still running and remains powered up!

**DANGER**

**Danger to life!** Do NOT remove any panels, covers or cables. The equipment is an electric hazard when the covers are removed. Only an authorized service engineer can perform maintenance or service operations!



DANGER

**Danger to life!** DO NOT touch any of the **system live electronics, live electrical wiring or live electrical components!** Electric shock may result in severe injury or death! Only authorized service engineers can perform maintenance or service operations!



DANGER

**Danger to life!** Even when the system is powered OFF and even after any EMO button has been used, **UPS and chiller are still charged and the UPS output is switched off.**



DANGER

**Danger to life!** High magnetic field around the ion pump in the SEM column can cause **implanted pacemaker and cardioverter defibrillators to cease operation.** Maintain 30 cm / 12 inch safe distance from the ion pump! (This label applies only for TESCAN service engineer when baking the column above 350° C.)

If you have any questions that are relevant to safety, please contact TESCAN ORSAY HOLDING, a.s.

## 2.8 Radiation Safety

All valid radiation hazards are regularly monitored by the relevant authorized staff member. Protocols are being updated and shared (T@M website). To acquire these protocols please ask your local distributor.

### 2.8.1 Ionizing Radiation

When the electron column is in operation, electron particles are emitted towards the sample inside the chamber. Ionizing radiation is released when these electron particles strike the sample. The covers and shielding built into the microscope protect the user from ionizing radiation adequately within the safety limits according to Directive 2013/59/Euratom.

The maximum amount measured is 1 µSv/h at a distance of 10 cm from the sample surface during operation.



#### WARNING

**DO NOT remove any covers.** Do not remove any covers from the system, especially when the microscope is in operation! Only the authorized service engineer is allowed to remove covers.

## 2.8.2 Magnetic Field

The strength of the magnetic field is determined by the speed of pumping. The ferrite shields protect the user from the effects of the magnetic field adequately within the safety limits according to Directive 2013/35/EU.

The maximum amount measured is 0.08 mT at a distance of 30 cm from the ion pump surface and 0.20 mT at a distance of 10 cm from the ion pump surface during operation. All required safety labels are placed on the ion pumps.

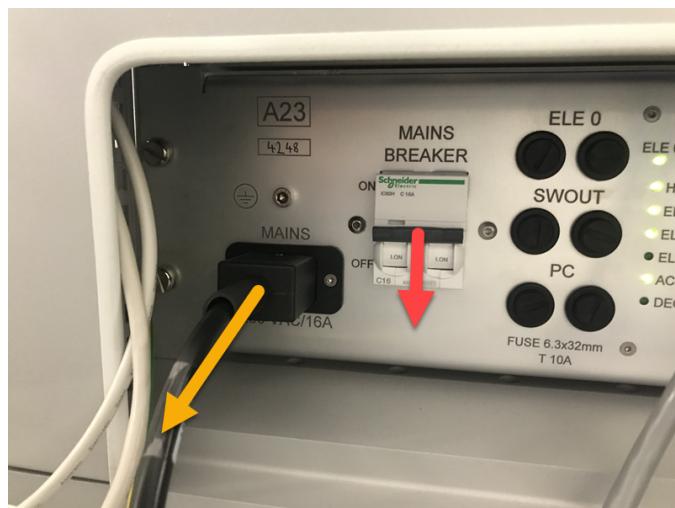


#### WARNING

**DO NOT remove the ferrite shielding from the ion pump.** Do not remove the ferrite shielding from the ion pump during the pumping or bake-out procedures. Only authorized service engineer is allowed to remove covers. Bake-out procedure can be also done only by the authorized service engineer.

## 2.9 EMO (EMergency Off) Button

**Note:** The EMergency Off (EMO) switch is an optional part of delivery. Follow this section only if your system has been supplied with EMO. If your system is not equipped with an EMO button, **in case of emergency** go to the back of the SEM electronics cabinet and **put the MAINS BREAKER to the position OFF** (the red arrow below) or unplug the cable from the MAINS port (the yellow arrow).



All system operators must be trained in EMO operation procedures and must memorize the position of the EMO switch so the operator can press it immediately from any position.

EMO is located on the operator's table and can float. The position of the EMO button must be < 3 meters (10 feet) from the user. The function of EMO button is to switch off outputs from UPS immediately thus no electricity runs through the microscope system. But, UPS and chiller (if present) are still charged.

**In case of emergency activate EMO by pressing down the red button and the whole system is completely deenergized immediately.** After emergency OFF, the user is not allowed to deactivate it by releasing the button unless the system is checked by an authorized TESCAN service employee. Only an authorized service engineer is allowed to restart the system after an emergency power OFF.

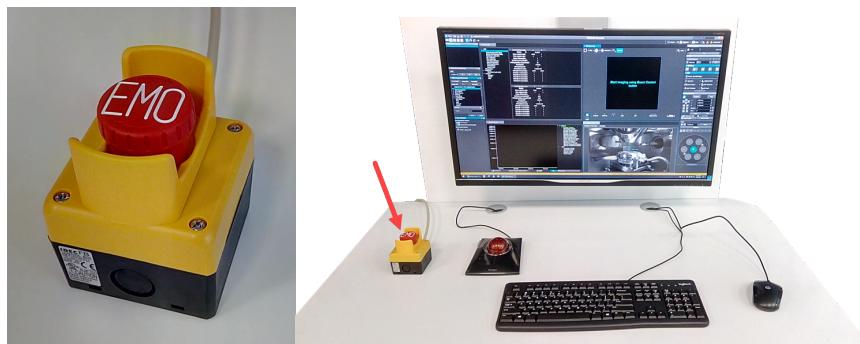


Figure 2-1 Position of the EMO button.

**NOTICE**

**Misusing EMO.** Misusing the EMO button when system is running may damage some system components. **Therefore EMO should be used only in case of emergency!** It is not intended for any other use than real emergency, e.g. such as fire, danger of electric current injury or similar. Never use EMO for just switching off the system after your work is finished.

**NOTICE**

**Keep EMO < 3 meters (10 feet) from the user.** The EMO button can be moved but it must be adjacent to the microscope operator all the time (< 3 meters!) so he / she can press it immediately from any position when sitting and working with the microscope or exchanging the sample.

**NOTICE**

**EMO deactivation.** Never deactivate any EMO button yourself after real accident (fire etc.).

**DANGER**

**Danger to life!** Even when the system is powered OFF and even after any EMO button has been used, **UPS and chiller are still charged and the UPS output is switched off.**

## 2.10 Chemicals

Read the applicable MSDS (Material Safety Data Sheet) prior to using or handling any chemicals. The user is responsible for obtaining any process-related MSDSs and should contact their suppliers to obtain them. The user must obtain the MSDSs from their chemical supplier, rather than TESCAN for chemicals which are not inherent in the system when shipped. The customer is responsible for the safe storage and disposal of all chemicals in accordance with applicable local and national regulations.

### Nitrogen (N<sub>2</sub>)

Nitrogen may be used to vent the system. Nitrogen is not poisonous, but is a potential asphyxiant.

**WARNING**

**Handling chemicals.** Avoid all spillage, skin, body and eye contact, as well as vapor inhalation when working with chemicals! Always use solvents carefully and sparingly. Wear gloves when handling parts that enter the vacuum chamber. Always wear a face shield and safety glasses.

## 2.11 Dismounting and Disposal

When disposing the microscope at the end of its service life, all applicable laws and regulations must be followed. As some of the construction materials are recyclable, these instrument parts can be recycled and / or re-used in compliance with local regulations.

The owner of the product must transfer the disposed equipment / chemicals / part(s) of the product only to entities that are authorized by local legislation, for the disposal, collection or purchase of this type of waste.

The system comprises mainly steel, aluminum, and copper. Standard PVC insulation is used on most cables. Further, the system contains components included in standard electronic equipment. Vacuum components may contain surface contaminants as a result of process chemistry. The GIS and the associated chemicals and crucibles must be treated as chemical waste. Process chemicals must be disposed of in compliance with local environmental requirements.

Please make sure you follow all the legal requirements for waste handling and disposal when working with the device. Consult your local environmental agencies for decontamination and cleaning procedures and for recycling and disposal of electrical equipment.

Particularly when installation, repair and maintenance are being carried out, pay attention to substances that cause water / land / air pollution such as:

- lubricants (greases and oils)
- hydraulic fluid
- cleansing fluids containing solvents
- residues of component contamination due to chemistry during instrument use

These substances should be stored in vessels, transported and disposed of in compliance with all applicable local regulations.

## Battery Replacement

The battery supply unit contains a lead-acid battery. Upon replacement, they must be treated as chemical waste and disposed of according to local regulations.

TESCAN ORSAY HOLDING, a.s. is not liable for any damages to the users health or for environmental damage due to non-compliance with these hygienic and ecological principles. Please contact TESCAN ORSAY HOLDING, a.s. for any further help that is needed for recycling / re-use.

## 3 Installation and Repair

### 3.1 Transport and Storage

The method of delivery is defined in the contract and is determined individually depending on the destination. The method of delivery must be approved by the manufacturer. The instrument is packed and delivered in a partially disassembled state. The purchaser is obliged to check the status of the boxes at handover from the delivery service provider. In case any damage is detected, it is necessary to catalog the damage and inform the manufacturer without delay. The packed instrument must be stored in a clean and dry place within the temperature range of -20 °C and +40 °C and must not be exposed to corrosive substances which can cause oxidation (acid vapors etc.). Relative humidity must be less than 80 %.

### 3.2 Moving the Microscope

If the microscope is to be moved e.g. to another room, an authorized TESCAN service engineer must be contacted in order to measure possible interference in the new room. The microscope must never be moved without TESCAN supervision.

If a non-TESCAN equipment (e.g. a lifting equipment) is specified or recommended for handling the microscope or its part(s), and such equipment is not supplied by TESCAN, the non-TESCAN supplier must provide full safety and user documentation for all such equipment. In case it is not provided, we strongly recommend the user to request the supplier for this documentation before using the equipment.

### 3.3 Installation Instructions

Microscope delivery includes installation which 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 from either the manufacturer or an approved company complete the installation, connection to mains and user training. The customer is forbidden from connecting the microscope to the mains or any other manipulation, apart from moving the microscope to the storage location. The installation company will draw up an installation protocol. The warranty period starts on this date and the user can begin using the instrument normally as described in this manual.

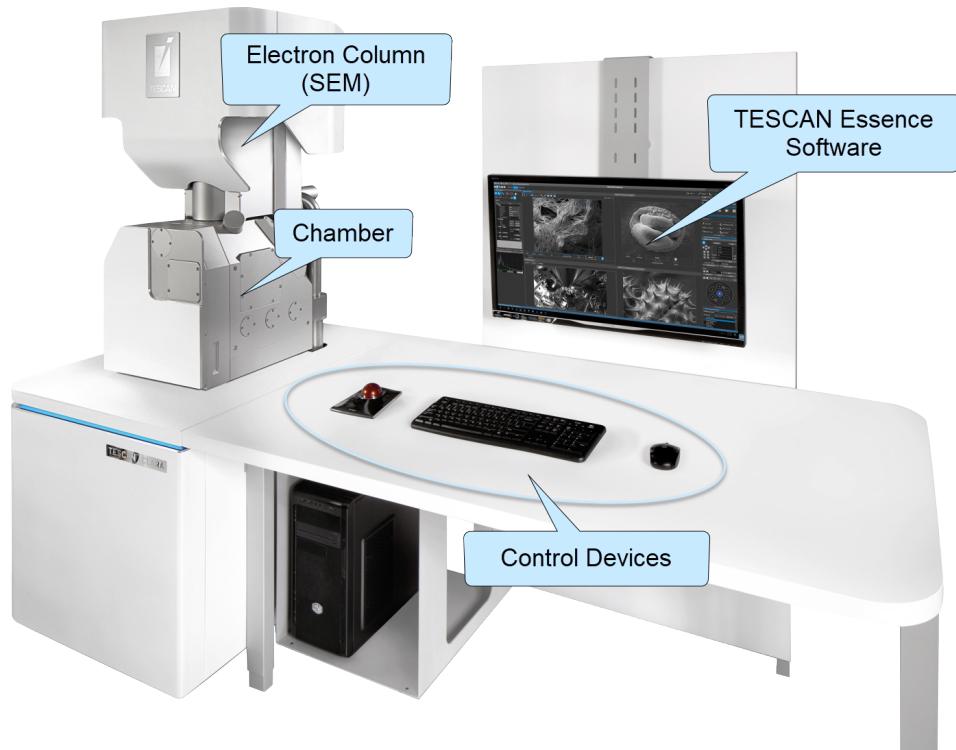
### 3.4 Fuse Replacement

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 an authorized service engineer. Fuses must be replaced only by those of the exact same type; the type is described in the documentation or on the fuse holder.

### 3.5 Instrument Repair and Spare Parts Usage

Only original spare parts delivered by the manufacturer must be used in all cases. Repair and maintenance other than the procedures mentioned in this manual must be performed only by a service technician or by a service technician either from a manufacturer or an approved company.

## 4 System Description



**Figure 4-1** Main parts of the TESCAN CLARA microscope (GM chamber)

- **Electron Column (SEM)** - The electron column (SEM column) generates the electrons, focuses them into a beam and points it at a given spot on the sample.
- **Chamber** - The chamber is a solid container where samples are placed during investigation.
- **Detection System** - Any signal, e.g. light, x-rays, secondary or back-scattered particles, from collisions of the primary beam particles with the sample surface are detected by several detectors located in the chamber and the SEM column.
- **TESCAN Essence Software** - The microscope is operated via computer software with various functionalities and modules for diverse applications.
- **TESCAN Essence Software** - The microscope is operated via computer software with various functionalities and modules for diverse applications.
- **Control Devices** - Every TESCAN microscope is provided with a keyboard, mouse and trackball. Optionally a Control panel can be included.

## 4.1 Electron Column (SEM)

The electron column (SEM column) generates and focuses the primary electron beam. It is located vertically on the top of the chamber.

The following scheme shows the SEM column cross-section:

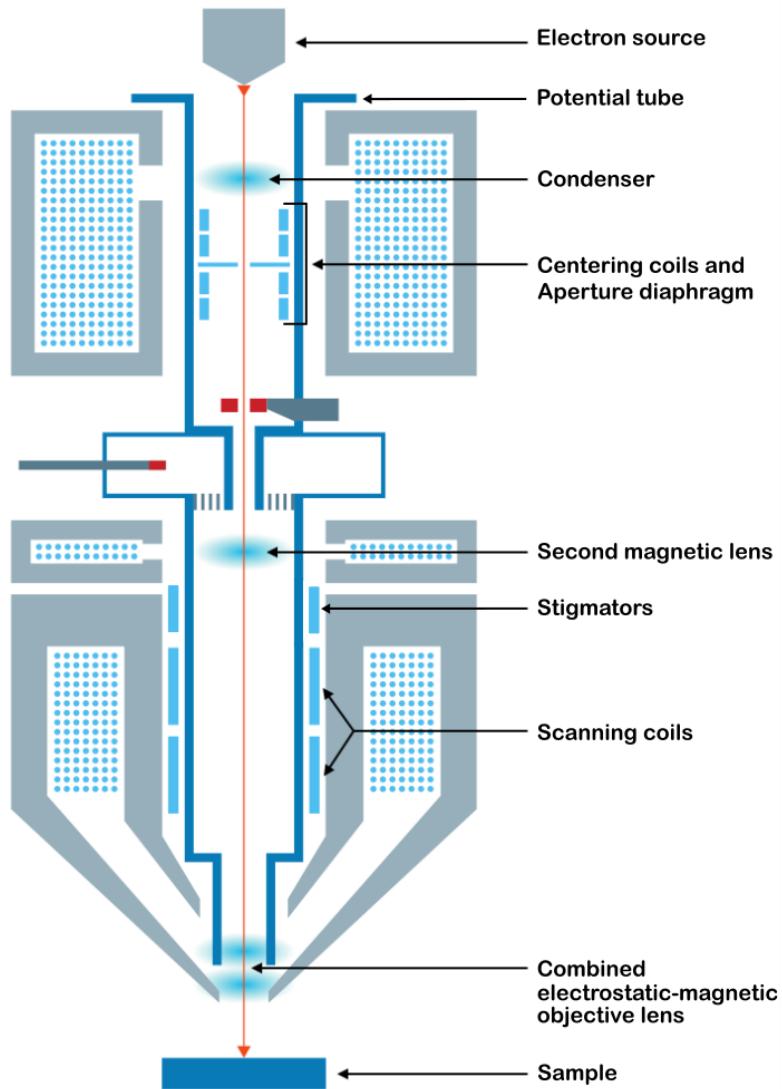


Figure 4-2 Cross-section of the electron column with its main parts

**Note:** For better clarity the electron primary beam is drawn as straight line. Practically its thickness / cross-section is changing on the way down due to effect of the electron column optical elements.

The SEM column consists of the following parts:

- **Electron source** (electron gun) - the source of accelerated electrons. Kinetic energy of the electrons can be set by changing the SEM parameter **Landing Energy** in the control software.
- **Potential tube** - keeps the primary electrons at a higher energy while passing through the electron column elements. It reduces susceptibility to external electro-magnetic noise and decreases aberration at the optical elements.

Potential tube has several working modes. See [SEM Potential Tube Modes on page 26](#).

- **Condenser** - a strong magnetic lens which controls the electron beam current, i.e. the amount of electrons landing on the sample. The electron beam current can be set by changing the SEM parameter **Beam Current** in the control software.
- **Centering coils** - a system of electromagnetic deflection coils under gun intended for the electron beam centering.
- **Aperture diaphragm** - an aperture that trims the electron beam. It is located under the condenser and the centering coils. The size of the diaphragm together with condenser lens excitation defines the electron beam current.
- **Second magnetic lens** - an auxiliary magnetic lens used for changing the aperture of the beam entering the objective lens or for direct focusing the beam if the objective lens is off.

It enables multiple display modes. See [SEM Scan Modes on page 23](#).

- **Stigmators** - electromagnetic elements intended for compensation of astigmatism in all display modes. Stigmators are controlled with the SEM parameter **Stigmator** in control software.
- **Scanning coils** - two stages of deflection coils perform scanning of the electron beam across the sample surface. Frequency of scanning is determined by the SEM parameter **Scan Speed** and the amplitude is determined by the SEM parameter **Field of View** (or **Magnification**) in the control software.
- **Combined magnetic-electrostatic objective lens** - the last lens of the column that focuses the electron beam onto the sample surface.

To learn more about SEM parameters (e.g. Landing Energy, Scan Speed etc.) see chapter **SEM Panel** in *Essence Help*.

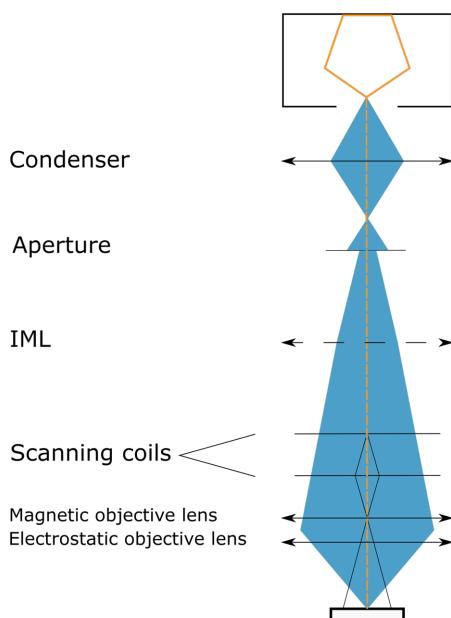
## 4.2 SEM Scan Modes

The electron column allows you to display an image in various scanning using the Wide Field Optics™. Available SEM scan modes (also Display or Imaging modes) are as follows:

1. **UH-RESOLUTION scan mode** for ultra-high resolution imaging.
2. **DEPTH scan mode** for ultra-high resolution with increased depth of focus.
3. **ANALYSIS scan mode** for imaging and analysis without the potential BrightBeam™ tube.
4. **OVERVIEW scan mode** for measurement and analytics made on large field of view.
5. **WIDE FIELD scan mode** for navigation over the sample with the widest field of view and the lowest magnification.

**Note:** The UH-RESOLUTION and DEPTH are the only scan modes that allow use of the potential tube and its potential modes. To learn more see [SEM Potential Tube Modes on page 26](#).

### 4.2.1 UH-RESOLUTION Scan Mode

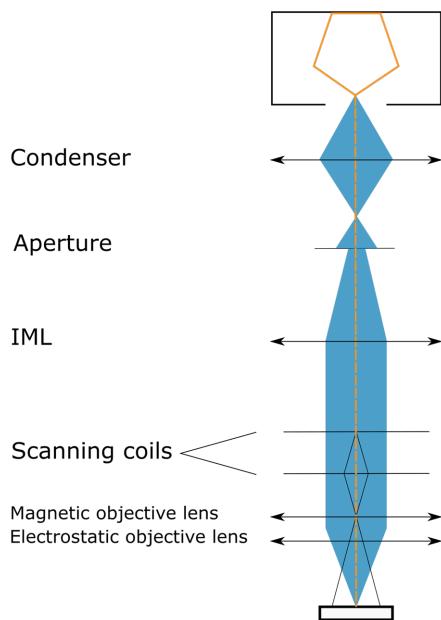


The UH-RESOLUTION (UH-R) scan mode is the **best choice for ultra-high resolution imaging** in wide range of currents (1 pA - 1 nA). Working distance for optimum resolution is **WD = 1 mm**. Final focusing of the electron beam is performed by the combined electrostatic-magnetic objective lens.

#### Characteristics:

- ultra-high resolution
- low depth of focus
- working energy 50 eV–20 keV
- potential tube ON

#### 4.2.2 DEPTH Scan Mode

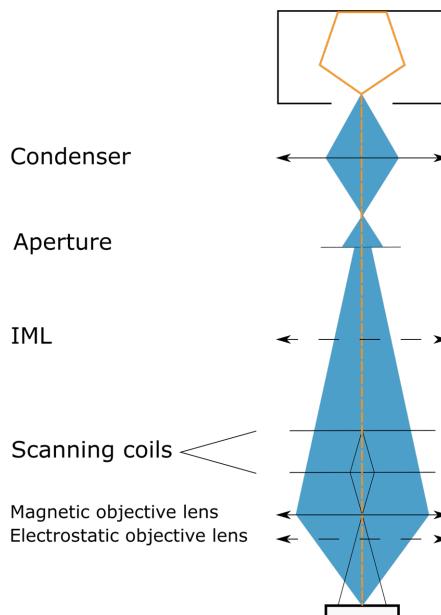


The DEPTH scan mode is recommended for **ultra-high resolution imaging with increased depth of focus**. However resolution is a bit worse than in the UH-RESOLUTION scan mode. Final focusing is performed by the combined electrostatic-magnetic objective lens.

Characteristics:

- increased depth of focus
- potential tube ON
- working energy 50 eV–20 keV

#### 4.2.3 ANALYSIS Scan Mode

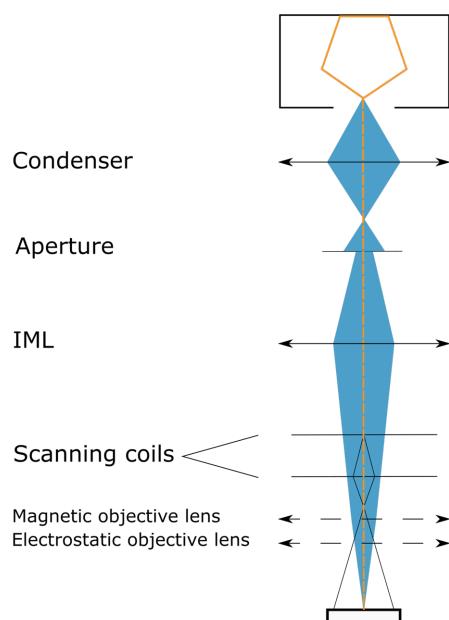


The ANALYSIS scan mode is suitable for imaging while the potential tube is OFF. Optimal working distance is about **2 mm** with an in-chamber E-T detector.

Characteristics:

- good resolution (worse than UH-RESOLUTION)
- working energy is 200 eV–30 keV
- potential tube OFF

#### 4.2.4 OVERVIEW Scan Mode

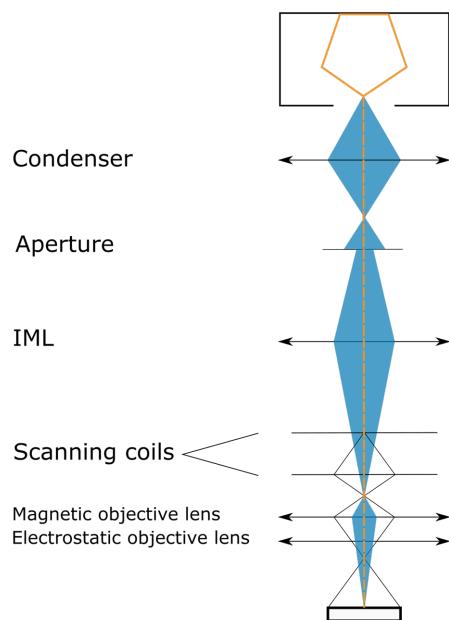


The OVERVIEW scan mode is the best choice when a **large field of view** with minimal distortion is required. Final focusing of the electron beam is performed by the second magnetic lens.

##### Characteristics:

- large field of view
- high depth of focus
- better spot size at high beam currents
- working energy 200 eV–30 keV
- potential tube OFF

#### 4.2.5 WIDE FIELD Scan Mode



The WIDE FIELD scan mode is the best choice when a **extra large field of view** is required. The mode is used to search for the part of the specimen to be examined.

##### Characteristics:

- extra large field of view
- image distortion is corrected
- potential tube OFF

### 4.3 SEM Potential Tube Modes

The potential modes are meant for customizing electrical potential applied on potential tube in the [Electron Column \(SEM\) \(page 21\)](#). The typical tube potential is further automatically controlled according to high voltage to achieve optimal performance.

Within the TESCAN Essence software there are three potential modes – **Bright Beam**, **Universal** and **Axial BSE**.

1. **Bright Beam** for best resolution.
2. **Universal** for low-kV BSE imaging and energy filtering.\*
3. **Axial BSE** for compositional contrast.\*\*

Detected particles within those potential modes are summarized in the following table:

Potential mode	Multidetector		Axial detector	E-T detector
	grid OFF	grid ON		
Bright Beam	In-Beam SE	<i>grid disabled</i>	Axial SE	Topographic BSE
Universal	In-Beam SE	In-Beam (filtered) BSE	Axial SE	Topographic BSE
Axial BSE	In-Beam SE	In-Beam (filtered) BSE	Axial BSE	Topographic BSE

**Table 4-1** Detected particles within potential modes

\*Maximum landing energy with full BSE filtering in the Universal mode is 1000 eV.

\*\*Maximum landing energy with full BSE filtering in the Axial BSE mode is 4100 eV.

**Note:** All these modes are available only in the UH-RESOLUTION and DEPTH scan modes. For the remaining scan modes the potential modes are inactive. To learn more about these scan modes see [SEM Scan Modes on page 23](#).

## 4.4 Chamber

The chamber is a solid container under the SEM column where samples are placed for investigation. The samples are fixed on the stage, thus allowing you to move them using the Essence SW.

Conventional SEM requires samples to be examined **under vacuum**, because a gas atmosphere rapidly spreads and attenuates the electron beam. Therefore the chamber is evacuated (pumped) during sample investigation. When the chamber is to be opened it must be refilled with nitrogen (vented) otherwise the pressure difference inside and outside keeps the door closed.

Once the chamber is pumped, samples can be examined in various vacuum modes. To learn more, see [Vacuum Modes on page 28](#).

**Note:** How to pump / vent the chamber, see [SEM Basics Step-by-Step on page 52](#).

Available chambers:

Chamber / Specifications	Large Analytical (LMH)	Large Analytical (LMU)	Extra Large Ana- lytical (GMH)	Extra Large Ana- lytical (GMU)
Vacuum mode	HighVac only	HighVac, LowVac	HighVac only	HighVac, LowVac
Movement in the X axis	80 mm (-40 mm to +40 mm)	80 mm (-40 mm to +40 mm)	130 mm (-65 mm to +65 mm)	130 mm (-65 mm to +65 mm)
Movement in the Y axis	60 mm (-30 mm to +30 mm)	60 mm (-30 mm to +30 mm)	130 mm (-65 mm to +65 mm)	130 mm (-65 mm to +65 mm)
Movement in the Z axis	49 mm	49 mm	95 mm	95 mm
Tilt ( <i>WD and sample size dependent</i> )	-80° to +80°	-80° to +80°	-60° to +90°	-60° to +90°
Rotation	360°	360°	360°	360°
Maximum <b>sample size</b> (diameter):	100 mm*	100 mm*	180 mm*	180 mm*
<b>Maximum specimen height:</b>				
• without rotation stage	76 mm	76 mm	136 mm	136 mm
• with rotation stage	49 mm	49 mm	95 mm	95 mm
<b>Maximum sample weight:</b>				
• without rotation stage	1000 g	1000 g	8000 g	8000 g
• with stage rotation	500 g	500 g	1000 g	1000 g

\*full XY moves and rotation, no tilt (larger samples possible with limited stage travel and rotation)

**Table 4-2** Chamber overview with specifications and sample limitations

## 4.5 Vacuum Modes

The following pressure modes are available in which the sample can be examined:

- **HighVac Mode** - A high vacuum mode when a sample can be examined once the chamber pressure reaches at least to 0.04 Pa.
- **LowVac Mode (OPTIONAL)** - A low vacuum mode when a sample can be examined with chamber pressure range of 7–500 Pa. The LowVac mode is intended for investigation of non-conductive samples. In LowVac the chamber can be filled with nitrogen (LowVac N<sub>2</sub>) or water vapor (LowVac H<sub>2</sub>O; if purchased). The mode requires a LowVac aperture placed in the SEM objective. To learn how to insert it see [Inserting / Removing the LowVac Aperture on page 104](#).

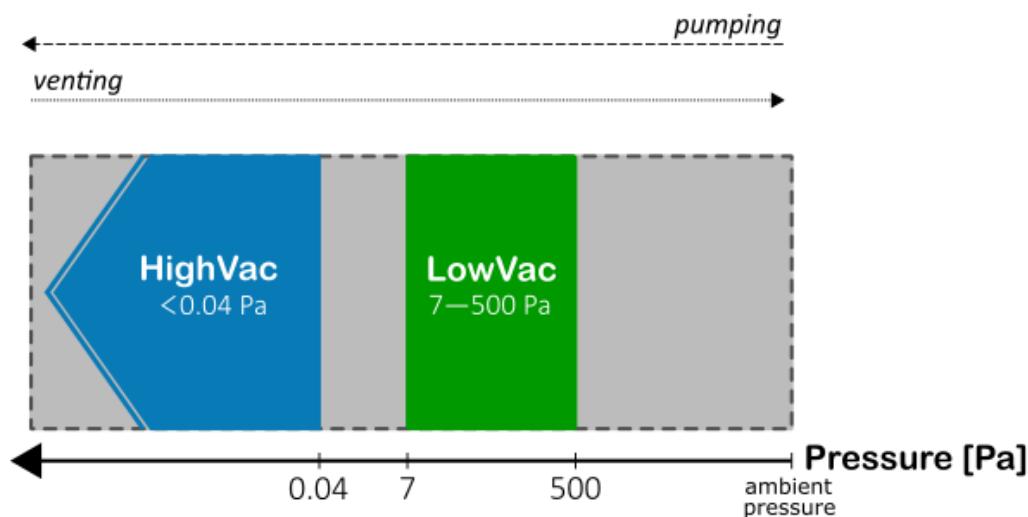


Figure 4-3 Scheme of available vacuum modes

**Note:** Both of these modes have very similar working and imaging strategies. To learn how to work in the HighVac mode, see [SEM Basics Step-by-Step on page 52](#); to learn how to work in the LowVac mode, see [SEM Basics Step-by-Step on page 52](#) first and then [Imaging in the LowVac Mode on page 64](#).

## 4.6 Sample Stage

While observing samples in the microscope they are placed inside the chamber and mounted on a stage. The stage allows sample movement so it is possible to examine different portions. The stage type may vary according to your microscope settings and the type of your chamber. This topic describes the stage features and how to control them.

The part of the stage with mounted samples is called the **stage carousel**. The following figure shows the standard stage with indicated movement axes X and Y.

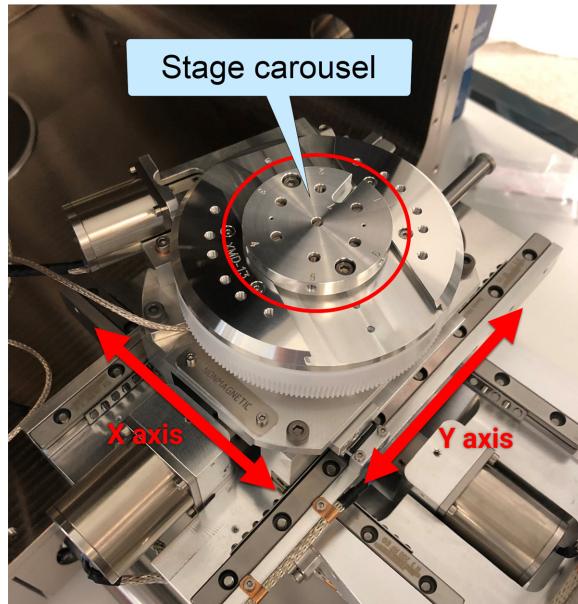
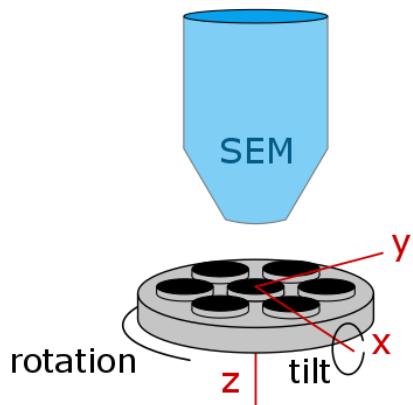


Figure 4-4 Illustration of the stage with marked movement axes

### 4.6.1 Description of Stage Movements

The sample stage is capable of five different kinds of movement: **translation along X, Y, Z axes, rotation around the Z axis and tilt around the X axis**.

#### Sample stage movements



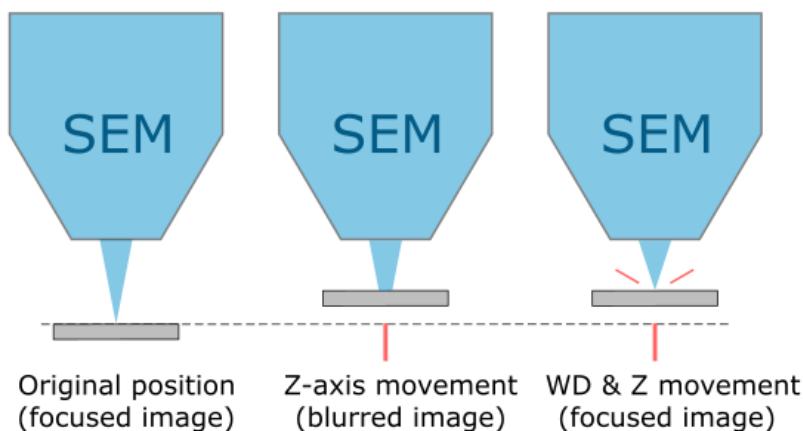
The following sections describe these movements together with two supportive control functions **WD&Z** and **Keep view field**.

#### 4.6.1.1 Movement along XYZ axes

When **stage tilt** is  $0^\circ$  a three-dimensional **Cartesian coordinate system** with left-handed orientation is used for stage navigation. The **X** and **Y** axes defines a horizontal plane where the stage can move so its distance from the objective remains the same. The **Z** axis allows downward movement (away from the objective - positive direction) and upward movement (towards the objective - negative direction).

**WD&Z function** - When simply moving the stage along the Z axis your SEM image become blurry because the electron beam is still focused at the original sample position. Instead of moving the stage with subsequent focusing you can use **WD&Z** function in the **Stage Control** panel. This function moves the stage and at the same time it adjusts the WD parameter of the SEM.

#### Z-axis movement compared to WD & Z function

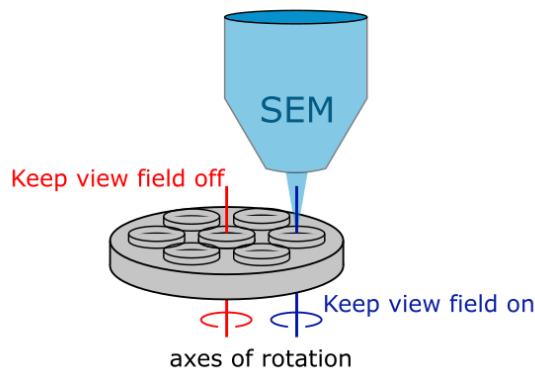


**Note:** Use the **WD&Z** function only when the image is properly focused to avoid physical collision of the sample with other microscope hardware parts.

#### 4.6.1.2 Rotation

By default the stage carousel rotates around its center (the origin of the default coordinate system XY[0,0]). But if you require rotation when examining some spot on a sample located off the carousel central point you need to use **Keep view field** function. **Keep view field** function moves the axis of rotation to the center of active scanning window.

**Note:** **Keep view field** checkbox also affects tilting of the stage. See **Tilt** section below.

**Rotation with "Keep view field" feature****How To Turn Keep View Field Function ON / OFF**

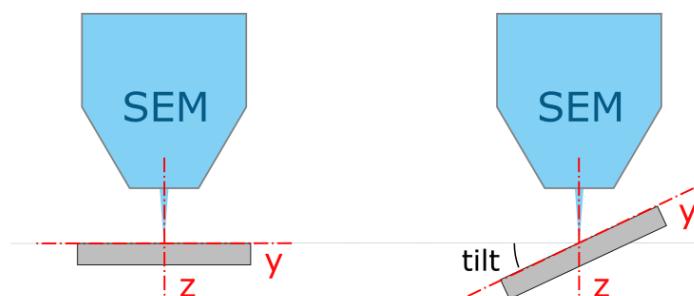
To turn Keep view field function on check the Keep view field checkbox in the Stage Control panel. To turn it off uncheck the checkbox.

**Note:** Keep view field is available only in expert mode of the Stage Control panel (use icon to switch the panel mode).

**4.6.1.3 Tilt**

**Stage tilt or tilting the sample** means stage rotation **around X axis**. It is called tilting because when observing the process in the scanning window it seems as if the sample is tilting instead of rotating.

- Tilting changes the coordinate system of the stage movements as can be seen in the following figure.

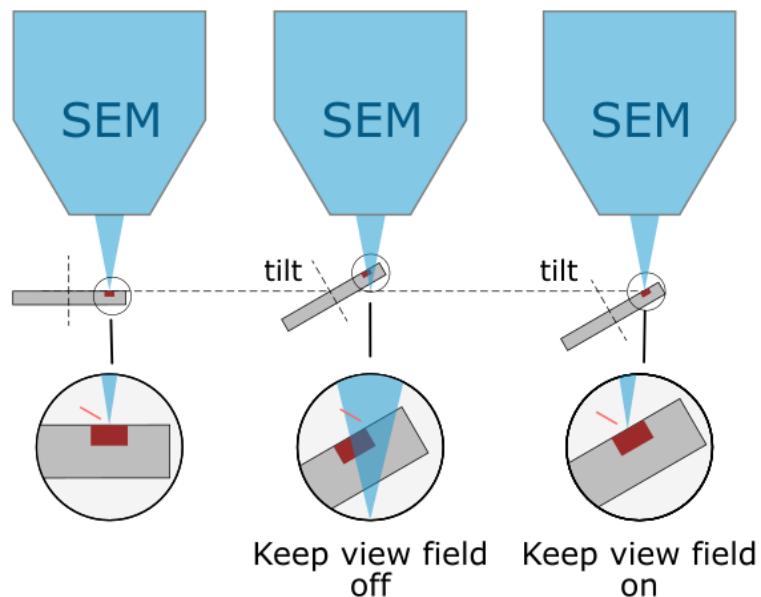
**Coordinate system transformation after stage tilt**

When sample is tilted, axes Y and Z are not perpendicular anymore. Also the image in the SEM scanning window becomes skewed - that can be compensated using geometric transformations (see chapter **Geometric Transformations** in *Essence Help*).

- **Keep view field** function for tilting is analogous in principle as for rotation. The function moves the axis of

tilting to the center of the active scanning window and to the sample surface z-level (the sample must be focused in the scanning window). Therefore after tilting the sample you should see the same spot in the scanning window as before.

#### Tilt with "Keep view field" feature



**Note:** Keep view field checkbox also affects rotation of the stage. See Rotation section above.

## 4.7 Detectors

The detection system contains a set of detectors designed for detecting various signals resulting from electron beam interaction with the sample surface.

### 4.7.1 Electron Beam-Sample Interaction

When the electron beam enters the sample, electrostatic interactions with primary electrons (from the electron gun) and electrons of the target atoms generate secondary particles.

The observed contrast in SEM images is largely determined by characteristics of the selected detector and the scattering of secondary particles, mainly signals from secondary electrons (SEs) and back-scattered electrons (BSEs).

**Secondary electrons (SEs)** are electrons generated when the electron beam interacts with the sample surface (they leave the sample surface with energy  $E < 50$  eV). The final SE signal is generally composed of three separate contributions:

- $SE_1$  - generated close to the electron beam impact point.
- $SE_2$  - generated by the BSEs (see below) when leaving the surface area.
- $SE_3$  - generated by the BSEs that hit the objective polepiece and / or specimen chamber walls.

**Back-scattered electrons (BSEs)** are fractions of the primary electrons which are scattered back into the vacuum with energy  $E > 50$  eV.

During the SEM-sample interaction, primary electrons also ionize target atoms. When the atoms fall back into a lower energy state, they emit the **Auger electrons** or **X-rays**. The X-ray energy in the scanning electron microscopy is used for elemental identification (EDS or WDS spectrometry).

When the electron beam interacts with the sample, **visible light** might also be generated. Technique that uses generated light for imaging purposes in scanning electron microscopy is called **cathodoluminescence (CL)**.

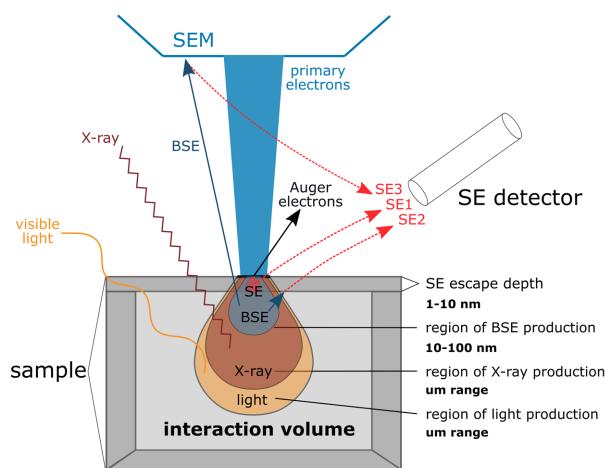


Figure 4-5 SEM-sample interaction scheme

The microscope is always delivered with the **In-Beam Axial detector**, the **In-Beam Multidetector (MD)** and the **E-T detector**. Other detectors can be added optionally.

Detector	Availability	Vacuum Modes	
		HighVac	LowVac
In-Beam Axial detector	standard	•	
In-Beam Multidetector		•	
E-T		•	
LE BSE*	optional	•	•
R-BSE*		•	•
LE 4Q BSE*		•	•
Water Cooled BSE*		•	•
Al-Coated BSE*		•	•
Retractable HADF STEM*		•	•
CL*		•	•
LVSTD			•
GSD			•
TESCAN EDS*		•	•
EDS	3 <sup>rd</sup> party products		
WDS <sup>G</sup>			
EBSD			
RISE <sup>G</sup>			

**Figure 4-6** List of available detectors

\*Equipped with retractable mechanics. When not in use, it should be fully retracted and placed in its parking position.

<sup>G</sup>Available only for GM chamber

**Note:** DO NOT use any motorized BSE detector with another motorized BSE detector at the same time.

#### 4.7.2 In-Beam Axial Detector

Detected particles	<b>axial SE, axial BSE, SE (BDM)</b>
Imaging contrast	<b>topography, material</b>
Vacuum mode	<b>HighVac only</b>

The In-Beam Axial Detector is a scintillator type detector. The detector is located inside the SEM column and detects electrons from a small radial area around the optical axis.

In the **Universal** and **Bright Beam** potential tube modes In-Beam Axial detector detects axial secondary electrons (SE) and in the **Axial BSE** potential tube mode it detects axial back-scattered electrons (BSE). Best choice for fast and high-resolution SE imaging at small working distances.

#### 4.7.3 In-Beam Multidetector (MD)

Detected particles	<b>SE (grid OFF), narrow-angle BSE (grid ON), low-loss BSE (grid ON)</b>
Imaging contrast	<b>topography, material</b>
Vacuum mode	<b>HighVac only</b>

The detector is equipped with a **filtering grid** where the signal electrons can be filtered according to their energy.

- When the **filter grid is OFF**: signal electrons are detected unfiltered, the resulting image will be topographic with typical edge contrast (SE contrast)
- When the **filter grid is ON**: signal electrons are detected filtered according the filtering energy. See example use in the following table:

Filter grid energy	Filtered signal	Contrast
-0.5 keV	SE part of signal	narrow angle BSE for Z-contrast
-1 keV	SE and slow BSE part of signal	detecting 1-2 keV BSE
-1.9 keV	SE and slow BSE part of signal	low-loss BSE for surface sensitivity

**Table 4-3** Examples of filter grid use for 2 keV

In-Beam Multidetector (MD) is located in the SEM column. It is designed to detect especially low energy back-scattered electrons (BSE) with possibility of energy filtering (low-loss BSE) which makes the material contrast much more surface sensitive. It also provides part of secondary electrons with higher SE energies which reduces contamination and charging effects in the image.

#### Working Conditions

- Recommendations: Very short working distance → improved resolution.
- Limitations: SE signal on Multidetector is present only in SEM scan modes with activated tube potential (UH-RESOLUTION, DEPTH). Filtering grid is disabled in the Bright Beam potential tube mode. To learn more see [SEM Potential Tube Modes on page 26](#).

**Note:** The *In-Beam* type of detection is sometimes called “in-lens” or “in-column” in the literature.

### In-Beam Axial & In-Beam Multidetector - Naming in Essence SW

Scan Mode	Potential Mode	SW name of Axial Detector	SW name of Multidetector	SW name of Multidetector (grid ON)
UH-RESOLUTION DEPTH	Bright Beam	Axial	MD	<i>grid disabled</i>
	Universal	Axial	MD	MD (f-BSE)
	Axial BSE	Axial (BSE)	MD	MD (f-BSE)
ANALYSIS OVERVIEW		Axial (BSE)	MD (BSE)	MD (f-BSE)
WIDE FIELD		Axial	MD	<i>grid disabled</i>

Table 4-4 Naming of In-Beam detectors in Essence SW

#### 4.7.4 Everhart-Thornley (E-T) Detector

Detected particles	SE, topographic BSE
Imaging contrast	topography
Vacuum mode	HighVac only

The Everhart-Thornley detector (E-T detector or ET detector) is a basic standard detector for topographic imaging. It detects topographic back-scatter electrons (BSE) when the potential tube is ON, which allow imaging of topographic contrast without edge effect and charging artifacts. When the potential tube is OFF, the detector detects secondary electrons (SE).

#### 4.7.5 Retractable BSE (R-BSE) Detector (Optional)

Detected particles	wide-angle BSE
Imaging contrast	(topography), material
Vacuum mode	HighVac, LowVac

Retractable BSE detector is an annular back-scattered electron detector for detecting wide-angle **back-scattered electrons** (BSE) and thus enhances **material contrast** of the sample. It is placed in the optical axis directly under the objective pole piece and can be retracted / inserted when needed. The retraction mechanism is motorized.

#### 4.7.6 Low Energy BSE (LE BSE) Detector (Optional)

Detected particles	wide-angle BSE
Imaging contrast	(topography), material
Vacuum mode	HighVac, LowVac

Low Energy BSE (LE BSE) detector is an annular back-scattered electron detector designed to work at **low energies down to 200 eV**. It detects wide-angle **back-scattered electrons** (BSE) and thus enhances **material contrast** of the sample.

It is placed in the optical axis directly under the objective pole piece and can be retracted / inserted when needed. The retraction mechanism is motorized.

#### 4.7.7 Low Energy 4Q BSE (LE 4Q BSE) Detector (Optional)

Detected particles	<b>BSE</b>
Imaging contrast	<b>topography, compositional</b>
Vacuum mode	<b>HighVac, LowVac</b>

Low Energy 4-Quadrant BSE (LE 4Q BSE) detector is retractable detector designed for acquisition of back-scattered electrons (BSE). The retraction mechanism is motorized. The detector is located under the objective and composes of 4 diodes, that symmetrically surround the central opening for the electron beam pass. All four diodes have the same shape and area, therefore are called quadrants. To distinguish the quadrants, they are numbered in clockwise order and noted as Q1, Q2, Q3, Q4.

The detector allows to obtain information about both: sample composition and topography. Obtained information depends on the way how is the signal from all four quadrants mixed (adding and/or subtracting diode signal) into a resulting image. The signal is processed in the TESCAN Essence software offering four detector modes:

1. **COMPO** for composition
2. **TOPO** for topography
3. **Custom** for manual diode signal addition / subtraction
4. **Color** for color acquisition in HSV (hue, saturation, value) color model

To learn more see chapter **4Q BSE Mixer** in *Help*.

**Note:** Chamber view is unavailable when using the LE 4Q BSE detector.

**Note:** In case the detector was reinitialized (e.g. after leaving Power save mode), its preamplifier needs some time to stabilize. Wait few minutes before using.

#### 4.7.8 Water Cooled BSE Detector (Optional)

Detected particles	<b>wide-angle BSE</b>
Imaging contrast	<b>(topography), material</b>
Vacuum mode	<b>HighVac, LowVac</b>

Water Cooled BSE detector is a retractable annular scintillation detector specially designed for applications in which the sample needs to be heated to such high temperatures that could damage the standard BSE detector. The detector can operate at very high temperatures thanks to an **automatic water circulation cooling system**.

The detector also serves as a **heat radiation shield** against heating stage. For this purpose, the detector must be inserted i.e. in the working position.

Limitations: DO NOT use this detector with another motorized BSE detector at the same.

The retraction mechanism is motorized.

**Note:** When the detector temperature is reaching critical value, that can damage the detector, a warning appears. When this critical value is fully reached, the detector is retracted automatically to protect itself.

#### 4.7.9 Aluminum-Coated BSE Detector (Optional)

Detected particles	<b>BSE</b>
Imaging contrast	(topography), material
Vacuum mode	HighVac, LowVac

Aluminum- Coated BSE detector is a retractable detector enabling simultaneous acquisition of cathodoluminescence (CL) and BSE signals. It helps to avoid the cross-talking between BSE and CL detectors because of the protective aluminum layer preventing photons emitted from the BSE scintillator to reach the CL detector.

The retraction mechanism is motorized.

#### 4.7.10 Retractable HADF STEM (R-STEM) Detector (Optional)

Detected particles	<b>transmitted electrons</b>
Imaging contrast	<b>compositional, orientation</b>
Vacuum mode	<b>HighVac, LowVac</b>

Retractable STEM (R-STEM, Retractable Scanning Transmission Electron Microscopy) detector enhanced with HADF (High Angle Dark Field) imaging provides a complementary method for image acquisition of **transmitted electrons**. The detector consists of several semiconductor sensors for bright field (BF), dark field (DF) and high angle dark field (HADF) imaging. These sensors detect electrons scattered in different angles with information arising from within a thin foil used for scanning transmission electron microscopy (STEM):

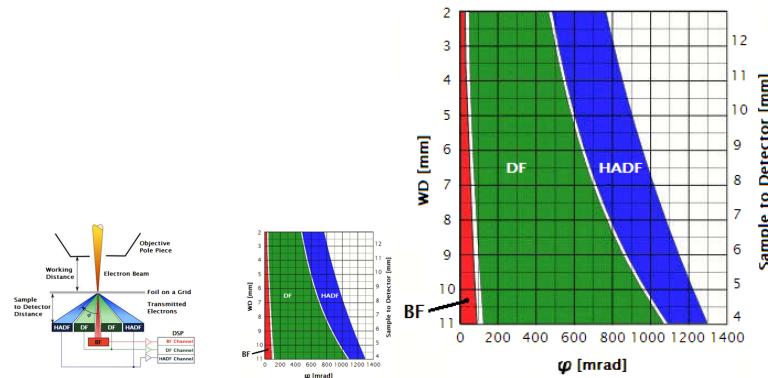
- The **Bright Field** (BF) signal typically represents Bragg-diffraction contrast and absorption contrast on thin foils.
- The **Dark Field** (DF) contains partly orientation contrast and scattering from light elements
- The **High Angle Dark Field** (HADF) contains maximum information about material contrast and minimum Bragg-diffraction contrast.

In the **Bright Field** imaging an **aperture size** (diameter) can be manually customized within the hardware. Four aperture sizes are available: 1 mm, 500 µm, 300 µm and 100 µm. The smaller the aperture size the more narrow the Bright Field angle and thus better contrast when examining light materials.

By placing the detection system below the specimen, the transmitted electron signal can be collected. It allows movement of the sample above the detector or observation of multiple samples without opening the chamber.

The scattering angles depend on the **sample material**, **foil thickness** and the **energy of the beam**. The segments of the detector can receive different portions of the scattered electrons, depending on the sample distance. Changing the sample working distance therefore also affects the type of signal detected by each segment / channel. The sample can be navigated easily to the position for maximum contrast using the working distance.

The schematic of acceptance angle distribution of detector segments depending on sample working distance is shown below:



**Figure 4-7** R-STEM with HADF schematics (left) and R-STEM angle signal distribution (right)

## R-STEM Sample Holders

- **APG-10** Sample holder with 8 positions for 3.05 mm TEM Grids. Positions 7 and 8 are designed for analytical purposes (minimizing background from the holder for EDS). They are also suitable for Lift-out grids.



**Figure 4-8** APG-10 sample holder for R-STEM

### 4.7.11 Cathodoluminescence (CL) Detectors (Optional)

Detected particles	light
Imaging contrast	CL contrast
Vacuum mode	HighVac, LowVac

The following are the available CL detectors for your microscope configuration. All of them are optional and retractable (manually or motorized).

1. **Retractable Panchromatic CL Detector** (standard version) with wavelength range of the detected light **350 - 650 nm** (mainly visible and near UV light).
2. **Retractable Panchromatic CL Detector** (standard version) with wavelength range of the detected light **185 - 850 nm** range (UV, visible and near IR light).
3. **Retractable Rainbow CL Detector** (standard version) - enables simultaneous panchromatic and color CL imaging of the sample in **four separate channels**. Spectral range of the detector is 350 - 850 nm. The panchromatic channel of the detector collects the total CL signal over the entire spectral range. Three color (red, green and blue) channels collect signal in the corresponding parts of the spectrum. The combination of R, G and B channels gives then a live color image of the scanned area.
4. **Compact Retractable Panchromatic CL Detector** - a compact version of Retractable Panchromatic CL detector (350 - 650 nm) for simultaneous CL and BSE detection with manually retractable mechanism.
5. **Compact Retractable Panchromatic CL Detector** - a compact version of Retractable Panchromatic CL detector (185 - 850 nm) for simultaneous CL and BSE detection with manually retractable mechanism.
6. **Compact Retractable Rainbow CL Detector** - a compact version of Retractable Rainbow CL detector (185 - 850 nm) for simultaneous CL and BSE detection with manually retractable mechanism.

**Note:** The Chamber View is automatically switched off when the CL detector is in use.

#### 4.7.12 Low Vacuum Secondary TESCAN (LVSTD) Detector (Optional)

Detected particles	<b>SE</b>
Imaging contrast	<b>topography</b>
Vacuum mode	<b>LowVac only</b>

LVSTD (Low Vacuum Secondary TESCAN Detector) is a detector of secondary electrons, specially designed for the 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 separate detector chamber pumped using a small turbomolecular pump.

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

**Note:** Secondary electrons, in contrast to back-scattered electrons, are much more sensitive to specimen surface charging, as they are very low in energy. There are several approaches to eliminate charging: using a higher pressure in the chamber, using a lower accelerating voltage of primary electrons, using a lower electron beam current or using another scanning strategies, i.e. drift accumulation.

#### 4.7.13 Gaseous Secondary Electron (GSD) Detector (Optional)

Detected particles	<b>SE</b>
Imaging contrast	<b>topography</b>
Vacuum mode	<b>LowVac only</b>

Gaseous Secondary electron detector is a detector of secondary electrons, specially designed for the low vacuum mode. It is suitable for the investigation of non-conductive samples without need of conductive surface coating.

The detector is optimally biased according to the current low pressure in order to get an optimal image without detector arcing. The detector bias can be also controlled manually by the user to increase the image contrast, or to avoid the image saturation. To learn how to control the detector bias manually, see chapter **Gaseous Detector Panel** in *Essence Help*.

**Note:** The stability of the signal from the GSD depends strongly on the pressure inside the chamber. In order to obtain images with stable brightness, it is necessary to have stable pressure in the chamber. Therefore, whenever the required pressure value is changed, the image might become darker until the pressure and then the detector bias reach their new levels and become stable (respectively).

**Note:** Secondary electrons, in contrast to back-scattered electrons, are much more sensitive to specimen surface charging, as they are very low in energy. There are several approaches to eliminate charging: using a higher pressure in the chamber, using a lower accelerating voltage of primary electrons, using a lower electron beam current or using another scanning strategies, i.e. accumulation. See [SEM Imaging of Non-conductive Samples on page 58](#).

#### 4.7.14 TESCAN EDS Detector (Optional)

Detected particles	X-rays
Imaging contrast	chemical composition
Vacuum mode	HighVac, LowVac

TESCAN EDS (Energy-Dispersive X-ray Spectrometry) detector is an optional micro-analytical tool used to separate the characteristic x-rays of different elements into an energy spectrum.

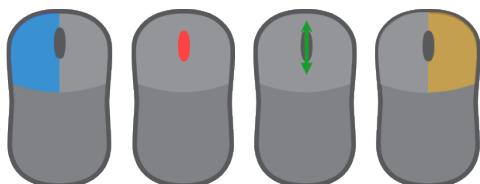
The detector position is fixed or it has manually retractable mechanism, i.e. it must be inserted prior an analysis.

## 4.8 Control Devices

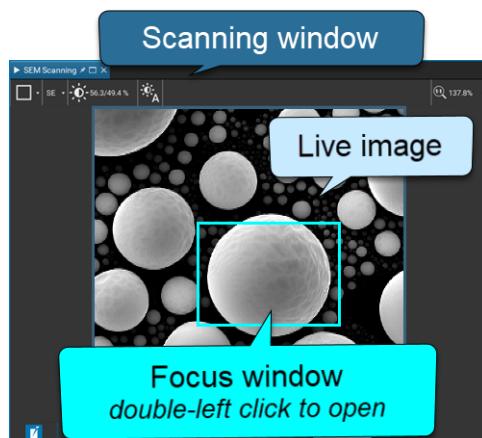
Every TESCAN microscope is provided with a keyboard, mouse and trackball. Optionally a Control Panel can be included.

### 4.8.1 Mouse

The mouse usage follows standard Windows system conventions.



Mouse Functions in Live Image	
Right-click	opens contextual menu for quick program control
Scrolling the mouse wheel	changes Scan Speed (scanning window must to be active)
Double-left click	turns the Focus window ON / OFF
Mouse Functions in Focus Window	
Dragging with the right-mouse button	resizes the Focus window
Dragging with the left-mouse button	moves the Focus window
Moving with the Stage	
Clicking the mouse wheel	moves the selected object in the center of the scanning window
Dragging with the mouse wheel	moves the selected object to the selected position of the scanning window
Mouse wheel in Pad	
Scrolling the mouse wheel	increases / decreases the value (click into field with value, press CTRL & scroll)



**Note:** Standard behavior of mouse buttons may differ in some Essence modules. Such differences are described in dedicated Help chapters.

**Note:** Holding down the mouse wheel and pressing CTRL on your keyboard on the selected object in the Scanning window for longer than 1 second moves the stage so that the object lies in the center of the Scanning window and the magnification is increased. To learn more find *Center&Zoom* in *Essence Help*.

#### 4.8.2 Trackball

The trackball is often used with the Pad panel:

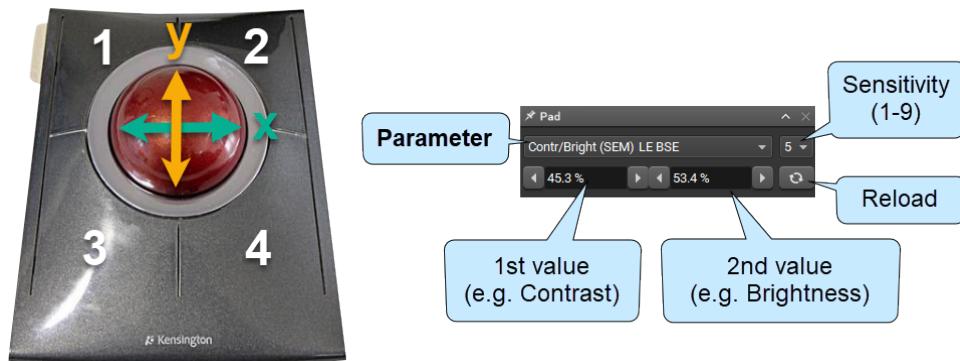


Figure 4-9 Trackball and Pad panel

#### Operation

- Horizontal motion (**X axis**) changes the 1st value of the active parameter
- Vertical motion (**Y axis**) changes the 2nd value of the active parameter
- Four buttons (**1, 2, 3, 4**) for step-wise changing of values
- **Trackball sensitivity** of the selected function can be changed in **Pad** (1–9).

#### F11 & F12 keys

- To change 1st value (e.g. Contrast): Press&hold **F12** to lock 2nd value (e.g. Brightness) and move the trackball in horizontal direction (**X axis**)
- To change 2nd value (e.g. Brightness): Press&hold **F11** to lock 1st value (e.g. Contrast) and move the trackball in vertical direction (**Y axis**)

## Trackball Remote Control

Trackball cannot be controlled remotely. Instead of trackball, you can use **keyboard shortcuts**:

1. Go to Pad and select the parameter you want to change (e.g. Brightness / Contrast).
2. In Pad also select **Sensitivity**. Start with higher numbers (7–9), afterwards you can decrease the sensitivity for fine tuning.
3. Activate the scanning window (i.e. left-click on it).
4. Use keyboard shortcuts **SHIFT** + arrow key:
  - **SHIFT** +  $\leftarrow$  decrements 1st value
  - **SHIFT** +  $\rightarrow$  increments 1st value
  - **SHIFT** +  $\uparrow$  decrements 2nd value
  - **SHIFT** +  $\downarrow$  increments 2nd value

→ [Keyboard Shortcuts on page 143](#)

### 4.8.3 Control Panel

The TESCAN Control Panel (CP) is an **optional** hardware accessory developed for scanning control. This panel can control **magnification**, **focus**, **image shift and rotation**, **stigmators alignment** and other parameters necessary for working with the microscope. These parameters are operated using the buttons and knobs in the control panel. Some CP buttons can be customized (those with no labels).

The panel is connected to the computer by a USB cable. Control panel is designed to be placed on the left of the keyboard.



Figure 4-10 Control panel

## Knobs

- Knobs dedicated to **magnifying** and **focusing** (WD) are placed in the bottom left of the control panel.
- Image movement (not stage movement) is controlled using the knobs **Image Shift X and Y** and **Image Rotation**, located just under the TESCAN logo.
- Under the knobs for image shift / rotation, there are two knobs and one button for SEM centering control: **Stigmator X / Y** knobs primarily for X and Y alignment of Stigmators parameter and the **Wobble** button for activation of the SEM Objective centering wizard

**Note:** Stigmator X / Y knobs also control the XY parameter of the SEM column (Stigmator centering A / B, SEM Objective centering etc.) when the particular alignment wizard is running.

For example, when the SEM Objective centering wizard is running (e.g. when using the Wobble button on the Control panel), Stigmator X / Y knobs align the XY parameters of electron column objective.

- **Contrast, brightness** and **auto contrast / brightness** are controlled using two knobs and one button in the bottom right of the panel.

## Buttons

- There are four buttons in the top left corner of the panel. The top left button starts **image acquisition**, the button just below it turns the live image **accumulation on / off**. The top right button **minimizes magnification** and the button below that opens / closes the **focus window** (focus window will appear where it was last opened). These buttons do not have label and can be customized.

→ chapter **Control Panel Setup** in *Essence Help*

- Buttons located in the top right corner are linked to SEM scanning, the top one is for starting / stopping **SEM Continual scan**, the second one is for image autofocusing. These two buttons can also be customized.
- The **Wobble** button opens the SEM Objective Centering wizard. Once the wizard is open and the objective is centered (e.g. using the Stigmator X / Y knobs), this button also closes the wizard. This button cannot be customized (has a label).
- The **Auto C / B** button proceeds the auto contrast / brightness procedure. This button cannot be customized either.

## 5 Starting the Microscope

There is no need to start the microscope mechanism before using it, because the source of primary electrons (FEG - Field Emission Gun) is permanently switched ON. This ensures stability of electron emission without interruption over the entire lifetime of the Schottky cathode (thousands of hours). FEG is turned OFF only for a non-standard reason, e.g. prolonged power supply interruption, servicing the microscope etc.

The SEM emission is constantly monitored in the background by TESCAN Essence software and in case of a mains power failure, the SEM gun is switched OFF automatically. Therefore, **the software should be left permanently running** (logging is not needed).

The user has only to start the TESCAN Essence software to be able to work with the microscope (when the software is not already running).

**Note:** The user is able to monitor the high voltage (HV) power supply of the Field Emission Gun (FEG) of the SEM column in the **FEG HV Control** panel. In this panel, users at the supervisor level are allowed to turn FEG ON / OFF if needed (e.g. when the microscope will not be used for a long time).

### How To Log In

To log into the software a user name and a password are required. If you do not have a user account yet, ask your system supervisor.

1. Double-left-click on the TESCAN Essence software icon  located on the Windows desktop.
2. Select your **user name** and fill in your **password**. Optionally, you can select a **project** that you are going to work on (visible only if any project exists).
3. Click OK or confirm with ENTER.
4. In case the microscope is in **Sleep mode** or **Power save mode**, the microscope needs to be reinitialized (the control button in toolbar is orange: ). Click the button to switch back to standard operating mode. When the microscope was in Power save mode, clicking this button also initializes the chamber pumping procedure.

## 5.1 User Access Levels

The TESCAN Essence software can be operated from various user accounts. Every user account stores its own system settings and software layout. It is also possible for many user accounts to share settings.



If you do **not have a user account** yet, ask your system supervisor. Only supervisors are allowed to create an account (via Menu » Options » User Manager).

Two user levels of different authorization are available - **Supervisor** and **User**:

- **Supervisor** - Microscope and software administrator who manages other user accounts. The supervisor can set general software parameters and has more functions available than a regular user. Supervisor level is the only level where the user controlling panel **User Manager** can be operated.
- **User** - An account for routine software operations.

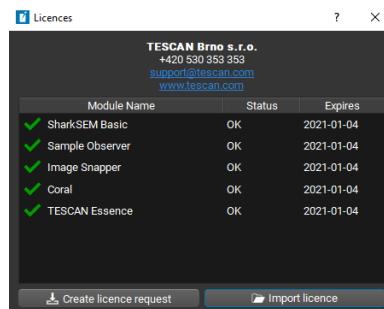
+ **Alias** user level is a **special multi-user account** to which other user accounts can be assigned. These accounts then share the system settings and interface arrangement. Alias itself does not behave as a regular account - it just links other assigned user accounts. That is why alias account will not show up in the Log in screen - only assigned user accounts can be selected.

→ Chapter **User Management** in *Essence Help*

## 5.2 Licences

TESCAN Essence software contains many **optional modules that require a product activation licence**, e.g. Image Snapper, Coral etc. Each module has its own special identification number which is assigned to a unique licence key. Licences are provided for various time periods depending on your order. Licence lifetime can be extended.

Licences are managed in TESCAN Essence through the **Licences** panel. If you purchased your optional modules in one order together with your microscope, **TESCAN activates all your modules automatically during the final assembly**. There is no action required from your side. To check your licence status, open the **Licences** panel (via Menu » Help » Licences).



ACTION IS REQUIRED only if you **additionally order an optional module** or want to **extend your licence** → Chapter ***Licence Management*** in *Essence Help*.

*To purchase optional modules please contact your local distributor.*

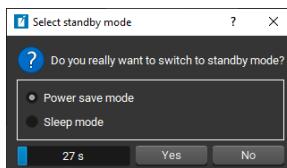
### 5.3 System Saving Modes

There are two system savings modes - **Sleep mode** and **Power save mode**:

- **Sleep mode** - Use in case you just need to interrupt your work for couple of hours and continue later. In this mode, SEM emission is blanked.
- **Power save mode** - Use this mode when you finish your work and the microscope is to be left unused overnight or longer. In this mode: computer is ON, SEM emission is blanked, part of the control electronics and the pumping of the chamber are OFF. Power consumption is reduced in comparison to normal operation.

	PC	Microscope	SEM	Chamber pumping
<b>Sleep mode</b>	ON	ON	blanked	ON
<b>Power save mode</b>	ON	ON	blanked	OFF

Both saving modes are controlled using the moon icon  located in the top-right corner of the screen:



Once the system is in a saving mode (Sleep mode or Power save mode, it does not matter), the moon icon turns orange and starts flashing .

To **reinitialize** the system, click the moon button again to switch back to standard operating mode. When the microscope was in Power save mode, clicking this button also initializes the chamber pumping procedure.



#### DANGER

**Danger to life! The microscope works with electric voltages that can be lethal!** Keep in mind that even in the *Power save mode* the microscope is still running and remains powered up!

## 6 Working with the SEM

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

To learn more about how electron beam is generated and the description of the relevant hardware see [Electron Column \(SEM\) on page 21](#).

The following topic lists important SEM parameters and main control features necessary for working with the SEM:

### SEM Parameters

As an SEM user most of the time you will be dealing with the following important SEM parameters:

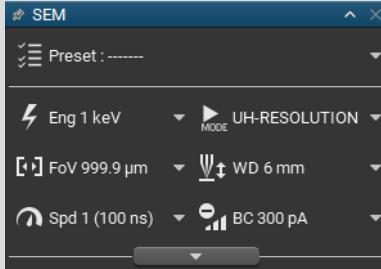
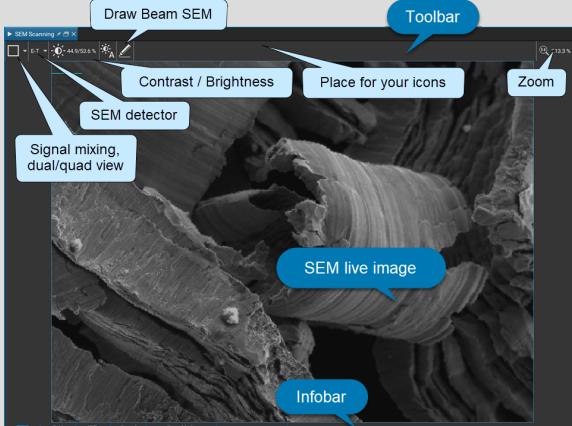
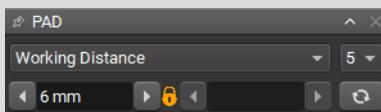
- **Spot size** equals the circle area (cross sectional diameter) of the sample surface onto which 50% of the beam current lands. The spot size is smaller at shorter working distances.
- **Aperture angle** determines the angle at the vertex of the cone-shaped focused electron beam. The wider the aperture, the lower the **depth of focus**. The aperture angle also depends on **beam current (BC)**, **working distance (WD)** and **scan mode**.
- **Beam current (BC)** is defined by the amount of electrons passing through a probe in a certain period of time. It is necessary to use more time for scanning the image at low beam intensities and vice versa.
- **Landing Energy (Eng)** determines the energy of primary electrons in the beam.

### Presets

While working with the SEM, various electron optics parameters are customized. Sometimes the settings of the same parameters are needed repeatedly and manual re-setting of all these parameters is unnecessary. For this there is a possibility of saving current settings via presets. To learn more see [Presets on page 70](#).

## SEM Software Control

Most of the control components in the microscope software connected to SEM are labeled with **blue** color. Main SEM control features are listed in the table below. Application-specific SEM controls are discussed within the application topics and features for maintaining SEM.

	<b>SEM Scan</b> - Panel for starting / stopping the SEM and image scanning process control.
	<b>SEM</b> - The panel with SEM parameters settings and SEM presets.
	<b>SEM Scanning</b> - This window shows live image from SEM scanning. It also has several control features.
	<b>Pad</b> - Universal panel with a variety of parameters.

## 6.1 SEM Basics Step-by-Step

The following instructions describe the process of working with SEM:

1. Prepare your samples.

The specimen should be **conductively fixed or glued** to the specimen **stub** before being inserted into the chamber. It is possible to use any of the specimen stub / holders delivered as microscope accessories. The 12.5 mm specimen pin-stub is recommended.

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

**Note:** When handling sample holders always use **powder-free gloves** or tweezers to avoid contamination of the chamber.

**Note:** Physical contact between the sample and any part of the chamber is indicated by a **Touch Alarm**. This circuit measures an electric current. Collision of non-conducting sample with any part of the chamber interior will not trigger the Touch Alarm and can cause damage to the microscope. Please move carefully when handling non-conductive samples.

2. "Wake the microscope up" if necessary.

Follow these instructions according to the current situation:

- Turn the microscope control software on and log in to your user account. If you don't have one, ask your supervisor for it.

- If the icon for power saving mode flashes with orange light , click on it to leave the mode. The icon is located in the top-right corner of the screen.

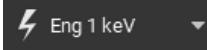
3. Insert your samples to the specimen chamber.

- a. If the chamber is evacuated, click on the **Vent** button  in the main toolbar of the control software to fill up the chamber with air.
- b. Put on clean powder-free gloves while operating your prepared samples to avoid microscope chamber contamination.
- c. When venting is finished, gently pull the chamber door to open it.
- d. Blow the sample and its stub using compressed dry air or nitrogen.
- e. Mount sample stubs onto the stage carousel and fix them with the screw.
- f. Before closing the door, make sure there is no risk of collision. Especially when some of your samples are big or non-standard size. If necessary, move the stage down, i.e. further from the objective, by increasing its Z coordinate in the **Stage Control** panel in the second sidebar.

- g. Close the microscope chamber by gently pushing it. Take off the clean gloves.
- h. Click the **Pump** button (same button as for venting) to evacuate the chamber. In the meantime fill up the **Sample Exchange** wizard from the **Wizard** drop-down menu located in the main toolbar  


4. Set the SEM parameters - Landing Energy, Beam Current, Potential Mode, Scan Mode, detector.

**Note:** The following steps guide you through setting the SEM parameters one by one. Another option is to apply a SEM Preset and then change only the necessary parameters according to your needs. See [Presets on page 70](#).

- a. Choose one of the following to set the **Landing Energy** parameter:
  - In the **SEM** panel, click the small arrow on the right side of the **Eng** (Landing Energy) icon  
 and select one from predefined values.
  - In the **Pad** panel, select the **Eng** function and set its value.
  - In the **SEM Scanning window** bottom infobar, right-click on the **Eng** parameter and select one of the predefined values. If the parameter is not displayed you can enable it in the **SEM Image Parameters** panel » Live window tab.
- b. Analogically to the previous step set the **BC** (Beam Current) parameter  

- c. In the **SEM Scanning window**, select a detector from the **Detector** drop-down menu. For sample navigation E-T detector is recommended.
- d. Go to main Menu » SEM » Potential Mode » and enable the **Universal** potential mode.
- e. In the **SEM** panel, set **Scan Mode** to ANALYSIS.

**Note:** To learn more about Scan Modes or Potential Modes see [SEM Scan Modes on page 23](#) or [SEM Potential Tube Modes on page 26](#).

5. Align the electron beam - focusing, column centering, astigmatism correction. [More...](#)

- a. In the **SEM Scan** panel, click on the **SEM Beam Control** icon  to turn the electron beam ON. You can hear the sound of valve opening.
- b. Set the **Spd** (Scanning Speed) parameter to 1 or 2 - fast scanning speed is preferable for sample overview and beam alignment. To do this, choose one of the following:
  - Hover the mouse cursor over the live image in the **SEM Scanning window** and use scroll button up / down to change the actual Scanning speed.
  - Press the key on your numeric keypad.

- In the **SEM** panel, select the required value from the parameter **Spd** (Scanning Speed) drop-down menu.
  - Select the function in the **Pad** panel and set the required value there.
  - Right-click the parameter in the **SEM Scanning window** infobar if present and select the required value.
- c. Right-click on the live image in the **SEM Scanning window** and select **Maximal Field of View**. Then right-click again and select **Auto Brightness / Contrast**.
- d. In the **SEM** panel, set **Scan Mode** to UH-RESOLUTION.
- e. Focus the image:
- i. Make sure the **SEM Scanning window** is active (i.e. marked blue rectangle around it). If not, click anywhere inside the window to activate it.
  - ii. In the **SEM Panel**, select parameter **WD** (Working Distance).
- Note:** Double-clicking in the SEM Scanning window opens the **Focus Window** for faster rescanning. To remove the Focus window double-click anywhere in the SEM Scanning window.
- iii. Use trackball and by scrolling it left / right focus the image.
  - iv. Decrease the **FoV** (Field of View) parameter - use the **Pad** panel, the **SEM** panel or the **SEM Scanning window** infobar.
  - v. Focus the image again.
- f. Center the SEM objective:
- i. Open the **SEM OBJ Centering** wizard from the **Alignments** drop-down menu  located in the **SEM Scan** panel.
  - ii. In the wizard, check the **Fine Centering** option if you are going to work at high magnifications (ultimate resolution). For common work (moderate magnifications) Fine centering is not needed.
  - iii. Minimize image movement using trackball with F11 and F12 keys:
    - Press&hold F11 to lock X axis. Stop up-down image movement using the trackball.
    - Press&hold F12 to lock Y axis. Stop left-right image movement using the trackball.
  - iv. Focus the image again.
- g. Correct for astigmatism (recommended when the magnification is higher than 100 000 x). If the image is blurred, unclear, or appears stretched out and is not correctly focused, the user should definitely correct for astigmatism:

- i. In the **SEM panel**, select parameter **Stg** (Stigmator).
- ii. Use trackball to correct the astigmatism:
  - Press&hold F11 to correct the astigmatism in horizontal-vertical directions (other directions are locked).
  - Press&hold F12 to correct the astigmatism in diagonal directions (other directions are locked).

**Note:** It is recommended to adjust stigmators on round objects.

**Note:** During the procedure **Focus Window** is recommended.

- iii. Focus the image using the **WD** (Working Distance) parameter.

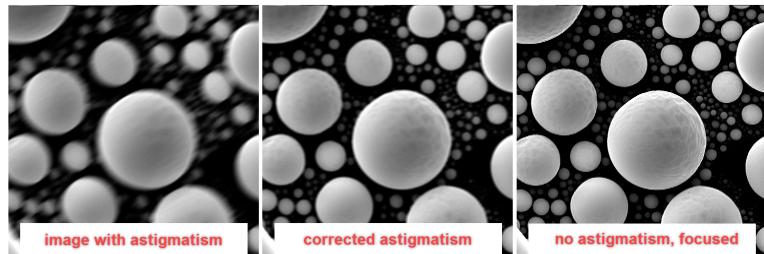


Figure 6-1 Example of astigmatism correction

- iv. Repeat steps i-iii until the image is focused properly.

**Note:** If the image moves while correcting for astigmatism, center the stigmators using the **SEM Stigmators Centering** wizard. Open the wizard from the **SEM Scan panel** » Alignments drop-down menu » **SEM Stigmators Centering**. Minimize image movement using the trackball with F11 and F12 keys. To learn more see [What To Do If ... The Image Moves While Correcting Astigmatism?](#).

**Note:** If you still cannot obtain a properly focused image, use the **SEM Gun Centering** wizard. This wizard contains two centering procedures - Auto Gun Centering followed by OBJ Centering (OBJ Centering should always be done after Auto Gun Centering). Then continue with SEM Objective Centering. To learn more see chapter **SEM Gun Centering Wizard** in *Essence Help*.

6. Navigate the sample stage to find the desired feature on the sample surface for imaging.

Choose one of the following:

- Click with the middle-mouse button in the **SEM Scanning window** image to move the place of click to the center of the live image.
- Use arrow icons or stage coordinates in the **Stage Control** panel.

- Use keyboard shortcuts CTRL+arrow key for slow movement or CTRL+SHIFT+arrow key for fast movement (the **SEM Scanning window** must be active).

**Note:** For more information on sample stage movements see [Sample Stage on page 29](#) and chapter *Sample Stage Navigation* in *Help*.

7. Set the parameters of SEM image acquisition - scanning speed, image format and size, infobar.

**Note:** The live image in the SEM Scanning window has separate settings from an image obtained by the image acquisition process. Both settings are located in the **SEM Image Parameters** panel - **Live window** tab and **Acquisition** tab.

- a. Go to main Menu » SEM » Image Parameters » Acquisition tab.
- b. Set required parameters for final image:
  - optional image ratio and size
  - scan speed preferably 5 or higher to reduce noise
  - enable / disable the infobar in the final image by checking / unchecking the **Show infobar** checkbox - select which parameters are to be shown
- c. Click **Apply** button to save the changes.

8. Acquire an image and optionally make adjustments on it.

- a. In the **SEM Scan** panel, click on the **Acquire**  icon for image acquisition.

- b. By default the acquired image opens in a new window and also the **Document Header** window appears. If you want to save the image directly without further editing, click **OK** and you will be asked for a file name and target folder.

**Note:** Software behavior after image acquisition can be set in software **Preferences** in the **General** tab. Type Preferences into the Search bar (CTRL+F) or go to main Menu » Options » Preferences.

**Note:** If you want to edit the image, open the **Image Processing** panel from main Menu » Tools » Image Processing or type Image Processing into the Search bar (CTRL+F).

9. Optionally take your samples out from the chamber.

- a. In the **SEM Scan** panel, click on the **SEM Beam Control** icon  to stop electron emission.
- b. Click on the **Vent** button and wait for the chamber to be filled up with air. In the meantime put on clean gloves.
- c. Gently pull the chamber door to open it.

- d. Remove the samples by releasing the screws holding them.
- e. Optionally mount new samples.
- f. Close the door by gently pushing it.
- g. Click on the **Pump** button to evacuate the chamber even with no samples inside.

**Note:** Never leave the microscope for long periods with air inside the chamber.

10. Consider turning ON the **Power save mode** or the **Sleep mode** before leaving the microscope and log off.

- a. If you want to turn on any saving mode click  icon in the top-right corner of the screen. There are two saving modes:
  - **Sleep mode** - Use in case you just need to interrupt your work for couple of hours and continue later. In this mode, SEM emission is blanked.
  - **Power save mode** - Use this mode when you finish your work and the microscope is to be left unused overnight or longer. In this mode: computer is ON, SEM emission is blanked, part of the control electronics and the pumping of the chamber are OFF. Power consumption is reduced in comparison to normal operation.



#### DANGER

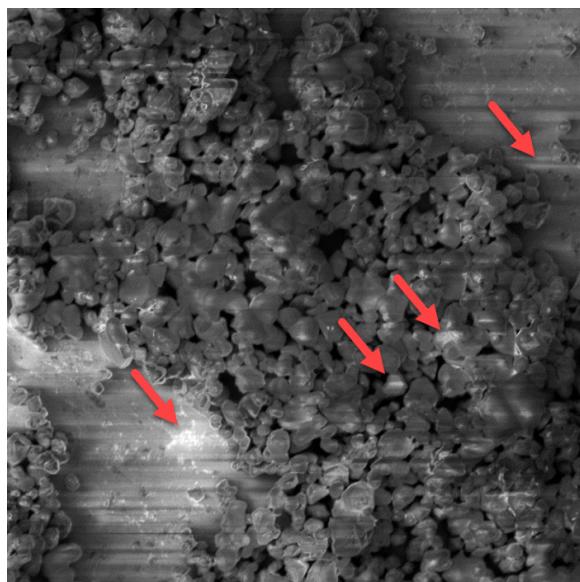
Danger to life! The microscope works with electric voltages that can be lethal! Keep in mind that even in the *Power save mode* the microscope is still running and remains powered up!

- b. To log off from your user account choose one of the following:

- Click the Close icon  in the top-right corner of the screen and select **Log off**.
- In the Search bar (CTRL+F) type **Log off** and confirm with **Yes**.

## 6.2 SEM Imaging of Non-conductive Samples

Imaging of non-conductive samples could pose problems due to the **charging effect**. Sample charging is caused naturally by SEM emission of secondary electrons (SE) and back-scattered electrons (BSE) during the interaction between the electron beam and the sample in high vacuum. The charging effect distorts the image with artifacts like glowing, sparkling, drifting, etc.



**Figure 6-2** Charging effect example

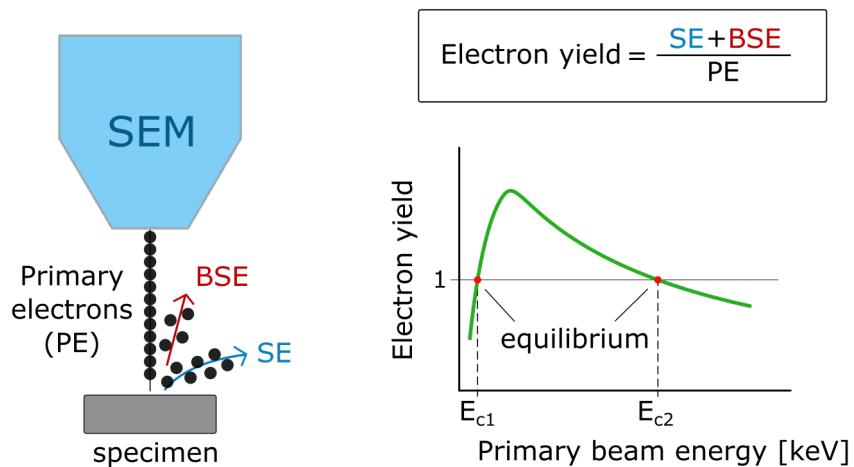
Following are some methods and advanced scanning strategies for suppressing the charging effect. They can be used independently or in combination:

6.2.1 Low Energy Imaging .....	59
6.2.2 Ultra-Low Energy Imaging in BDM .....	61
6.2.3 Imaging in the LowVac Mode .....	64
6.2.4 Advanced Scanning Strategies .....	68
6.2.5 Conductive Coating of Sample Surface .....	68

**Note:** The first two methods are preferable as they yield excellent resolution - better than low vacuum mode imaging. On the other hand, low vacuum mode is not as harmful to the sample as the conductive coating method.

### 6.2.1 Low Energy Imaging

Low energy imaging is a scanning strategy to **compensate for sample charging** caused by the emission of secondary electrons (SE) and by incorporation of primary electrons (PE) into the sample. The principle of this method is to reach beam energies close to the critical energy ( $E_{c1}$  or  $E_{c2}$ ; see figure below) where secondary emission is in equilibrium with the beam current, i.e. **number of primary electrons from the beam is equal to the sum of SE and BSE emitted from the sample surface**.



Some parameters may **affect the charging rate**, e.g. beam energy, sample tilt or scan speed.

Here is a table summarizing critical energies of some common materials.

Material	$E_{c2}$ [keV]	Material	$E_{c2}$ [keV]
5% PB7/nylon	1.40	PE	1.50
Acetal Ketal	1.65	PE + acrylic acid	1.04
Acrylamide	1.30	PMMA resist	1.60
Alumina	2.90 / 4.20	Polycaprolactone	1.14
CaF <sub>2</sub>	1.90	Polysulfone	1.10
Capton	0.40	PP	1.50
Cr on glass	2.00	PP copolymer	0.90
GaAs	2.60	PS	1.30
Glass passivation	2.00	PVC	1.65
KCl	1.60	Pyrex glass	1.90
LiF	1.90	Quartz	3.00
Low density resist	0.55	Resist	0.55 - 0.70
NaCl	2.00	Resist on Cr	0.70
Nylon	1.18	Resist on oxide	0.90
PA	0.95	Resist on poly-Si	1.10
Paper	2.65	Teflon	1.82

## SEM Low Energy Imaging

1. Go to **SEM Panel** and set **Eng** (Landing Energy) < 1 keV.
2. Navigate your sample and adjust the image (as described in [SEM Basics Step-by-Step on page 52](#)).
3. Go to the **Pad** panel, select the **Landing Energy (SEM)** parameter and gradually increase the value in steps of 100 eV. Keep checking the image to see whether the charging effect is suppressed or not.

**Note:** In case the charging effect changes the contrast from black to white or vice versa, it means the critical energy value has been exceeded.

**Note:** Combinations of materials with very different critical energies might be difficult to observe with low energy imaging. When the critical energy of one component is reached, the other will still be affected by charging. In this case use other methods for non-conductive sample imaging, e.g. [Conductive Coating of Sample Surface on page 68](#).

4. Focus the image properly.
5. Select the desired **Spd** (Scan Speed) and acquire the image (see [SEM Basics Step-by-Step on page 52](#)).

### 6.2.2 Ultra-Low Energy Imaging in BDM

Beam Deceleration Mode (BDM) allows the user to reach primary beam energies less than 200 eV (up to 50 eV). In this mode, the primary electrons are decelerated just before interaction with the specimen surface using the electrostatic field formed by a negative sample bias. To learn more see chapter **Beam Deceleration Mode** in *Essence Help*.

In BDM, the secondary electron signal is then detected by the **In-Beam Axial detector**, back-scattered electrons are then detected by **Multidetector** (at short working distances; to learn more see [Detectors on page 33](#)).

**Note:** When the Beam Deceleration Mode is active, In-Beam Axial detector is called **Axial (SE BDM)** detector and Multidetector is called **MD (BDM)** detector.

**Note:** We do not recommend using BDM for samples with strong morphological features. Morphology causes distortion of the electrostatic field used to decelerate the primary electron beam and therefore limits imaging possibilities.



#### NOTICE

**Park all retractable parts and remove stage attachments.** Before BDM is switched ON, any retractable detectors like BSE, EDS, EBSD, CL or nanomanipulators must be retracted and the Peltier module (or any other stage attachments) must be removed. There should be no contact between the stage and the rest of the microscope!



#### NOTICE

**Touch Alarm does not work in BDM.** If Beam Deceleration Mode (BDM) is active, touch alarm is deactivated (there is no beep sound in this case). To learn more find **Touch Alarm** in *Essence Help*.

### How To Use Beam Deceleration Mode

#### 1. Prerequisites:

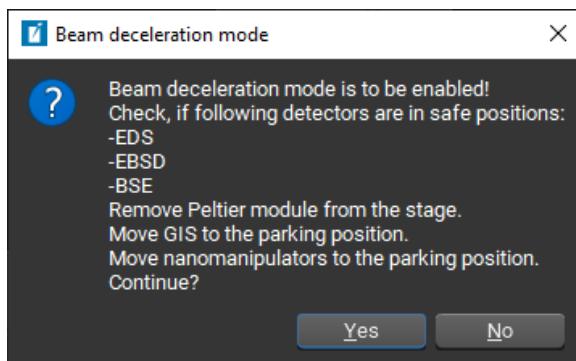
1. Suitable specimen.

BDM is particularly suitable for examining relatively **flat specimens**.

- The specimen should not be tilted.

- It is recommended to examine areas away from the edge of the specimen as edges can introduce astigmatism into the image. The ideal location for observation is the center of the specimen.
  - The best results are obtained if the specimen is conductive, but small non-conductive specimens may be used as well. Large non-conductive specimens can obstruct the formation of the electrostatic field above the specimen.
2. All retractable detectors (e.g. CL, BSE, STEM, EDS, EBSD) are parked.
  3. GIS is parked.
  4. Nanomanipulators are parked.
  5. **SEM** is ready for work.
  6. Stage tilt is a maximum of  $\pm 5^\circ$ .

2. Activate the Beam Deceleration Mode by going to main Menu » SEM » Beam Deceleration. A new dialog with prerequisites listed in step 1 appears:



BDM activates automatically after you confirm the dialog with **YES**.

3. In the **SEM Panel**, set the **Eng** (Landing Energy) parameter.
4. In **Pad panel**, select the **BDM Retarder Voltage (SEM)** parameter and set the negative bias applied to the specimen stage by changing it. Do not forget to type the "-" operator, e.g. "- 5000" V.

**Note:** The BDM Retarder Voltage parameter is available only when BDM is activated.

5. Observe your sample. Recommended working conditions are the following:
  - The recommended **working distance is approximately 2 mm**. At shorter working distance, e.g. 1 mm, discharge may occur. However, the further away the specimen is from the objective, the worse is the resolution.
  - The specimen **cannot be tilted** during observation in the BDM. The tilt may cause deformation of the electrostatic field.
  - Generally BDM improves resolution for low values of Landing Energy. If Landing Energy is set to more than 5 keV, the difference in resolution is not readily obvious. The Landing Energy can be

decreased down to 50 eV automatically and down to 0 eV in manual regime (available on supervisor level only).

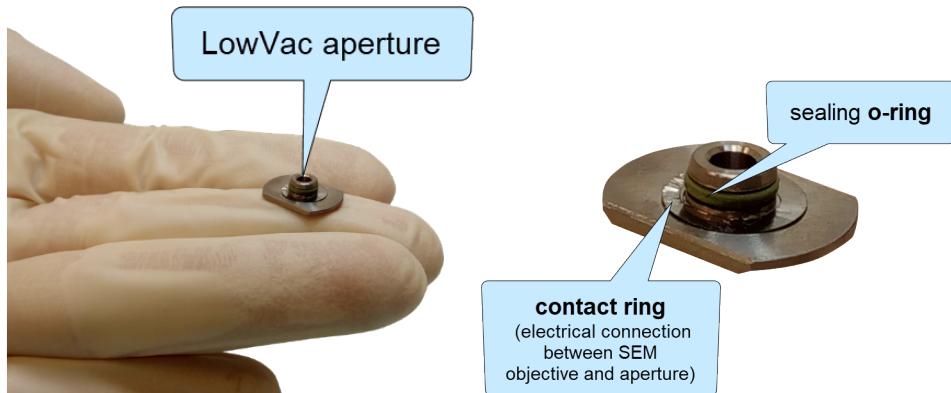
- Recommended scanning mode is UH-RESOLUTION. All [SEM Scan Modes \(page 23\)](#) can be used except WIDE FIELD.
  - BDM can be switched from any [SEM Potential tube mode](#). Once in BDM, the whole SEM column (incl. the potential tube) is automatically set to the highest possible imaging resolution (and thus the UH-RESOLUTION scan mode is recommended).
    - The SEM centering procedure in BDM is easier if it is performed first without beam deceleration.
    - As specimen examination at low keV tends to be adversely influenced by contamination, it is recommended to use **Decontaminator** before specimen observation. This step is optional.
6. Deactivate the Beam Deceleration Mode. To do this, go to main Menu » SEM » Beam Deceleration (the Beam Deceleration icon in the menu is highlighted in blue, which indicates that the BDM is active). BDM deactivates after you click on this Beam Deceleration option in the menu.

### 6.2.3 Imaging in the LowVac Mode

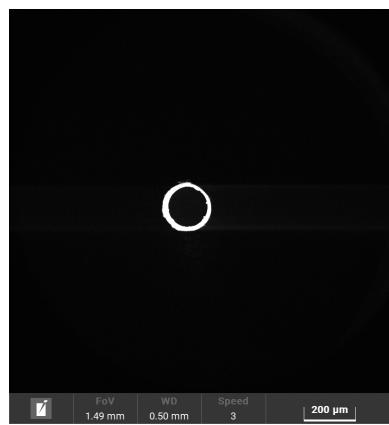
*LowVac IS OPTIONAL*

The LowVac mode is a low vacuum microscope regime in which the chamber is filled with a certain amount of gas and the **chamber pressure is between of 7–500 Pa**. The LowVac mode is intended for imaging **non-conductive samples** - in this mode the charging effect is suppressed by gas molecules which remove charging electrons from the sample surface. In LowVac the chamber can be filled with **nitrogen** (LowVac N<sub>2</sub>) or **water vapor** (LowVac H<sub>2</sub>O; if purchased). We recommend to use water vapor if available (better image quality). The water vapor is generated from the purified water stored in a water reservoir (located in the the electronics cabinet under the microscope chamber).

When working in the LowVac mode, a **LowVac aperture** must be inserted. The LowVac aperture is mounted into the bottom part of the SEM objective, accessible from the microscope chamber. To learn more about the aperture see [Inserting / Removing the LowVac Aperture on page 104](#).



**Note:** If the aperture is installed and the high vacuum mode (HighVac) is active, there is no microscope damage. It only affects the image - when the Field of View is maximized, the user can see only a narrow view field through a small circle in the middle of the image (see example below).



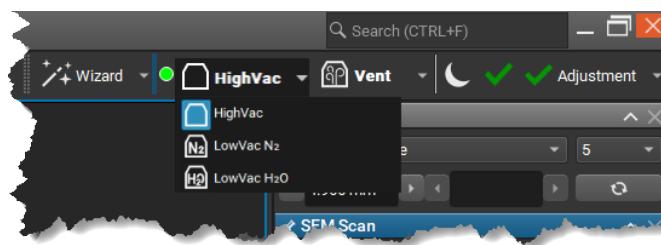
Standard E-T detector is not available for LowVac operations. TESCAN has developed **GSD (Gaseous Secondary electron Detector)** and **LVSTD (Low Vacuum Secondary TESCAN Detector)** that give topographical information from samples in LowVac. The BSE detector is available for both LowVac and HighVac modes and gives compositional information. To learn more, see [Detectors on page 33](#).

**Note:** In LowVac mode only **GSD, LVSTD, LE BSE, CL, HADF R-STEM and EDS** detectors are allowed.

**Note:** In LowVac mode **BDM, Decontaminator, Load Lock** are disallowed.

**Note:** In LowVac mode only the **ANALYSIS** scan mode is available and the maximum Field of View is limited to 500 µm.

When your microscope is equipped with the LowVac mode, there are options **LowVac N<sub>2</sub>** and **LowVac H<sub>2</sub>O** (or only **LowVac N<sub>2</sub>** - depending on your configuration) in the **Vacuum Mode** control drop-down menu in the software toolbar:

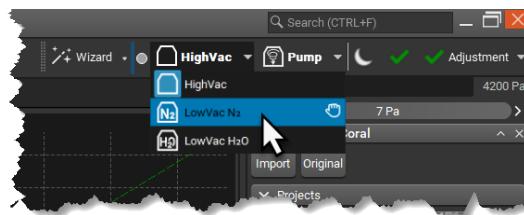


### Imaging in LowVac Step-by-Step

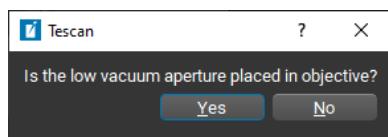
1. Insert the **LowVac aperture** according to the instructions in chapter [Inserting / Removing the LowVac Aperture on page 104](#). During the aperture insertion, **mount your samples** on the sample stage.

**Note:** Frequent insertion and removal of the LowVac aperture can result in surface **deformation of the metal contact ring**. This does not affect the functionality of the contact ring, the ring works properly despite deformation, i.e. continues to provide electrical connection between the SEM objective and the aperture. **DO NOT remove the contact ring!**

2. Switch the microscope into the LowVac mode by clicking on **Vacuum Mode** icon and selecting the option **LowVac N<sub>2</sub>** or **LowVac H<sub>2</sub>O** (LowVac H<sub>2</sub>O is recommended for better image quality - if available). The icon is located in the software toolbar (see below).



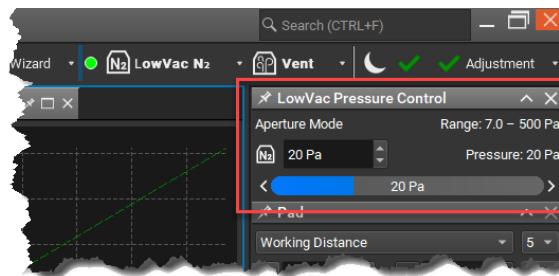
3. Pump the chamber into LowVac by clicking the **Pump** button.
4. When entering LowVac mode, the following dialog appears: *Is the low vacuum aperture placed in the objective?* Confirm aperture presence by clicking **Yes**.



By confirming this dialog the microscope enters the **Aperture mode**. In this mode, the low vacuum aperture is automatically added into **3D collision model** (3D collision model then also prevents collisions between the aperture and your sample). Aperture mode is active until you vent the chamber. To learn more use *Essence Help*.

**Note:** When entering the LowVac H<sub>2</sub>O mode, the pressure might significantly fluctuates. Please wait for the pressure stabilization.

5. The **LowVac Pressure Control** panel automatically appears in one of the sidebars. In this panel, set the target chamber pressure by typing the pressure value and pressing ENTER, or using the arrows (e.g. to 20 Pa).



**Note:** The panel can be also opened from main Menu » Tools » LowVac Pressure Control or by typing **LowVac Pressure Control** in the Search bar (CTRL+F).

**Note:** To change the pressure unit (Pascal, Torr or millibar) throughout the software, go to main Menu » Options » Preferences » General tab.

6. In the **SEM Scanning window**, select detector(s) to use.

**Note:** When LVSTD detector is selected, in the SEM Scanning window toolbar a new icon **LVSTD pumping**  appears. The user must activate LVSTD detector by clicking on this icon before using it.

7. If the sample is charging, gradually increase the pressure in steps of 10 Pa. Keep checking the image to see whether the charging effect is suppressed or not.
8. Center SEM and focus the image:
  1. If needed, center the circular view field using the *Image Alignment (SEM)* parameter (select it in Pad).
  2. Center SEM objective as step 5-f in [SEM Basics Step-by-Step on page 52](#).
  3. Repeat these two sub-steps above until the electron beam is centered properly.
  4. If needed, correct image astigmatism using the **Stg** (SEM Stigmators) and the **WD** (Working Distance) parameters; see step 5-g in [SEM Basics Step-by-Step on page 52](#).

**Note:** Focus the image using the Working Distance parameter throughout this step.

**Note:** If you prefer, feel free to switch the microscope to HighVac and center the SEM here (more detectors available). Even in HighVac, the microscope is still in the Aperture Mode (the low vacuum aperture is placed in the objective, only the LowVac compatible scan modes are available etc.). Once centered, switch back to LowVac (the centering will not change).

9. Navigate the sample stage, set the acquisition parameters and acquire the image according the steps 6-8 in [SEM Basics Step-by-Step on page 52](#).

**Note:** When finished, turn the LVSTD off by single clicking the LVSTD pumping icon .

**Note:** You may also remove the aperture from the objective polepiece by gently pulling it downwards from the objective.

**Note:** When you finish your work in LowVac H<sub>2</sub>O and want to switch the microscope into the **Power save mode**, please note that the primary (rotary vane or scroll) **pump will be still running** few minutes after switching into this mode (the pump needs to remove water vapour from its interior).

### 6.2.4 Advanced Scanning Strategies

This section contains some **tips for suppressing the charging effect**. They can be used independently or in combination with all other non-conductive imaging methods. To learn more see [SEM Imaging of Non-conductive Samples on page 58](#).

- Keep **Scan Speed** as low as possible (Scan Speed 1 or 2) and enable **Image Averaging** (go to Menu » SEM » Image Parameters » Averaging tab, turn **Accumulation** on and set its parameters). To learn more find *Image Averaging* in *Essence Help*.
- Select a **detector not sensitive to SE charging** - generally any BSE detector. To learn more see [Detectors on page 33](#).

**Note:** E-T detector (located inside the chamber) is generally less sensitive to charging effect than the Multidetector (located inside the SEM tube).

- Reduce the number of pixels in the image (**Image size**). Reducing the number of pixels will reduce the electron dose in the target area and may suppress the charging effect; see chapter **Image Parameters** in *Essence Help*.
- **Image rotation** helps in some cases. If an object is longer along one direction than the other, rotating the scanning pattern can reduce charging. To learn more find *Image rotation* in *Essence Help*.
- To compensate for drift due to charging, turn on the **Drift corrected frame accumulation** (DCFA). To turn the accumulation on / off press **A** on your keyboard. To learn more find *DCFA* in *Essence Help*.

**Note:** DCFA is available for the SEM acquisition window only.

### 6.2.5 Conductive Coating of Sample Surface

Another way of suppressing the charging effect is to **coat the sample with a conductive layer** using either a carbon coater or sputter coater. Keep in mind that the sample coating must be conductively in contact with the sample holder. Otherwise the Touch Alarm will not work properly. To learn more find *Touch Alarm* in *Essence Help*.

**Note:** Collision of a non-conductive sample with any part of the chamber interior will not trigger the **Touch Alarm** and can cause damage to the microscope. Please move carefully when handling non-conductive samples.

### 6.3 Simultaneous Signal Acquisition & Signal Mixing

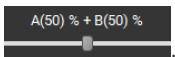
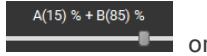
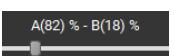
The TESCAN Essence software allows the user to **display up to four signals** simultaneously from up to four various detectors. The component images are displayed side by side. Also, there is a possibility to **mix two detector signals** in one image.

#### How To Display More Signals Simultaneously

1. Go to **SEM Scanning window**.
2. Select **Detector view**:
  - For **two** signals, select **Dual** ( →  →  →   - a. Assign a detector signal to **Channel 1** ( Chan. A →  LEBSE).
  - b. Select **Channel 2** and assign another detector signal to it.
  - c. Do it for all channels.

#### How To Mix Two Signals

You can **add** one signal to another or **subtract** one signal from another.

1. Go to **SEM Scanning window**.
2. Select **Detector view**:
  - To **add** one signal to another: select **Single Add** ( →  A(50) % + B(50) %
  - To **subtract** one signal from another: select **Single Subtract** ( →  A(50) % - B(50) %
3. Assign a signal to the particular view (called "Channel" here):
  - a. Assign a detector signal to **Channel 1** ( Chan. A →  LEBSE).
  - b. Select **Channel 2** and assign another detector signal to it.
4. Move the slider to change the percentage of the resulting mixed signal, e.g.  A(15) % + B(85) % or  A(82) % - B(18) %.

## 6.4 Presets

While working with SEM, various beam and optics parameters are customized (e.g. energy, scan mode, column centering, stage position etc.). Sometimes the settings of the same parameters are needed repeatedly and manual re-setting of all these parameters is unnecessary. That's why there is a possibility of saving current settings via presets. The preset is a **saved combination of SEM parameter values** ready to load when required and thus to switch easily between different conditions for different operations.

Presets are automatically stored into the user configuration files, so they are fully available for further login.

Two **preset levels** are available:

- **User presets** - Each user has the ability to create and edit their own user presets. These presets are not visible to other users.
- **System presets** - Defined by the system supervisor or an authorized service engineer during system installation / maintenance. System presets are shared by all users and may work as an initial state for creating user presets. Only supervisors can overwrite system presets but we do not recommend it (instead of it, "copy" the system preset and edit its copy).

In TESCAN Essence, there are two locations from which presets can be controlled:

- quick control through a **Preset** menu located in the **SEM** panel (see below)
- **preset management** through a **Presets** panel in main Menu » Tools » Presets (see chapter **Presets (Panel)** in *Essence Help*)

### Preset Menu

Each preset is identified by its name. The name of the currently active preset is displayed on top of the **Preset** menu (see below "My Preset"). The arrow button opens the context menu with the list of predefined user presets (system presets are hidden here) and some preset-controlling buttons.

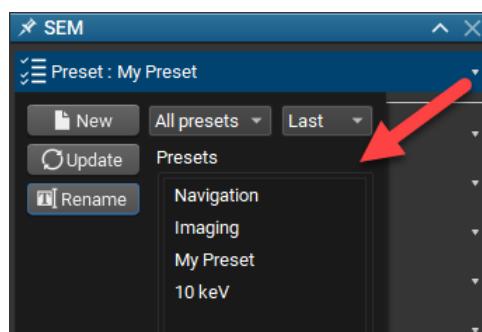
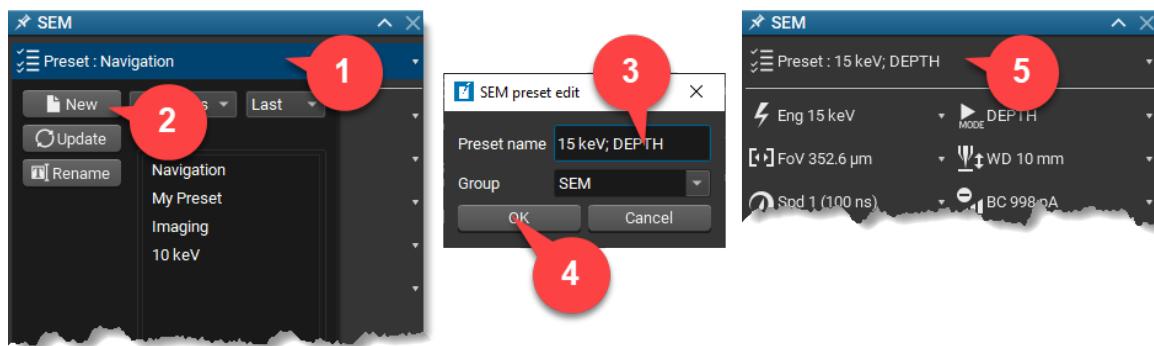


Figure 6-3 Preset menu for SEM

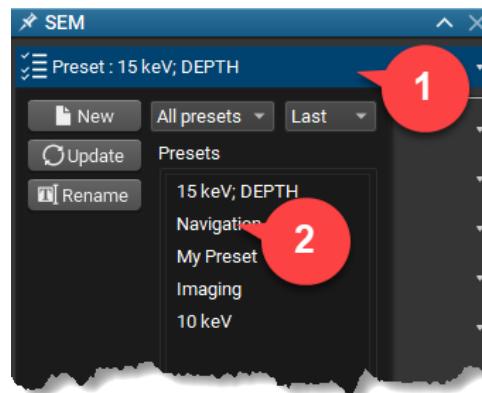
### 6.4.1 Creating a Preset

1. In the **SEM** panel, set SEM parameters and center the column properly (or save a stage position).
2. In the panel, click on the **Preset** menu (anywhere on the preset name; 1 - see figure below).
3. Click **New** (2). A **SEM preset edit** dialog appears.
4. In the dialog, fill in a **Preset name** and assign the preset into a SEM / Stage group (3). Click **OK** (4).
5. A new preset is now saved (5). When you hover the mouse over the preset name, all saved preset parameters appear in a blue tooltip.



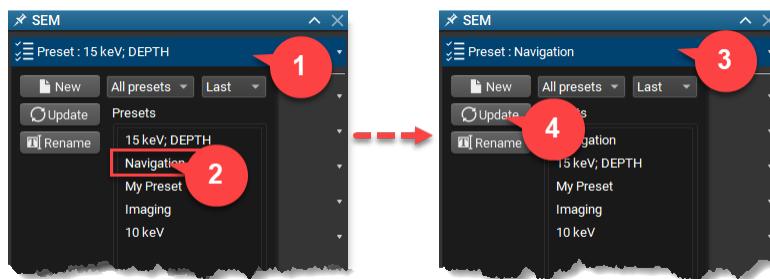
### 6.4.2 Activating a Preset

1. In the **SEM** panel, click on the **Preset** menu (anywhere on the preset name; 1 - see figure below).
2. Left-click on the preset name from the list Presets.



### 6.4.3 Editing a Preset

1. In the **SEM** panel, click on the **Preset** menu (anywhere on the preset name; 1 - see figure below).
2. Left-click on the preset you want to edit (2). The preset activates.
3. Change the required parameters (e.g. scan mode, centering, energy etc.).
4. Open the **Preset** menu again (3), click **Update** (4) and confirm the change.

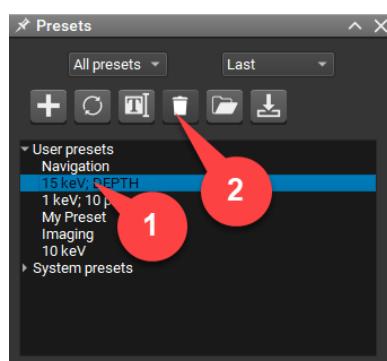


To change a preset name, open the **Preset** menu and click **Rename**.

### 6.4.4 Removing a Preset

Presets can be removed in the advanced **Presets** panel only.

1. Open the **Presets** panel by going to main Menu » Tools » Presets.
2. Select the preset/s you want to delete (1) and click **Remove selected preset** (2). To remove all user presets at once, select all user presets using CTRL+A and click **Remove selected preset** (2).



## 7 Finishing Up Work with Microscope

The source of primary electrons (FEG - Field Emission Gun) is permanently switched ON, even when the microscope is not operated. This ensures stability of electron emission without interruption over the entire lifetime of the Schottky cathode (thousands of hours). FEG is turned OFF only for a non-standard reason, e.g. long-prolonged power supply interruption, servicing the microscope etc.

Thus, when finishing up your work with the microscope, there is no need to switch SEM emission OFF.

We also **do not recommend closing the TESCAN Essence software**, because the software constantly monitors the SEM emission and in case of mains power failure it automatically switches OFF the SEM gun.

When leaving the microscope, we recommend you to just **log off**. Optionally you can switch the microscope into **Sleep mode** or **Power save mode** before logging off. Either mode will switch the beam OFF.

- **Sleep mode** - Use in case you just need to interrupt your work for couple of hours and continue later. In this mode, SEM emission is blanked.
- **Power save mode** - Use this mode when you finish your work and the microscope is to be left unused overnight or longer. In this mode: computer is ON, SEM emission is blanked, part of the control electronics and the pumping of the chamber are OFF. Power consumption is reduced in comparison to normal operation.



### DANGER

Danger to life! The microscope works with electric voltages that can be lethal! Keep in mind that even in the *Power save mode* the microscope is still running and remains powered up!

### How To Switch the Microscope Mode and / or Log Off

1. Consider turning on the **Sleep mode** or the **Power save mode** before leaving the microscope. To do this, click icon in the top-right corner of the screen. Select the **Sleep mode** or the **Power save mode** and confirm by YES.
2. To log off from your user account choose one of the following:
  - Click the Close icon in the top-right corner of the screen and select **Log off**.
  - In the Search bar (CTRL+F) type **Log off** and select **Yes**.

## 8 Microscope Maintenance

Inspection and maintenance of the system at regular intervals is necessary to keep the system in optimum operating conditions as well as to allow the system to operate for a prolonged period. Therefore, regular inspection and maintenance should be given the highest priority.

Most of maintenance interventions have to be performed only by authorized service engineers. These procedures are not described in this manual. The following chapters only summarize actions that need to be done by the customer.

### 8.1 Safety Precautions



#### NOTICE

**Clean operation.** Take care of clean and dust-free environment during maintenance. Use only clean spare parts and tools.



#### NOTICE

**Inspection period.** Time interval for inspection, cleaning or replacement are strongly depending on operating conditions. The indicated time intervals for maintenance are indicative for a laboratory environment with regular use of the system on a 220 days / year, 8 hours / day base. Maintenance intervals may need to be changed according to individual site requirements.



#### NOTICE

**Read safety instructions.** Prior any maintenance ready the chapter [Proper Use \(page 12\)](#) and follow the instructions in this chapter during maintenance.



#### NOTICE

**Unauthorized manipulation.** Any manipulation of the device not mentioned in these instructions, especially removal of the housing and manipulation of electrical components of the microscope including servicing procedures, may be carried out only by an authorized service engineer.

## 8.2 Maintenance Schedule for Customers - Overview

The following actions need to be done by the customer. Some of them must be done on a regular basis, some procedures are performed only under certain circumstances. The following tables provide an overview of all procedures. The last table ([Schedule for Regular Maintenance on page 77](#)) lists all the procedures that need to be done regularly.

Procedures which can be performed **only by system supervisors** are marked with an **asterisk (\*)**.

### STAGE

What	When	How
Calibration	Once every week	Go to SW » Stage Control panel » <b>Calibrate</b>
Stage center adjustment*	Stage is not moving precisely, after each sub-stage replacement + once every week	<a href="#">Stage Center Adjustment (page 78)</a>
Field of view fine adjustment	Optional manual precise calibration (an image with an object of known size is needed)	<a href="#">Field of View Fine Adjustment (page 79)</a>

\*SUPERVISOR ONLY

### SEM COLUMN

What	When	How
SEM column centering	Image is blurred, unclear, appears stretched out and is not correctly focused	<a href="#">SEM Centering Tutorials (page 96)</a>
Turn OFF SEM source*	In case of long-term microscope switch-off only (e.g. long power supply interruption)	<a href="#">Switching the Electron Source OFF (page 98)</a>
Turn ON SEM source*	SEM source is OFF and you want to work with the microscope	<a href="#">Switching the Electron Source ON (page 99)</a>

\*SUPERVISOR ONLY

**R-STEM DETECTOR**

What	When	How
Change of aperture size	When you want to work with another aperture size	<a href="#">Changing the R-STEM Aperture (page 100)</a>
Detector centering	Bright Field segment is not located in the center of the image + when changing a larger aperture for a smaller one	<a href="#">Centering the R-STEM Detector (page 101)</a>

**LowVac**

What	When	How
LowVac aperture insertion	Before entering the LowVac mode	<a href="#">Inserting / Removing the LowVac Aperture (page 104)</a>
LowVac aperture cleaning	Every 3-6 month (or earlier when dirty)	<a href="#">Cleaning the LowVac Aperture (page 106)</a>
Exchange of LowVac aperture o-ring	O-ring is damaged	<a href="#">Exchanging the LowVac Aperture Sealing O-Ring (page 107)</a>
Water reservoir refill	When Essence SW asks you to do it	<a href="#">Refilling LowVac Water Reservoir (page 108)</a>

**CHAMBER & SYSTEM ACCESSORIES**

What	When	How
Chamber abrasion check	Once every week	Visual check (The chamber and internal fittings on the system must not be abraded or scrubbed so that particulates are not generated in the breathing zone.)
UPS check	Once every month	Check UPS if there are any errors on the display. If yes call service.

**SCHEDULE FOR REGULAR MAINTENANCE**

<b>What</b>	<b>Periodicity</b>	<b>How</b>
Sample stage calibration	Once every week	Go to SW » Stage Control panel » <b>Calibrate</b>
Stage center adjustment*	Once every week + after each sub-stage replacement + when stage is not moving precisely	<a href="#"><u>Stage Center Adjustment (page 78)</u></a>
Chamber abrasion check	Once every week	Visual check (The chamber and internal fittings on the system must not be abraded or scrubbed so that particulates are not generated in the breathing zone.)
UPS check	Once every month	Check UPS if there are any errors on the display. If yes call service.
LowVac aperture cleaning	Every 3-6 month (or earlier when dirty)	<a href="#"><u>Cleaning the LowVac Aperture (page 106)</u></a>

\*SUPERVISOR ONLY

### 8.3 Stage Center Adjustment

*SUPERVISOR ONLY*

Adjusting the mechanical center of stage rotation sometimes becomes necessary; without that, **Keep View Field** function does not work properly. In Essence, you will find an automated procedure called **Find center of rotation** for this adjustment.

**Proceed when:**

- when the stage does not move precisely
- after each sample loading using the [Load Lock](#) (if possible)
- after each sub-stage replacement
- once a week on a regular basis

#### Stage Center Adjustment Step-by-Step

1. Prerequisites: Adjustment sample is mounted on the sample stage **position 7**. For this adjustment use a sample with some readily-identified structure.
2. In the **SEM panel**, set large field of view (**FoV**) - but not so large that you see the SEM objective in the **SEM Scanning window**, i.e. the sample must fully fill the scanning window.
3. Center the column properly in UH-RESOLUTION and ANALYSIS scan modes → [Common Centering Procedure \(Regular Work\) \(page 96\)](#).
4. To increase noise reduction (and thus increase the reliability of image correlation), go to the **SEM panel** and set higher SEM energy (**Eng**) and higher beam current (**BC**). For this procedure, no scan mode is recommended. Feel free to use e.g. one of the above mentioned scan modes.
5. In the **Stage Control** panel:
  - a. Calibrate the stage using the **Calibrate** button.
  - b. Set **Z** < 20 mm.
  - c. Go to position **X** = 0 mm; **Y** = 0 mm.
  - d. Using the **Rotation** parameter rotate the stage a bit and try to find where the real stage center is in the **SEM Scanning window**, i.e. around which point the stage rotates.
6. Right-click on the live image in the **SEM Scanning window** and select **Central crosshair**. Move the point around which the stage rotates from the previous step to the center of this crosshair (roughly).
7. Go to main Menu » Options » Stage Configuration » Axis adjustment tab and click on the button **Find center of rotation**. Wait until the procedure finishes.
8. Run the procedure again with a smaller field of view (< 400 µm).

Error messages and their meanings:

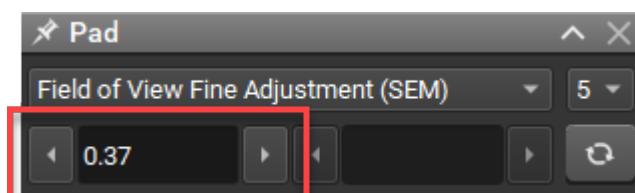
- **Correlation quality was very low** → change the SEM energy and beam current to higher values to reduce noise and repeat the procedure. If not helpful, repeat the procedure again with a different (more structured) sample.
- **Found shift was above threshold** → the real stage center was too far from the center of the scanning window. Try to move the real stage center closer to the center of the scanning window and repeat the procedure.

## 8.4 Field of View Fine Adjustment

This function is dedicated for manual precise calibration of field of view size (field of view size calibrating = pixel size setting). The size is calibrated according to an image with an object of known size (a standard). This calibration applies **only for current scanning conditions** (keV, scanning mode etc.). Once you change any of these scanning conditions, the calibration is invalid.

### FoV Manual Fine Adjustment

1. Prepare an image with an object of known size.
2. Go to [Pad](#) panel and select **Field of View Fine Adjustment (SEM)**. Change this parameter in Pad until the field of view size will match the object of known size (the standard). You can do it using the arrows or you can enter the value here and confirm with ENTER. The value of this parameter can be from 0.00 to 10.00.



## 8.5 SEM Centering Overview

To acquire high-quality images, it is necessary to center the electron optics of the column. The centering is automatic / semi-automatic and fully controlled by the TESCAN Essence software.

### 8.5.1 (Intro) Centering Background

The user can center the following column optics components:

- SEM gun (centering)
- SEM objective lens (centering)
- SEM stigmators (correction and centering)

The column should be centered from top to bottom, starting with the gun. Gun centering is recommended for higher beam currents ( $> 500$  pA). Once the electron gun is centered, the user should center the objective lens and focus the image. During OBJ centering the need to correct for astigmatism or center stigmators could arise. If the stigmators were centered, OBJ centering must proceed again. This does not apply to astigmatism correction - do not proceed OBJ centering after astigmatism correction. See the scheme below for better clarity.

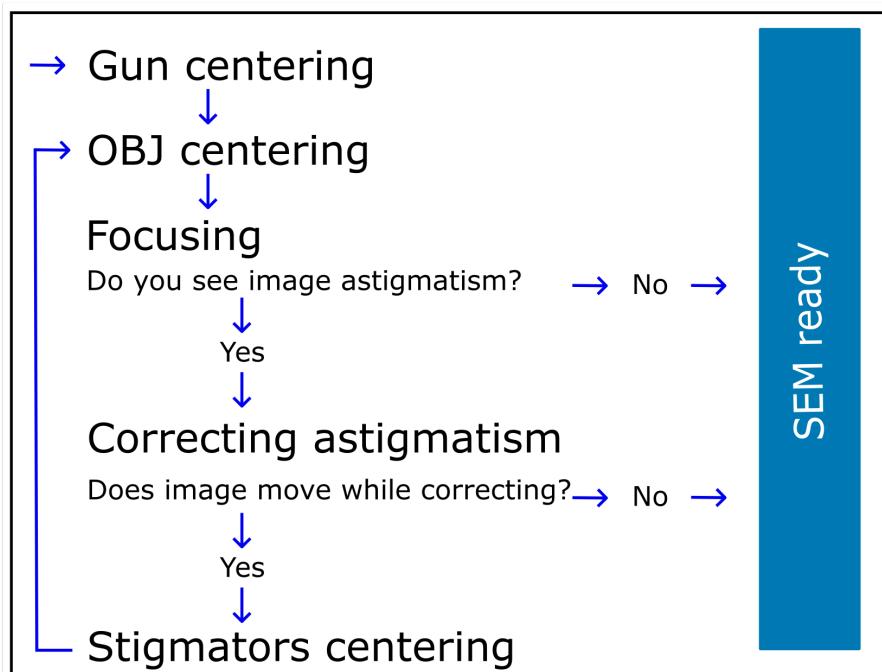


Figure 8-1 SEM centering scheme

All those components (gun, OBJ, stigmators) can be centered **automatically (recommended)** or **semi-automatically**.

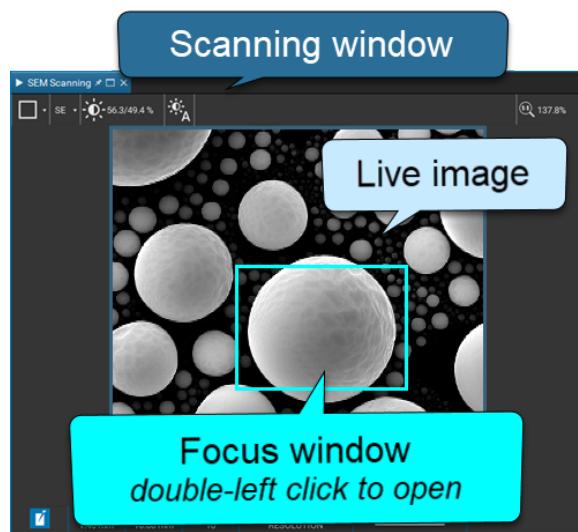
### 8.5.2 Quick Overview (Recommended Auto Procedures)

To Center ...	Proceed This ...	When ...
Focusing	<a href="#">Auto Focus (page 92)</a>	Image is unclear
OBJ	<a href="#">Auto Objective Centering (page 90)</a>	Image moves when focusing
Brightness / Contrast	<a href="#">Auto Brightness / Contrast (page 93)</a>	Image is dark / bright
Astigmatism correction	<a href="#">Auto Stigmators (page 95)</a>	You see image astigmatism
Stigmators	<a href="#">Auto Stigmators Centering (page 91)</a>	Image moves when correcting astigmatism
Gun	<a href="#">Auto Gun Centering (page 89)</a>	All the previous centering attempts fail

### 8.5.3 Semi-Automatic Centering - Centering Wizards

For semi-automatic centering, there are **centering wizards**. Some center only one column optics component (e.g. only gun), and some combine two components (e.g. gun + objective). In general, **we recommend using automated centering procedures**. Use centering wizards **only when automated procedures provide non-satisfactory results** (or when automated procedures are unavailable - will be described later). To use a wizard, just open it and follow its instructions.

**Note:** In general, when centering (mainly when using centering wizards), a **Focus window** is recommended. Double-left clicking in the **SEM Scanning window** opens the Focus window for faster rescanning. To remove the Focus window, double-left click anywhere in the SEM Scanning window.



There are **four** SEM centering wizards:

<b>8.5.3.1 SEM Gun Centering Wizard</b> .....	82
<b>8.5.3.2 SEM Objective Centering Wizard</b> .....	84
<b>8.5.3.3 SEM Stigmators Centering Wizard</b> .....	85
<b>8.5.3.4 SEM User Alignment Wizard</b> .....	86
<b>8.5.3.5 Astigmatism Correction (Stigmators "Adjustment")</b> .....	87
<b>8.5.3.6 Image Alignment</b> .....	88

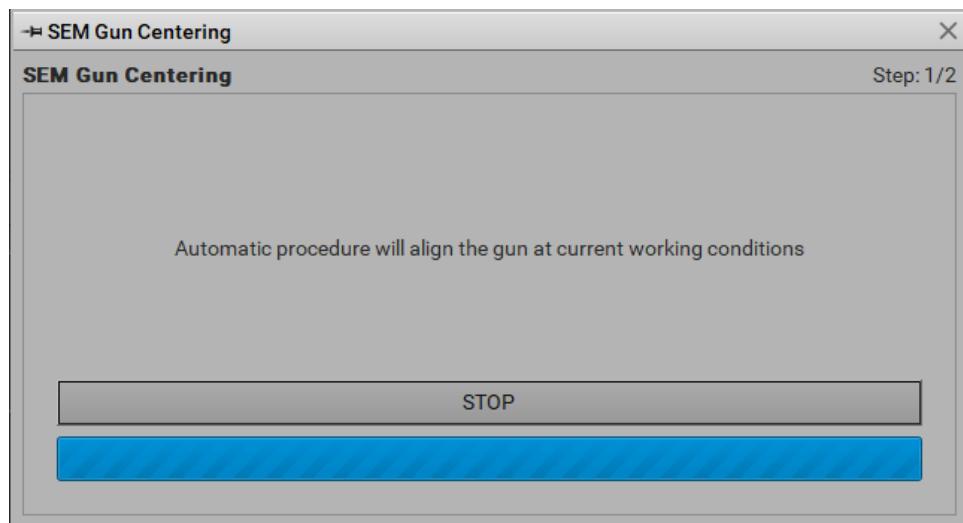
You can find them on two places in SW:

- **SEM Scan** panel » Alignments » ...
- Main toolbar » **Wizards** » ...

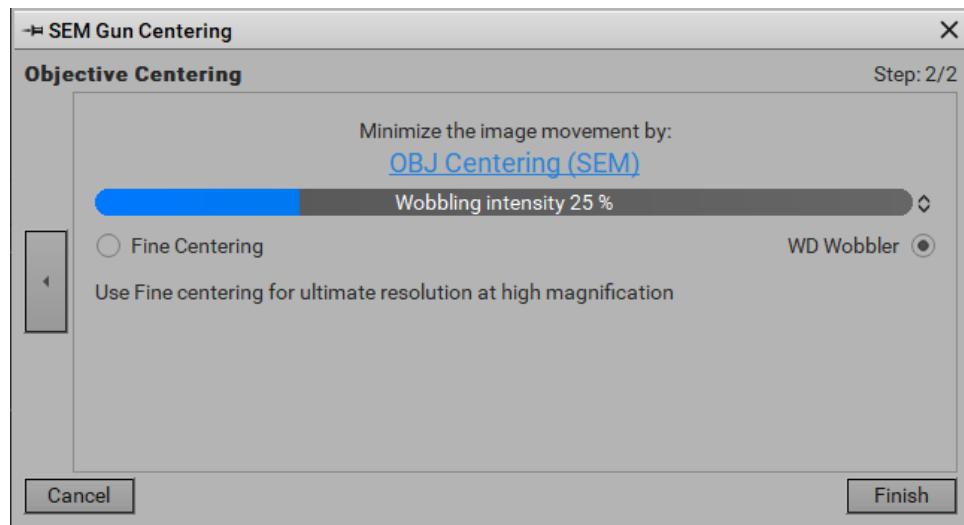
### 8.5.3.1 SEM Gun Centering Wizard

This wizard contains **two centering procedures** (two steps) respectively:

1. **Auto Gun Centering** (automatic procedure) - centers the electron gun automatically at the selected landing energy (Eng) for all beam currents (BC) at once.



2. **OBJ Centering** (semi-automatic procedure) - centers the SEM objective. **OBJ Centering should always be done after Auto Gun Centering.**



The result of the procedure is automatically **applied in all scan modes**.

#### Proceed when / if:

- Gun centering is recommended for higher beam currents (> 500 pA).
- This wizard should only be used when you have tried the whole centering and still cannot obtain a properly focused image.

In general, centering wizards should be used only when automatic procedures provide non-satisfactory results. First try to use [Auto Gun Centering \(page 89\)](#) followed by [Auto Objective Centering \(page 90\)](#).

**Quick Access:** Essence » SEM Scan panel » Alignments » SEM Gun Centering.

**Note:** It is recommended to center the electron gun on a flat homogenous sample surface. Only the sample which is non-sensitive to higher beam currents should be used.

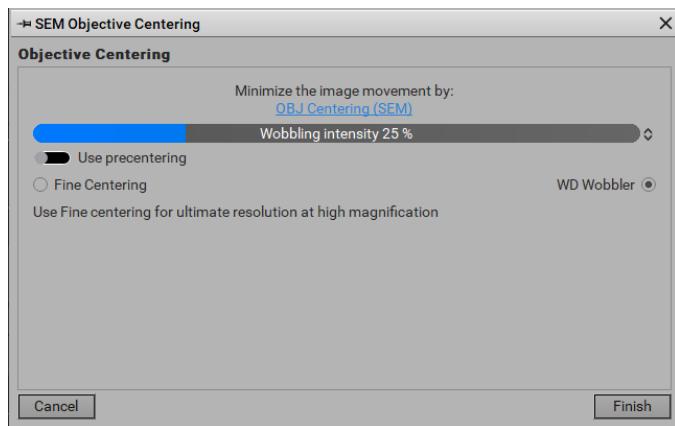
**Note:** In the OVERVIEW scan mode, objective lens is OFF, thus OBJ Centering wizard wobbles with intermediate lens (IML) instead of objective lens (OBJ).

→ Chapter **SEM Gun Centering Wizard** in *Essence Help*

### 8.5.3.2 SEM Objective Centering Wizard

This wizard centers the SEM objective lens. OBJ centering is done **only at the selected scan mode**, i.e. when the scan mode is changed, the user should center the objective again (if needed). When this wizard is used, the image starts wobbling (the wizard wobbles with the objective lens). The user is then prompted to minimize image movement using the trackball with F11 and F12 keys.

**Note:** In the OVERVIEW scan mode, objective lens is OFF, thus OBJ Centering wizard wobbles with intermediate lens (IML) instead of objective lens (OBJ).



- **Use precentering (SUPERVISOR ONLY)** - we recommend to use this option **only when discussed with an authorized service engineer**. Improper using may misalign the whole column.
- **Fine Centering** - check this option only when you want to reach the ultimate resolution at high magnification. It is highly recommended to use Fine centering for ultimate UHR imaging at accelerating voltages below 2 keV.

#### Proceed when / if:

- Image moves when focusing.
- It should be used **after any gun centering**.
- It should be also used **after stigmators centering**.

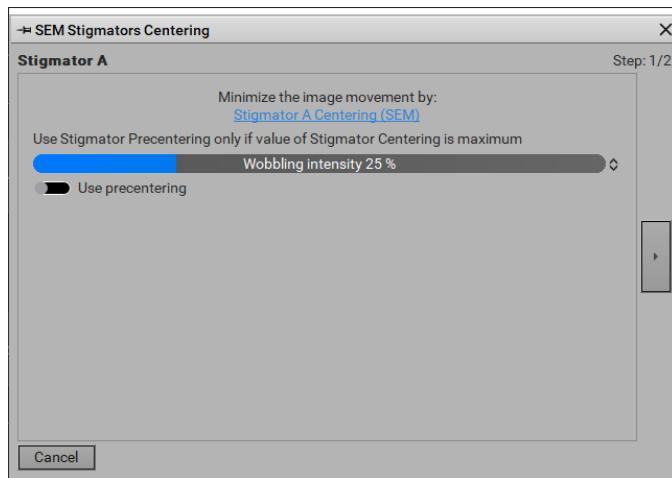
In general, centering wizards should be used only when automatic procedures provide non-satisfactory results. Try to use [Auto Objective Centering \(page 90\)](#) first.

**Quick Access:** Essence » SEM Scan panel » Alignments » SEM Objective Centering.

→ Chapter **SEM Objective Centering Wizard** in *Essence Help*

### 8.5.3.3 SEM Stigmators Centering Wizard

This wizard centers SEM stigmators (Stigmator A and Stigmator B). Stigmators centering is also done **only at the selected scan mode**, i.e. when the scan mode is changed, the user can center stigmators again (if needed). When this wizard is used, the image starts wobbling. The user is then prompted to minimize image movement using the trackball with F11 and F12 keys.



**Use precentering** - check this option **only if Stigmators centering values > 90%**. Go to Pad and check parameters "Stigmator A Centering (SEM)" and "Stigmator B Centering (SEM)". If any of these two parameters are > 90%, check this option "Use precentering" and continue in the stigmators centering procedure.

#### Proceed when / if:

This wizard should only be used when you see image movement during astigmatism correction.

In general, centering wizards should be used only when automatic procedures provide non-satisfactory results. Try to use [Auto Stigmators Centering \(page 91\)](#) first.

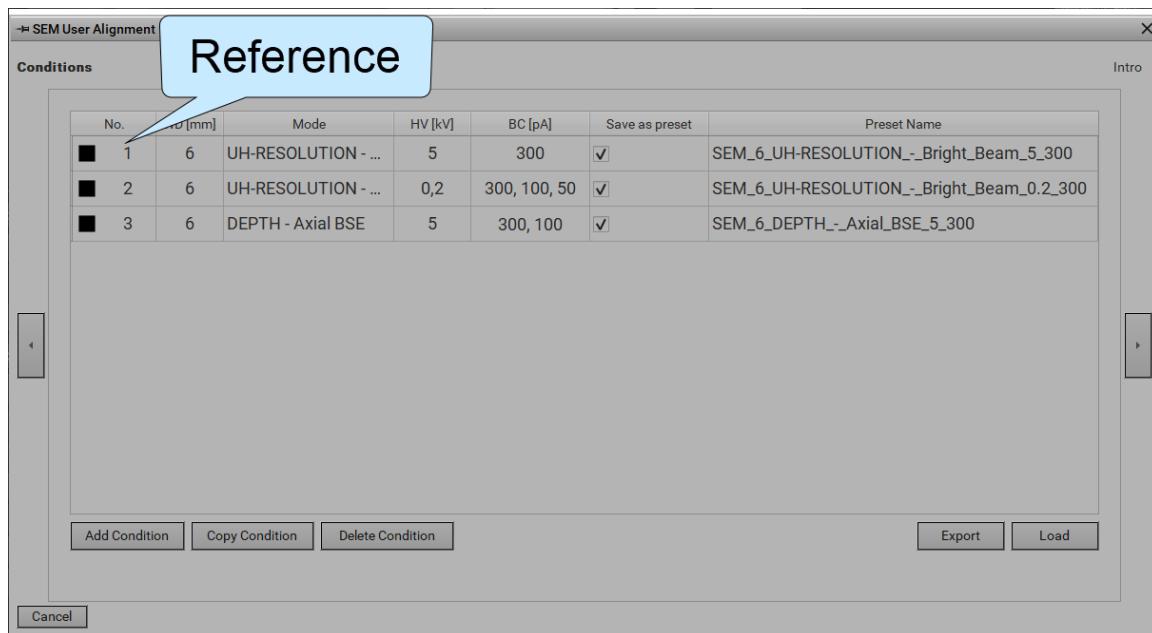
**Quick Access:** Essence » **SEM Scan** panel » Alignments » SEM Stigmators Centering.

→ Chapter **SEM Stigmators Centering Wizard** in *Essence Help*

#### 8.5.3.4 SEM User Alignment Wizard

The SEM User Alignment wizard enables **consistent step-by-step SEM centering and image alignment at any condition defined by the user**. It includes optional gun centering, stigmators centering, objective centering, image alignment, focusing and astigmatism correction. It is suitable for proper user centering of various conditions (e.g. different beam currents, different scan modes etc.). The output is a well-centered column and aligned set of imaging conditions most important for the particular user.

All defined conditions are aligned to one **reference condition** and can be saved as presets for further usage. Hypothetically, an unlimited number of conditions can be defined, centered, and aligned. The list of conditions can be saved for later use (export / import function).



#### Proceed when / if:

This wizard should be used when you want to center and align multiple imaging conditions at once.

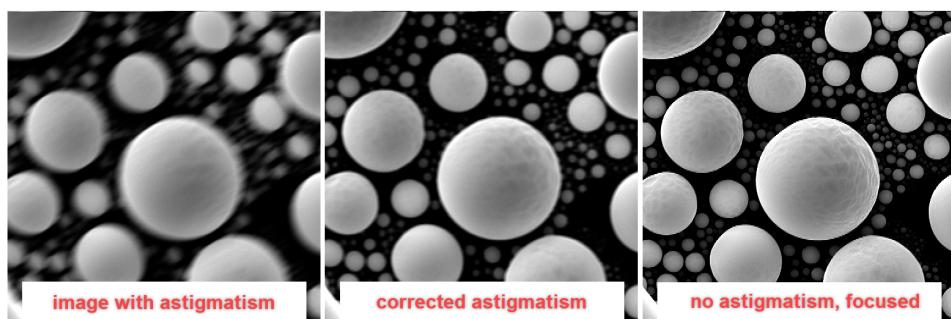
**Quick Access:** Essence toolbar » **Wizard** » SEM User Alignment.

→ Chapter **SEM User Alignment Wizard** in *Essence Help*

### 8.5.3.5 Astigmatism Correction (Stigmators "Adjustment")

There is no wizard for correcting astigmatism. When you **see astigmatism in your image** (image is blurred, unclear, or appears stretched), try to correct for astigmatism using [Auto Stigmators \(page 95\)](#) first. If it does not help, do the following:

1. In **SEM** panel, select parameter **Stg** (Stigmator SEM).
2. Use trackball to correct the astigmatism:
  - Press&hold F11 to correct the astigmatism in horizontal-vertical directions (other directions are locked).
  - Press&hold F12 to correct the astigmatism in diagonal directions (other directions are locked).
3. Focus the image by setting the **WD** (Working Distance SEM) parameter.



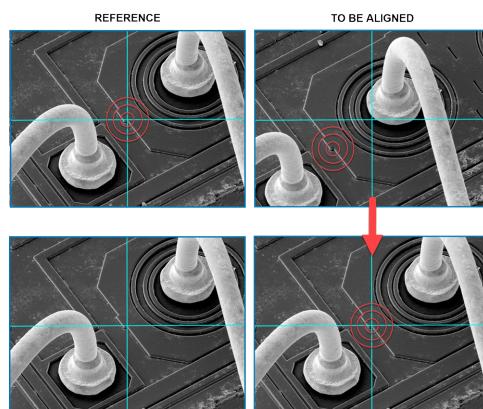
4. Repeat step 1-3 until the image is focused properly.
5. If you see **image movement** during astigmatism correction, SEM stigmators are centered incorrectly and they need to be centered → [Auto Stigmators Centering \(page 91\)](#).

**Note:** It is recommended to adjust stigmators on round objects.

### 8.5.3.6 Image Alignment

Image alignment is useful when you switch between two scanning modes during your work (e.g. UH-RESOLUTION and DEPTH) and live image in DEPTH is slightly shifted from the live image in UH-RESOLUTION. UH-RESOLUTION should always be taken as **reference** and other modes (in this case DEPTH) should be aligned to it. The image shift is compensated using parameter *Image Alignment (SEM)* in **Pad**.

For image alignment use the [SEM User Alignment Wizard \(page 86\)](#) with disabled option "Fine Optimization".



### Manual Image Alignment

1. Align the live image in e.g. DEPTH with the live image in UH-RESOLUTION:
  - a. In UH-RESOLUTION:
    - i. Find a distinctive feature.
    - ii. Put the feature into the center of live image using stage movements. We recommend to use **Central crosshair** (in both the reference image and the live image). To do this, right-click on both images and select Central crosshair.
    - iii. Acquire the image.
  - b. In the **SEM panel**, select the DEPTH scan mode.
  - c. In **Pad**, select the following parameter:
    - "*Image Alignment (SEM)*" parameter for DEPTH
    - "*OBJ Centering (SEM)*" parameter for OVERVIEW and WIDE FIELD
    - There is no need to align image in ANALYSIS with UH-RESOLUTION.
  - d. Align the live image in the **SEM Scanning window** with the acquired image in UH-RESOLUTION (the reference image) using the trackball. I.e. the feature located in the center of the reference image is located in the center of the live image in DEPTH as well. You can see the parameter in **Pad** changes.

### 8.5.4 Automatic Centering (Recommended)

We recommend users to proceed automatic centering prior centering wizards. Use centering wizards **only when automatic procedures provide non-satisfactory results.**

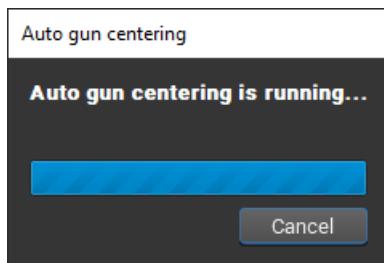
There are **six** automatic centering procedures:

8.5.4.1 Auto Gun Centering .....	89
8.5.4.2 Auto Gun Fine Centering .....	90
8.5.4.3 Auto Objective Centering .....	90
8.5.4.4 Auto Stigmators Centering .....	91
8.5.4.5 Auto Stigmators Precentering .....	91

You can find them in Essence SW: **SEM Scan panel » Alignments » ...**

#### 8.5.4.1 Auto Gun Centering

Automatically centers the electron gun at the **selected landing energy (Eng)** for all beam currents (BC) at once. The result of the procedure is automatically **applied in all scan modes**.



**Proceed when / if:**

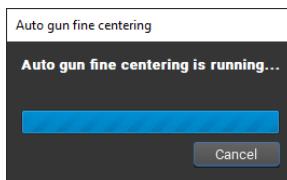
- When you want to **work at higher beam currents**.
- Cannot obtain a properly focused image and all the previous centering attempts fail.

**Quick Access:** Essence » **SEM Scan** panel » Alignments » Auto Gun Centering.

**Note:** It is recommended to center the electron gun on a flat homogenous sample surface. Only the sample which is non-sensitive to higher beam currents should be used.

#### 8.5.4.2 Auto Gun Fine Centering

Automatically centers the electron gun at the **selected landing energy** (Eng) and at the **selected beam current** (BC). This procedure is faster than standard Auto Gun Centering. The result of the procedure is automatically **applied in all scan modes**.



**Proceed when / if:**

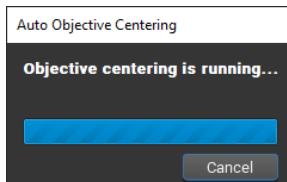
- Cannot obtain a properly focused image and all the previous centering attempts fail.
- When you want to **work at the selected beam current only**.

**Quick Access:** Essence » **SEM Scan** panel » Alignments » Auto Gun Fine Centering.

**Note:** It is recommended to center the electron gun on a flat homogenous sample surface. Only the sample which is non-sensitive to higher beam currents should be used.

#### 8.5.4.3 Auto Objective Centering

Automatically centers the SEM objective lens. OBJ centering is done **only at the selected scan mode**, i.e. when the scan mode is changed, the user should center the objective again (if needed).



**Proceed when / if:**

- Image moves when focusing.
- It should be used **after any gun centering**.
- It should be also used **after stigmators centering**.

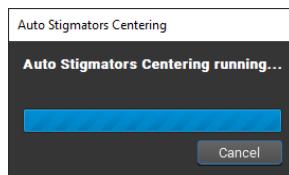
**Quick Access:** Essence » **SEM Scan** panel » Alignments » Auto Objective Centering.

In case of **non-satisfactory result** → [SEM Objective Centering Wizard \(page 84\)](#).

**Not available for** OVERVIEW and WIDE FIELD → Use [SEM Objective Centering Wizard \(page 84\)](#) instead for OVERVIEW. WIDE FIELD is not centered at all.

#### 8.5.4.4 Auto Stigmators Centering

Automatically centers SEM stigmators. Stigmators centering is done **only at the selected scan mode**, i.e. when the scan mode is changed, the user can center stigmators again (if needed).



##### Proceed when / if:

This wizard should only be used when you see image movement during astigmatism correction.

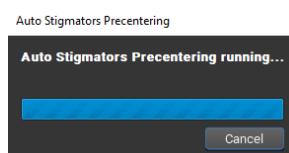
**Quick Access:** Essence » **SEM Scan** panel » Alignments » Auto Stigmators Centering.

In case of **non-satisfactory result** → [SEM Stigmators Centering Wizard \(page 85\)](#).

**Not available for** OVERVIEW and WIDE FIELD → Use [SEM Stigmators Centering Wizard \(page 85\)](#) instead.

#### 8.5.4.5 Auto Stigmators Precentering

Automatically precenters SEM stigmators. Stigmator precentering should be used only if Stigmator centering cannot be done (more than 100% needed). However it is common correction for all scan modes (is not remembered per scan mode) thus realignment in one mode may affect accuracy of Stigmator centering in other modes.



##### Proceed when / if:

**This wizard should only be used if Stigmators centering values > 90%.** Go to Pad and check parameters "Stigmator A Centering (SEM)" and "Stigmator B Centering (SEM)". If any of these two parameters are > 90%, run this procedure (see example below). Once done, proceed [Auto Stigmators Centering \(page 91\)](#).

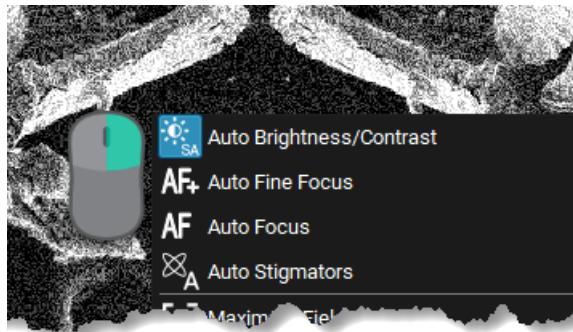


**Quick Access:** Essence » **SEM Scan** panel » Alignments » Auto Stigmators Precentering.

**Not available for** OVERVIEW and WIDE FIELD scan modes.

### 8.5.5 Auto Image Adjustments

In Essence SW there are some automatic procedures which might help you with quick adjustment of the live image. They are all located in Essence » **SEM Scanning** window » right-mouse click on live image:



#### 8.5.5.1 Auto Focus

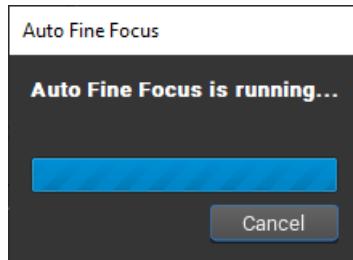
Automatically focuses the objective on the sample.

**Quick Access:** Essence » **SEM Scanning** window » right-mouse click on live image » Auto Focus.

In case of **non-satisfactory result** → focus the image using **WD** (Working distance) parameter and trackball.

#### 8.5.5.2 Auto Fine Focus

Automatically and finely focuses the objective on the sample within smaller range than Auto Focus (depends on field of view used: 0.3–1 mm).



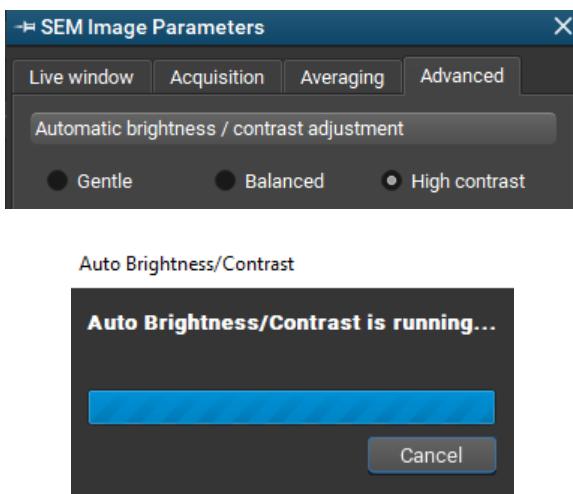
**Quick Access:** Essence » **SEM Scanning** window » right-mouse click on live image » Auto Fine Focus.

In case of **non-satisfactory result** → focus the image using **WD** (Working distance) parameter and trackball.

### 8.5.5.3 Auto Brightness / Contrast

Automatically sets optimal contrast and brightness of the live image. Three Auto B / C modes are available (can be changed in main Menu » **SEM** » Image Parameters » tab Advanced):

- **Gentle** - a mode in which there should be no excessive saturation in the image. This mode is suitable for work where it is necessary to see structures both on sample edges and surface + in sample holes. This is useful e.g. for cross sectioning.
- **Balanced** - an universal mode, which should provide suitable brightness and contrast in most cases.
- **High contrast** - higher contrast image mode suitable for low contrast samples. It is recommended for samples where is low signal to noise ratio (e.g. when working at low currents).



**Quick Access:** Essence » **SEM Scanning** window » right-mouse click on live image » Auto Brightness/Contrast.

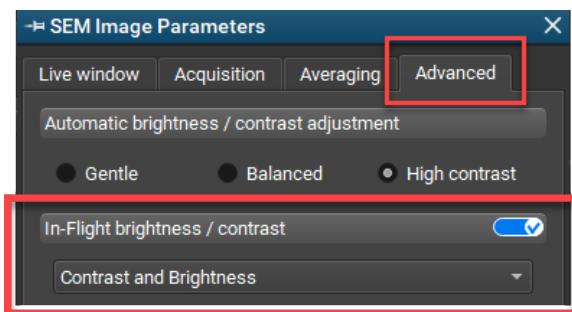
In case of **non-satisfactory result** → adjust **Brightness / Contrast** parameter in Pad manually.

#### 8.5.5.4 In-Flight Brightness / Contrast

Automatically and **continuously** sets optimal contrast and brightness of the live image. When landing energy is changed, In-Flight Brightness / Contrast (InA) is proceeded automatically to achieve the optimal image contrast. When brightness / contrast is changed manually, InA automatic proceeding is paused (it reactivates after using Auto Brightness / Contrast function). InA can be turned off in **SEM Image Parameters**.

As well as the standard Auto Brightness / Contrast, InA **is influenced by changing “auto brightness / contrast” mode** (Gentle / Balanced / High Contrast). InA has also its two dedicated modes:

- **Contrast and Brightness** - computes the optimal contrast and brightness. This mode is recommended for common work with InA.
- **Contrast only** - computes only the optimal contrast. This mode is recommended for advanced adjustment of InA. Also, change of the image is smoother (less noisy). The parameter **Adjustment target value** says how light (positive values) or dark (negative values) you want the image to be.



**Quick Access:** Essence » **SEM** » Image Parameters » tab Advanced » In-Flight brightness/contrast = ON.

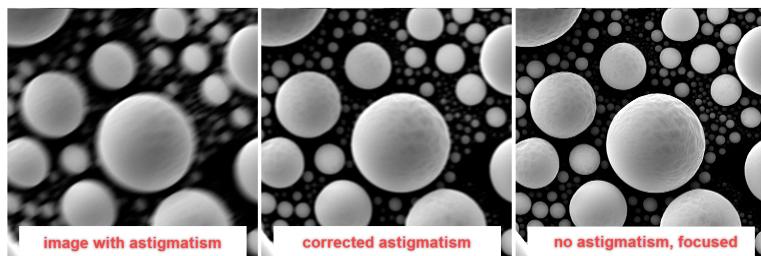
In case of **non-satisfactory result** → adjust **Brightness / Contrast** parameter in Pad manually.

### 8.5.5.5 Auto Stigmators

Automatically corrects image astigmatism.

#### Proceed when / if:

You see astigmatism in the image (image is blurred, unclear, or appears stretched).



**Note:** To improve imaging conditions suitable for the Auto Stigmators procedure, increase the signal either by adjusting beam current, brightness / contrast or increase view field (if you are in  $\mu\text{m}$  ranges).

Quick Access: Essence » **SEM Scanning** window » right-mouse click on live image » Auto Stigmators.

In case of non-satisfactory result → [Astigmatism Correction \(Stigmators "Adjustment"\) \(page 87\)](#).

### 8.5.6 Saving Your Centering

Changes in electron column settings made by SEM centering procedures can be **saved for later use into a preset** together with other parameters, e.g. beam current, scan mode etc. It is useful, if there is a repeated need for imaging with this set of specific column conditions. Instead of setting the parameters and centering the SEM column every time, just apply your preset and start imaging. The user can select which parameters are stored when creating a preset.

→ [Presets on page 70](#)

### 8.5.7 Restoring Default Centering

To reset user centering (e.g. OBJ centering) and restore its factory value, go to Pad panel » select *OBJ Centering (SEM)* » click the **Reset to default values** button .

You can also **reset the complete user alignment** of the SEM column and restore factory values. To do this, go to main Menu » SEM » Reset User Centering.

→ Chapter **Reset User Centering** in *Essence Help*

→ [SEM Centering Tutorials \(page 96\)](#)

## 8.6 SEM Centering Tutorials

### 8.6.1 Common Centering Procedure (Regular Work)

Use these tutorials when you want to mainly work **with one scan mode** (e.g. only in DEPTH).

#### 8.6.1.1 SEM Centering in UH-RESOLUTION

1. Set **imaging conditions** incl. scan mode (or activate a **Preset**).
2. Go to the **SEM** panel again and select the parameter **WD** (Working Distance) or press **W** on your keyboard.  
Now **focus** the image using the trackball (**Focus Window** recommended).  
In case you see ...
  - *image movement when focusing?* → run [Auto Objective Centering \(page 90\)](#)
  - *image astigmatism?* → run [Auto Stigmators \(page 95\)](#)
3. Focus the image properly (you can also use [Auto Fine Focus \(page 92\)](#)).
4. Update the preset. Now you may start your work.

#### 8.6.1.2 SEM Centering in DEPTH, ANALYSIS and OVERVIEW

1. Set **imaging conditions** incl. scan mode (or activate a **Preset**).
2. Go to the **SEM** panel again and select the parameter **WD** (Working Distance) or press **W** on your keyboard.  
Now **focus** the image using the trackball (**Focus Window** recommended).  
In case you see ...
  - *image movement when focusing?* → run [Auto Objective Centering \(page 90\)](#) (in OVERVIEW use [SEM Centering Tutorials \(page 96\)](#))
  - *image astigmatism?* → run [Auto Stigmators \(page 95\)](#)
3. Align the image with the image in UH-RESOLUTION → Use [SEM User Alignment Wizard \(page 86\)](#) with disabled option "Fine Optimization".
4. Focus the image properly (you can also use [Auto Fine Focus \(page 92\)](#)).
5. Update the preset. Now you may start your work.

#### 8.6.1.3 SEM Centering in WIDE FIELD

In WIDE FIELD, the image must be only aligned with the image in UH-RESOLUTION.

1. Set **imaging conditions** incl. scan mode (or activate a **Preset**).
2. Align the image with the image in UH-RESOLUTION → Use [SEM User Alignment Wizard \(page 86\)](#) with

disabled option "Fine Optimization".

3. Focus the image properly (you can also use [Auto Fine Focus \(page 92\)](#)).
4. Update the preset. Now you may start your work.

### 8.6.2 Centering of Multiple Conditions

When you want to work at multiple imaging conditions (e.g. different beam currents, different scan modes etc.), center the SEM column using [SEM User Alignment Wizard \(page 86\)](#).

## 8.7 Switching the Electron Source OFF / ON

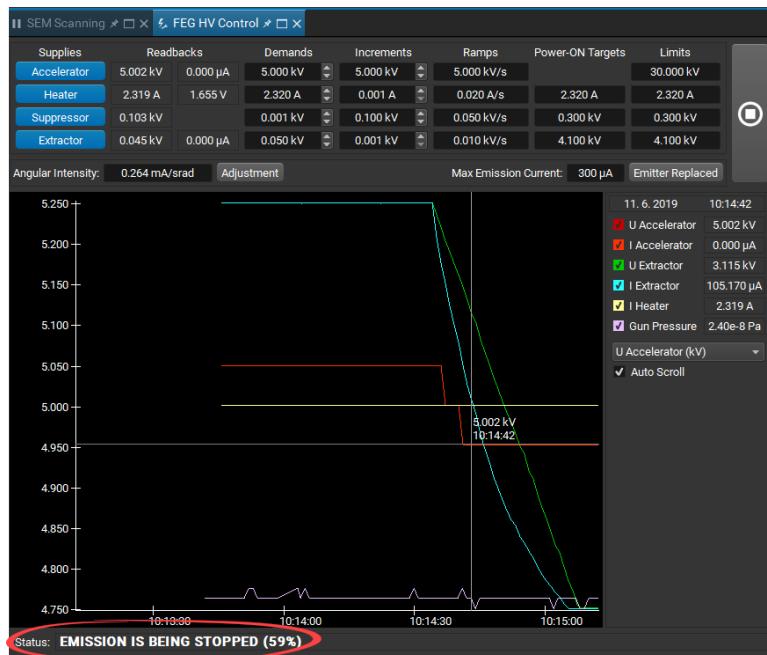
**SUPERVISOR ONLY**

The source of primary electrons (FEG - Field Emission Gun) is **permanently switched ON**. This ensures electron emission stability without interruption over the entire lifetime of the Schottky cathode (thousands of hours).

The FEG should be **turned OFF only for non-standard reasons**, e.g. prolonged power supply interruption, servicing the microscope etc. (For safety reasons, the electron source can be also switched OFF automatically by Essence SW, e.g. high pressure in the gun or long term power interruption.)

### 8.7.1 Switching the Electron Source OFF

1. Log in as supervisor.
2. Open the **FEG HV Control** panel - do one of the following:
  - Type **FEG HV Control** in the Search bar (CTRL+F).
  - Go to main Menu » SEM » FEG HV Control.
3. Click the **Power Off** button  to start the automatic shutdown procedure. Confirm with OK. Wait until the procedure finishes (see *Status* at the bottom of the panel).



4. (Optional) Switch the system into the Power save mode by clicking  icon in the top-right corner of the screen. Select the **Power save mode** and confirm with YES.
5. (Optional) Turn OFF the PC.

### 8.7.2 Switching the Electron Source ON

1. Log in as supervisor.
2. If the icon for Sleep mode / Power saving mode flashes orange , click on it to switch the microscope back into the normal state. The icon is located at the top-right corner of the screen.
3. Open the **FEG HV Control** panel - do one of the following:
  - Type **FEG HV Control** in the Search bar (CTRL+F).
  - Go to main Menu » SEM » FEG HV Control.
4. Click the **Power On** button  to start gun emission. Confirm with OK. Wait until the automated procedure finishes (see *Status* at the bottom of the panel).

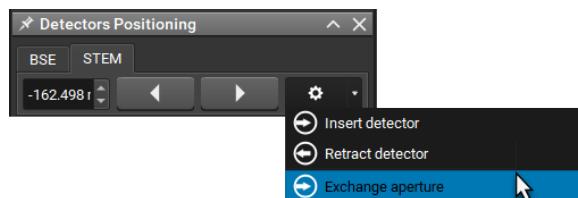


## 8.8 Changing the R-STEM Aperture

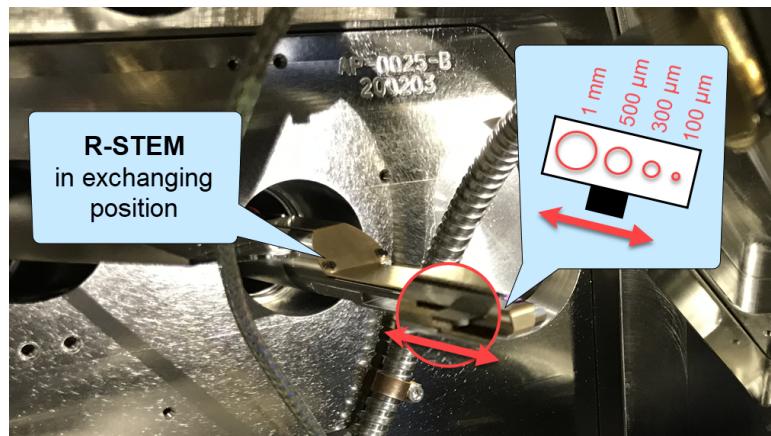
In the **Bright Field** R-STEM imaging mode an **aperture size** (diameter) can be manually customized. Four aperture sizes are available: **1 mm, 500 µm, 300 µm and 100 µm**. The smaller the aperture size the more narrow the Bright Field angle and thus better contrast when examining light materials.

### Step-by-Step Tutorial

1. Open the **Detectors Positioning** panel by e.g. going to main Menu » Tools » Detectors » Detectors Positioning. Go to the STEM tab, click on the sprocket drop-down menu and select **Exchange Aperture** (see below). The stage moves downwards to the safe position and the R-STEM detector moves to the exchanging position (i.e. approximately half-inserted).



2. Vent the microscope using the **Vent** button, put on **powder-free clean gloves** and open the chamber door.
3. Carefully insert your hand into the chamber and change the aperture using the **aperture plate** located on the detector on the left (you can move with it only forwards / backwards). There are four positions, each for one aperture size. Locations of the apertures are (front to back): 100 µm, 300 µm, 500 µm and 1 mm.

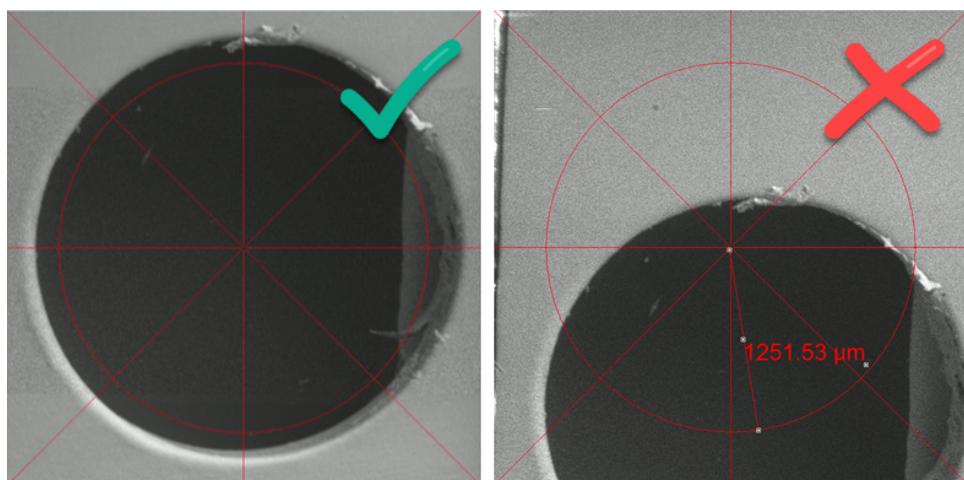


4. Close the chamber door, pump the chamber using the **Pump** button and take off the gloves.
5. Go to the **Detectors Positioning** panel » STEM tab » and click on the sprocket drop-down menu again and select **Retract detector**. The detector calibrates and moves to the parking position.
6. We recommend to center the detector as in [Centering the R-STEM Detector on page 101](#) (especially when changing a larger aperture for a smaller one).

## 8.9 Centering the R-STEM Detector

To ensure that the **Bright Field** segment (diode) of the R-STEM detector is located properly in the center of the SEM image (see figure below) it is necessary to center the detector. During the centering, both the horizontal and vertical position of the segment must be adjusted properly:

- **Horizontal centering** is controlled using the **Detectors Positioning** panel in the TESCAN Essence software.
- **Vertical centering** must be done manually using a screwdriver and two centering screws accessible through the detector cover on the left (see below).



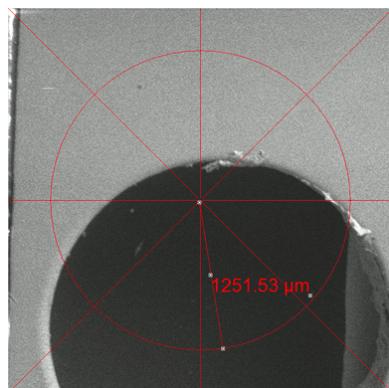
**Figure 8-2** Left - correctly centered detector i.e. the Bright Field segment is located in the middle of the SEM image; right - incorrectly centered detector.

### Centering Procedure Step-by-Step

1. Make sure the SEM column is centered properly (→ [SEM Centering Tutorials \(page 96\)](#)).
2. Select the E-T detector and the OVERVIEW scan mode.
3. Set **Maximum Field of View**.
4. Go to the **Detectors Positioning** panel (main Menu » Tools » Detectors » Detectors Positioning) » STEM tab » click on the sprocket and select **Insert detector**. The detector moves to the working position.
5. Open the **Measurements** panel (main Menu » Tools » Measurement) and activate the polar grid with lines by selecting the **Show polar grid with lines** view.



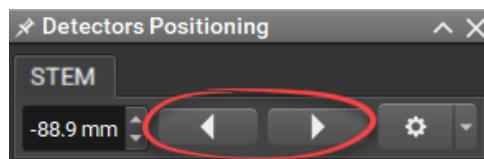
6. Using the Measurement panel measure the distance between the center of the Bright Field (BF) diode from the center of the SEM image (see image below). The distance must be less than 1.5 mm. **In case the distance is more than 1.5 mm, please call an authorized service engineer and do not continue with this centering procedure! The service engineer must readjust the whole device first.**



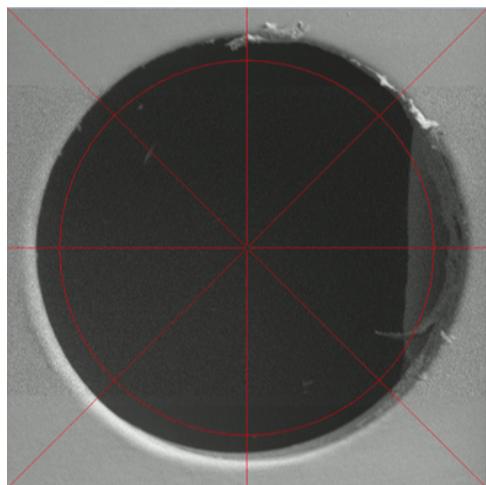
7. If needed, adjust the detector **vertically** using a 3 mm hexagonal screwdriver and the two centering screws accessible through the detector cover (see figure below), until the BF segment is adjusted properly in vertical direction.



8. If needed, adjust the detector **horizontally** using the arrows in the Detectors positioning panel until the BF segment is adjusted properly in horizontal direction.



9. Now the detector should be centered properly. See the example below:

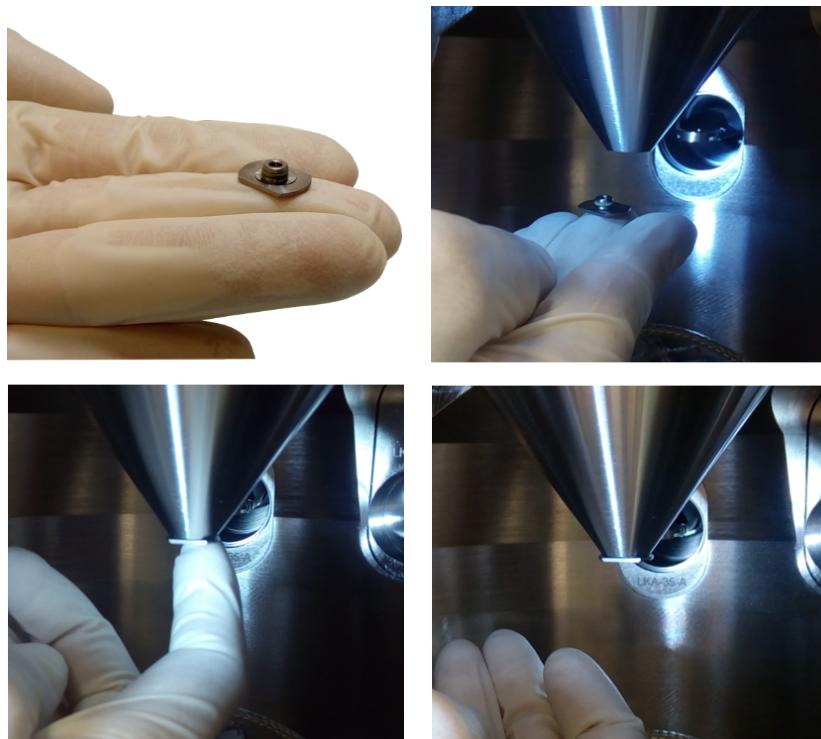


## 8.10 Inserting / Removing the LowVac Aperture

Before entering the LowVac mode, a special LowVac aperture must be **inserted into the bottom part of the SEM objective** (accessible from the microscope chamber). When your work in LowVac mode is finished and you want to go back to HighVac, remove the LowVac aperture from the objective.

### Inserting the LowVac Aperture

1. Prerequisites:
  1. All retractable detectors (e.g. CL, BSE, STEM, EDS, EBSD) are parked.
  2. Nanomanipulator is in the parking position (if present).
  3. Sample stage **Tilt** is set to zero (or use the **Home** button in the **Stage Control panel**).
2. Vent the chamber using **Vent**.
3. Put on **powder-free clean gloves** to avoid microscope chamber contamination.
4. When venting is finished, gently pull the chamber door to open it.
5. **Insert** the aperture into the SEM objective with the wider part downwards. Gently push the aperture until it is fixed in the objective.



To **remove** the aperture, gently pull the aperture downwards from the objective.

6. Close the chamber door by pushing it towards the chamber. Check whether the chamber door is tightly closed.
7. Pump the chamber using the **Pump** button. Now you may take off the gloves.

**Note:** Frequent insertion and removal of the LowVac aperture can result in surface **deformation of the metal contact ring**. This does not affect the functionality of the contact ring, the ring works properly despite deformation, i.e. continues to provide electrical connection between the SEM objective and the aperture. **DO NOT remove the contact ring!**

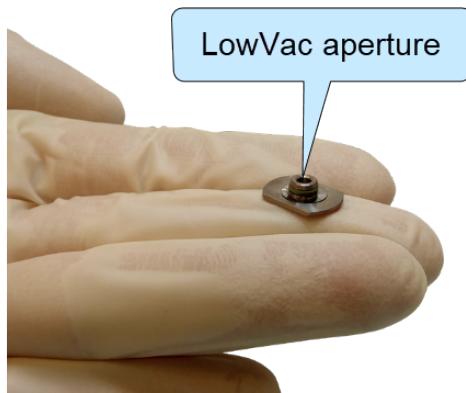
**Note:** The LowVac aperture sealing o-ring can be replaced when damaged → [Exchanging the LowVac Aperture Sealing O-Ring on page 107.](#)

## 8.11 Cleaning the LowVac Aperture

Contamination and impurities can get into the microscope during specimen exchange. This can result in deteriorating optical quality. Therefore the aperture needs to be cleaned periodically. The frequency and method of cleaning depend on the operating conditions. Under normal conditions, we recommend cleaning the aperture every 3-6 months.

**Note:** In case the sealing o-ring is damaged, replace it carefully using the tweezers. Extra o-rings are located in the accessories box. See [Exchanging the LowVac Aperture Sealing O-Ring on page 107](#).

**Note:** Frequent insertion and removal of the LowVac aperture can result in surface deformation of the metal contact ring. This does not affect the functionality of the contact ring, the ring works properly despite deformation, i.e. continues to provide electrical connection between the SEM objective and the aperture. **DO NOT remove the contact ring!**

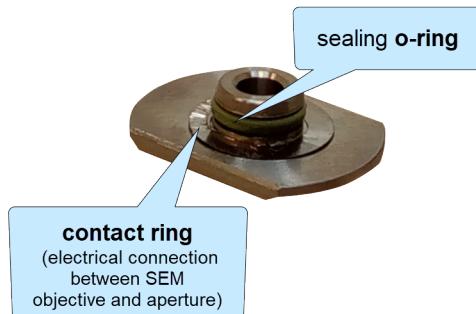


### Cleaning Procedure Step-by-Step

1. Put on **powder-free clean gloves** to avoid contamination.
2. Place the whole aperture into a beaker filled with isopropyl alcohol.
3. Wash the aperture in an ultrasonic bath for about 10 minutes.
4. Blow onto the aperture with cleaned compressed nitrogen.

## 8.12 Exchanging the LowVac Aperture Sealing O-Ring

Regular use of the aperture may damage the sealing o-ring. In case the o-ring is damaged, replace it carefully using tweezers (see the tutorial below). Extra o-rings are located in the accessories box.



**Note:** Frequent insertion and removal of the LowVac aperture can result in surface **deformation of the metal contact ring**. This does not affect the functionality of the contact ring, the ring works properly despite deformation, i.e. continues to provide electrical connection between the SEM objective and the aperture. **DO NOT remove the contact ring!**

### Exchanging Procedure

1. Put on a clean, **powder-free gloves** to avoid microscope chamber contamination.
2. Remove the damaged sealing o-ring using tweezers - pull the o-ring out of its groove using tweezers and roll the o-ring upwards with your fingers. Be careful not to scratch the aperture or any other aperture part.
3. Put on the new o-ring on the aperture tip and roll it downwards into its place with your fingers.

**Note:** The sealing ring of the low vacuum aperture **does not need to be lubricated with vacuum grease**. This is the only exception in the entire microscope system.

## 8.13 Refilling LowVac Water Reservoir

When working in the **LowVac H<sub>2</sub>O** mode, the chamber is filled with water vapor. During the examination, water vapor (and thus water) is constantly consumed. The higher the pressure, the higher the water consumption.

Water is stored in **water reservoir** located in the electronics cabinet under the microscope chamber. The amount of water in the reservoir is monitored by a sensor. There is no need from your side to monitor the amount of water in the reservoir or to do any other maintenance. Refill the water in reservoir only when TESCAN Essence software asks you to do it. When the amount of water in the reservoir goes **below 30%**, a warning appears in **Health Status: Vacuum: LowVac Water Reservoir: water is running low**.



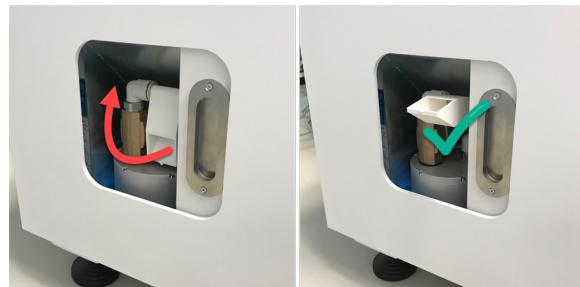
In TESCAN Essence software, there is a **Water Reservoir Refill** wizard which guides the user through water refilling procedure. The wizard is available for all user levels.

### Water Reservoir Refill Step-by-Step

1. Double-left click on the warning *Vacuum: LowVac Water Reservoir: water is running low* in **Health Status**. The Water Reservoir Refill wizard will be opened.  
You can also open the Water Reservoir Refill wizard by one of the following:
  - Type **Water Reservoir Refill** in the Search bar (CTRL+F).
  - Go to main software toolbar » **Wizard** drop-down menu » Water Reservoir Refill.
2. The wizard will then guide you through operations needed to be done before water refilling - full microscope chamber vent (step 2/4) and water reservoir vent (step 3/4).
3. In step 4/4, add water into the water reservoir:
  - a. Prepare a beaker or flask with purified water (approx. **200 ml**).
  - b. Open the water reservoir door by sliding them to the right. The door is located on the electronics cabinet under the microscope chamber, bottom left corner of the left cabinet side.



- c. Tip out the white plastic funnel so it lies horizontally.



- d. Put the water into the reservoir through this funnel. When the water in the reservoir reaches a minimum required level, the blue LED on the reservoir bottom starts shining. Nevertheless, keep refilling until the funnel starts to fill (water does not flow into the reservoir anymore).



- e. Carefully pour the excess water from the funnel back into the beaker or flask by putting the funnel into its vertical position. Wipe up spilled water.



- f. Close the water reservoir door.  
4. Go back to the wizard and click on **Finish**. This button closes the wizard and also starts chamber pumping.

**Note:** When you finish your work in LowVac H<sub>2</sub>O and want to switch the microscope into the **Power save mode**, please note that the primary (rotary vane or scroll) **pump will be still running** few minutes after switching into this mode (the pump needs to remove water vapour from its interior).

## 9 Troubleshooting

During your work with the microscope, you may encounter some difficulties with your sample observation. These are among the most common difficulties; here you will find a brief description of their characteristics and the steps we recommend to make your observation as smooth as possible:

### GENERAL TROUBLESHOOTING

If this occurs ...	This is probably because...	To fix this go to ...
Health Status problem	There is a problem in the system	<a href="#">What To Do If ... Health Status Reports A Problem? on page 112</a>
Settings problem	There is a problem with non-standard system settings	<a href="#">What To Do If ... Non-Standard System Settings Status Reports A Problem? on page 113</a>
You crashed with sample	Improper manipulation	<a href="#">What To Do If ... You Crashed with Your Sample? on page 114</a>
Signal lost	<i>Various reasons</i>	<a href="#">What To Do If ... You Lost Signal? on page 115</a>
Sample charging	Sample is non-conductive	<a href="#">SEM Imaging of Non-conductive Samples on page 58</a>
You see maximum view field through a circle	LowVac aperture is inserted in SEM objective	<a href="#">What To Do If ... Maximum View Field Is Limited? on page 116</a>

### CENTERING

If this occurs ...	This is probably because...	To fix this go to ...
SEM image moves when focusing	Objective is not centered properly	<a href="#">Auto Objective Centering (page 90)</a>
SEM image astigmatism	SEM stigmators are not aligned properly	<a href="#">Auto Stigmators (page 95)</a>
Image moves when adjusting SEM stigmators	SEM Stigmators are not centered properly	<a href="#">Auto Stigmators Centering (page 91)</a>
SEM Stigmators values > 90%	SEM Stigmators must be pre-centered	<a href="#">Auto Stigmators Precentering (page 91)</a>
Still cannot get a properly focused SEM image	Nothing of the above mentioned helped ...	What To Do If ... Centering Attempts Fail?

**ACCESSORIES**

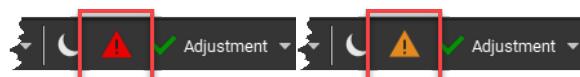
If this occurs ...	This is probably because...	To fix this go to ...
Load Lock requires restart	Something went wrong during operation	<a href="#"><u>What To Do If ... You Need To Restart Load Lock? on page 117</u></a>
LowVac reservoir requires refill	Low water level in LowVac reservoir	<a href="#"><u>Refilling LowVac Water Reservoir on page 108</u></a>

*If you are not sure what to do, ask microscope supervisor.*

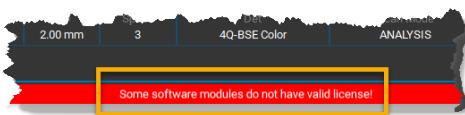
## 9.1 ... Health Status Reports A Problem?

### What Does It Look Like

Health status indicator (main software toolbar, the second icon from the right) has changed to a pulsing **red** or static **orange** triangle with an exclamation mark in the middle to draw your attention:

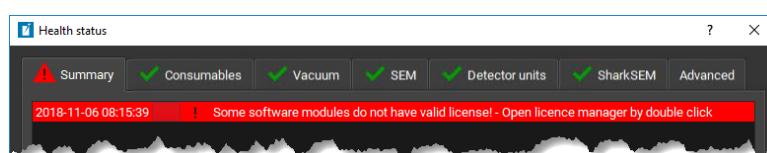


Also, the problem is shown in the software status bar in the bottom of the software interface. See the example below.



### How To Solve a Health Status Problem

1. To show system status and check what is wrong, **open the Health status panel** by one of the following:
  - Single-left-click on the Health status indicator / located in main toolbar.
  - Type **Status** in the Search bar (CTRL+F).
  - Go to main Menu » Diagnostics » Status.
  - Double-left-click on the software status bar.
2. All current problems are listed in the **Summary** tab - always with a date and a brief description of the problem (see example below). To solve the problem, double-left-click on it in the tab. The software will then guide you through operations that are needed to fix it.



To learn more, see chapter ***Health Status*** in *Essence Help*.

To learn how to fix the Adjustment icon problem → [What To Do If ... Non-Standard System Settings Status Reports A Problem? on page 113](#)

## 9.2 ... Non-Standard System Settings Status Reports A Problem?

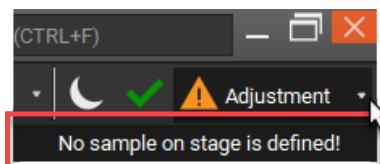
### What Does It Look Like

The **Adjustment** icon (main software toolbar, the first icon from the right) has changed to orange triangle with an exclamation mark in the middle to draw your attention:



### How To Solve a Non-Standard System Settings Problem

1. To show the problem and check what is wrong, single-left-click on the Adjustment icon. See the example below.



2. Single-left-click on the problem name. The software will then guide you through operations that are needed to fix it.

To learn more about Non-standard system setting status, see chapter **Health Status** in *Essence Help*.

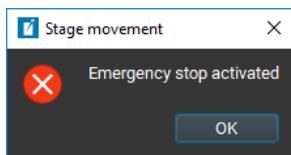
To learn how to solve a Health status issue → [What To Do If ... Health Status Reports A Problem? on page 112](#).

## 9.3 ... You Crashed with Your Sample?

### What Does It Look Like

In case of accidental collision between hardware components, e.g. hitting the SEM objective with the conductive sample, an electrical circuit is closed and the following actions are taken:

- All motorized movements are immediately stopped.
- A warning **high-frequency beep** starts sounding.
- The warning message appears:



This safety mechanism is called **Touch Alarm**.

### How To Restore the System After Collision Stopped by Touch Alarm

1. Click **OK** to close the warning message.
2. Find out what happened and which parts have collided.
3. Navigate the touching hardware components to separate them. Once they are no longer touching, the beep sound will stop.
4. Calibrate the hardware components where calibration is required, e.g., stage, detectors, etc.

### How To Avoid A Collision Next Time

To avoid a collision, do **ALL** of the following:

- Define dimensions of your sample in the **Sample Exchange** wizard.
- Monitor all in-chamber movement using the **Chamber View** and be prepared to terminate the movement anytime using the **Stop** button in the **Stage Control** panel.



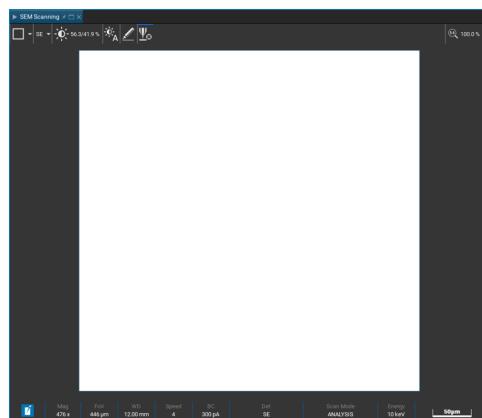
#### NOTICE

Touch Alarm **does not** work for **non-conductive samples**, **nanomanipulators** and when **BDM** is active (no beep sound in these cases).

## 9.4 ... You Lost Signal?

### What Does It Look Like

The live image goes completely blank (dark or white). Sometimes the blank image might be noisy.



### How To Get the Signal Back

To find out what is wrong with the signal, please ensure the following:

- **SEM** beam is ON
- Scanning is ON
- A suitable detector is used
- Parameter **AC** (**SEM** panel) is non-zero and corresponds to **Beam Current**

If the above steps do not restore the signal, try one of the following:

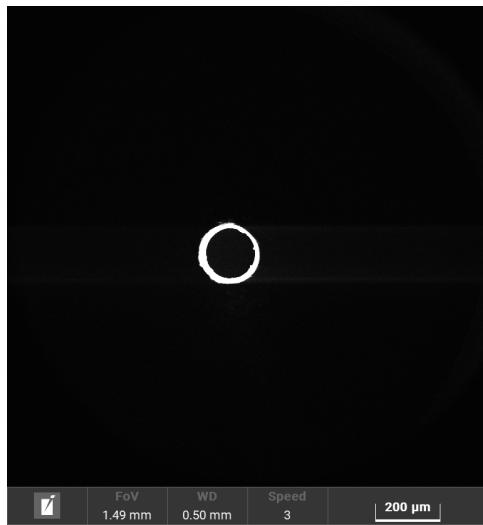
- Rescan the image (**SEM Scan** panel » **Single scan** )
- Right-click on the live image and select **Auto Brightness / Contrast**
- If you still cannot obtain the signal back, consider to re-center the SEM column → What To Do If ... Centering Attempts Fail?

## 9.5 ... Maximum View Field Is Limited?

### What Does It Look Like

When the view field is maximized, the user can see only a narrow view field through a small circle in the middle of the image (see example below).

This is because the **LowVac aperture was not removed** after leaving the LowVac mode. The presence of the aperture when using HighVac affects only the image (does not result in damage of the microscope).



### How To Remove the LowVac Aperture

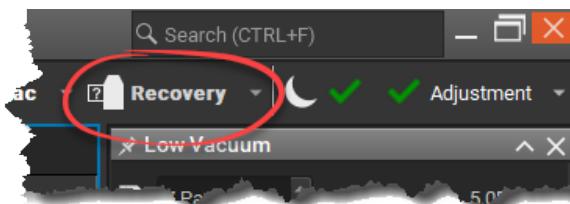
→ [Inserting / Removing the LowVac Aperture on page 104](#).

## 9.6 ... You Need To Restart Load Lock?

### When To Restart Load Lock

Restart the Load Lock if any of the following situations appears:

- The option **Recovery** appears on the top of the chamber control toolbar icon:



- Load Lock does not respond to the **Load sample** or **Unload sample** command.
- Load Lock gets stuck during the Load Lock operation.
- Something goes wrong during the Load Lock operation.

### How To Restart Standard Automated Load Lock

- Click on the **Recovery** button on top of the chamber control toolbar icon (see the figure above) or go to the chamber control drop-down menu » Recovery.
- A new dialog appears - select the current position of the sample. To find the current sample position (microscope chamber or on Load Lock), use **Chamber View**.

If the microscope and Load Lock get stuck in an unusual situation, e.g. open LSV (LSV= Load Separated Valve; the valve between the microscope chamber and the Load Lock chamber), the user may be also prompted to select between automated and manual recovery.

**Manual recovery** vents the microscope chamber and prompts the user to resolve the situation manually. If it is not possible, call TESCAN service. Once the manual recovery procedure is completed and the situation resolved, run the recovery procedure again and select the automatic procedure.

- Wait for the recovery process to complete. Once completed, the Load Lock arm should be located **back in the Home position**.

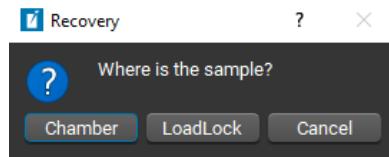


#### CAUTION

**DO NOT open the safety cover.** When the Load Lock is under operations, do not open the safety cover to avoid crush hazard!

## How To Restart Manual Load Lock

1. Click on the **Recovery** button on top of the chamber control toolbar icon (see the figure above) or go to the chamber control drop-down menu » Recovery.
2. A new dialog appears - select the current position of the sample. To find the current sample position (microscope chamber or on Load Lock), use **Chamber View**.



3. Wait for the recovery process to complete. If necessary, follow the instructions in the dialog window.



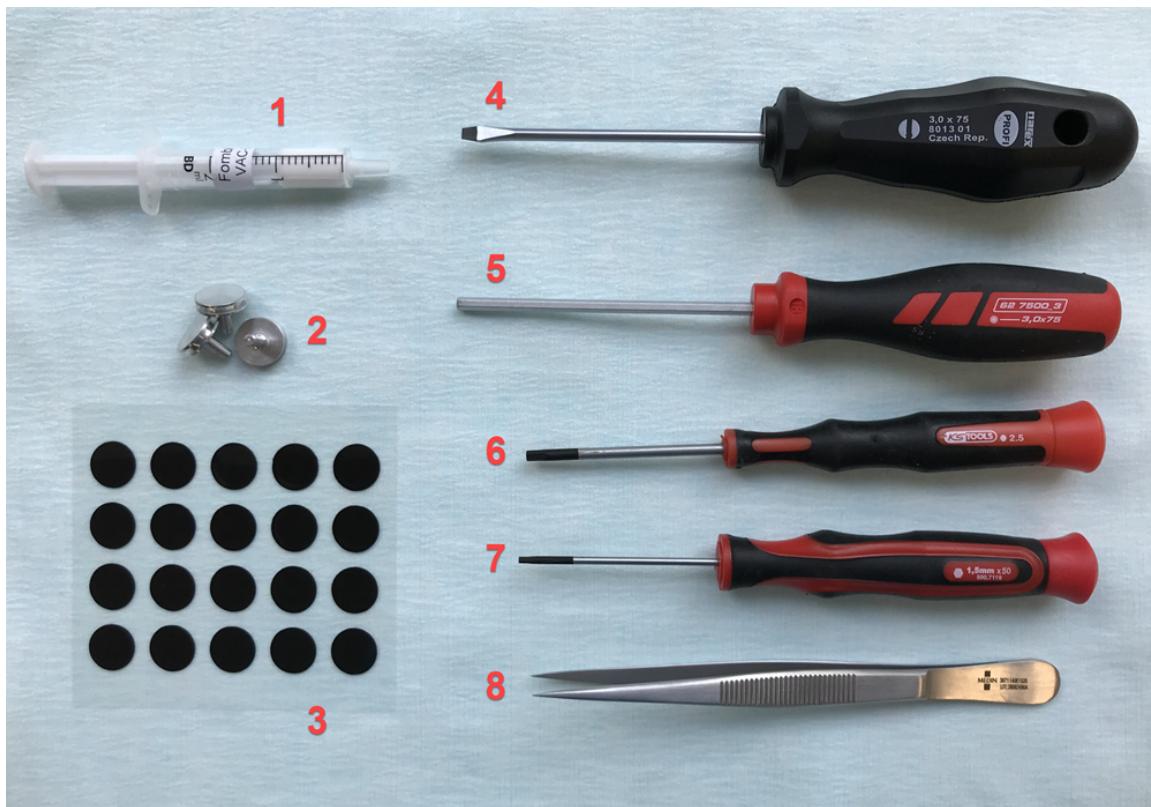
### CAUTION

**Crush hazard when using Load Lock.** The moving part of Load Lock has several pinch point hazards. Keep hands clear when the Load Lock is moving and always use the cover to avoid this hazard!

## 10 Appendix

## 10.1 Accessories Box

The following are the most important tools included in the microscope accessories box. The exact list is attached to the packaging list of the microscope.



**Figure 9-1** The most used microscope accessories

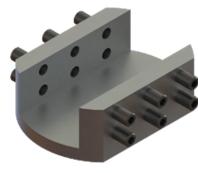
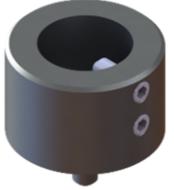
1. Vacuum grease - used for sealing of o-rings
2. Standard specimen stubs
3. Carbon conductive adhesive discs - used for bonding the sample to a stub
4. Flat screwdriver, size 3.2 mm - general use
5. Hexagonal screwdriver, size 3.0 mm - general use (the most common size used for screws)
6. Hexagonal screwdriver, size 2.5 mm - general use
7. Hexagonal screwdriver, size 1.5 mm - used for fixing the screws on the sample stage
8. Flat tweezers - general use

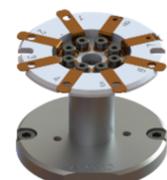
## 10.2 Sample Holders

There are many types of samples and therefore also their holders. TESCAN provides various types of sample holders. Some of them are delivered as standard, some of them can be purchased optionally. The list of provided sample holders differs according to your microscope configuration.

### 10.2.1 Standard & Most Common Sample Holders

Before the examination the sample must be fixed to a sample holder. List of specimen holders differs according to the microscope configuration. In the following table (continues on next page), the **most common types** are described:

Name + Description	Photo
<b>Pin Stub</b> Standard SEM pin stub Sizes: $\frac{1}{2}$ " (standard), 1", 1.25"	
<b>Pin Stub Extender</b> Supports pin stub for EBSD analysis	
<b>Set Screw Vice</b> Extension with centered groove Groove's width = 4 mm, groove's depth = 6 mm	
<b>Holder for Bulk or Flat Specimen</b> Up to 17 mm thick samples	
<b><math>\varnothing</math> 12 mm Holder</b> Holder for round shaped samples of diameter up to 12mm	

Name + Description	Photo
<b>ø 32 mm Holder</b> Holder for round shaped samples of diameter up to 32 mm (1")	
<b>Adapter for Stage Rotation</b> Multi-Holder for 7 standard (1/2") Pin Stubs	
<b>Pretilted Stub Holder 70°</b> Supports standard (1/2") Pin Stubs for EBSD analysis	
<b>Pretilted Stub Holder 55°</b> Supports standard (1/2") Pin Stubs for EBSD analysis	
<b>Grid Holder</b> For 6 grids ø 3.0 mm and 2 lift-out grids	

**Table 9-1** Description of the most common sample holders

## 10.2.2 R-STEM Sample Holders

In order to use optional R-STEM detector, special R-STEM sample holders must be mounted on the sample stage. In this chapter you will find description and instructions for the most commonly used R-STEM holders:

**Note:** On the bags in which the holders are stored, you can see a letter after each holder designation, e.g. APG-19-00-A. The "A" or other letter located at the end of the holder designation stands for **holder version**.

### 10.2.2.1 APG-32

A sample holder with 8 positions for 3.05 mm TEM grids. Positions 7 and 8 (engraved on the holder) are designed for analytical purposes (minimizing background from the holder for EDS). They are also suitable for lift-out grids.

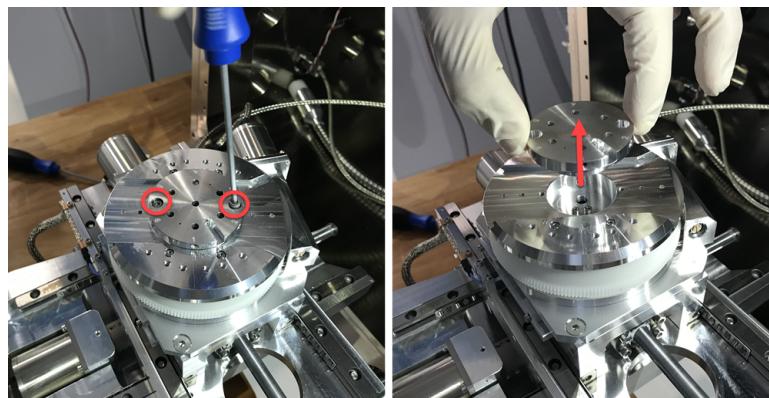
When you want to combine R-STEM imaging and [Standard Automated Load Lock \(page 127\)](#), use the APG-20 sample holder. For [Manual Load Lock \(page 134\)](#) use APG-36.



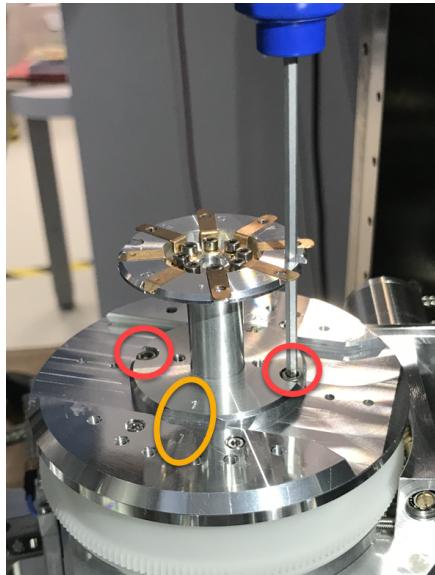
**Figure 9-2** Sample holder with 8 positions for 3.05 mm TEM grids

#### 10.2.2.1.1 APG & Sample Loading

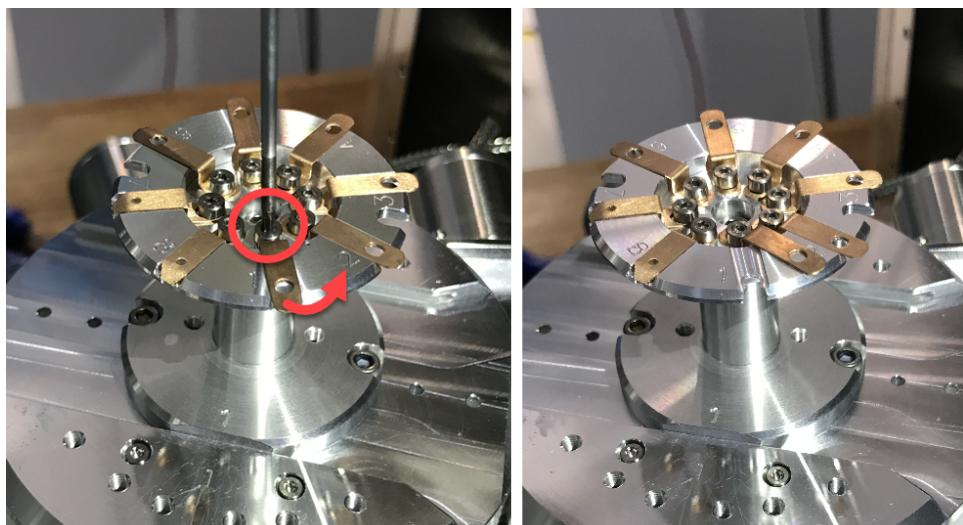
1. Vent the chamber using **Vent**.
2. Put on **powder-free clean gloves** to avoid microscope chamber contamination.
3. Open the chamber door, unscrew the standard carousel from the stage by **loosing its two holding screws** and remove it from the microscope chamber.



4. Place the APG sample holder (by default in accessories box) onto the stage the way number 1 on the holder faces number 1 on the stage (see below - orange). Fix the holder position by screwing the two holding screws (see below - red).

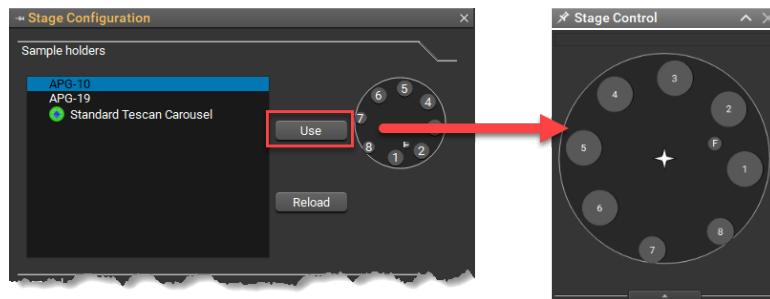


5. **Insert your sample** on the holder: loose the screw on the copper plate above the sample position using a screwdriver (see below left). Place the TEM grid to the recess on the carousel (see below right). Put back the copper plate upon the sample and tighten the holding screw to fix it. Check if the sample is fixed by the plate in the position.



6. Close the chamber door. Pump the chamber using the **Pump** button. Now you may take off the gloves.

7. In Essence, open the **Stage Configuration** panel from main Menu » Options » Stage Configuration. In the list of Carousels select **APG-10** (applies for all APG holders). Click **Use** and close the panel. Carousel overview in the **Stage Control** changes.



8. In the **Stage Control** panel, click **Calibrate** and wait until the calibration finishes.

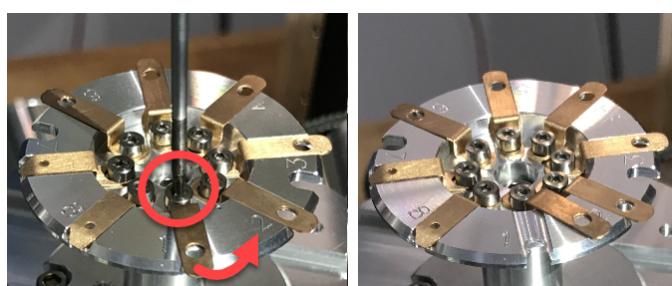
To **unload APG-10**: vent the chamber, remove the APG-10 from the stage and mount standard carousel instead, pump the chamber and in Essence, change the carousel back to **Standard Tescan Carousel**.

#### 10.2.2.1.2 APG & Standard Automated Load Lock

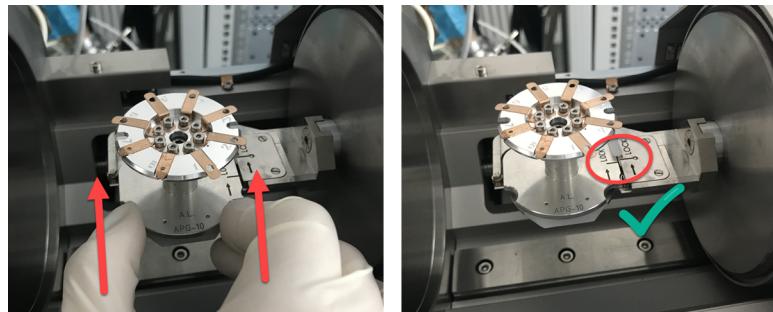
It is possible to use R-STEM sample holder using the [Standard Automated Load Lock \(page 127\)](#). For this purposes use the **APG-20** holder (on the holder bag the **APG-20** is written but on the holder itself the **APG-10** is written).

The loading / unloading procedure for APG-20 is the same as when loading / unloading standard carousel. The **lower part of APG-20 fits into Load Lock exchanging arm** even APG-20 is different from standard carousel. See the tutorial for **APG-20 loading** and use it as a reference also for unloading:

1. Put on **powder-free clean gloves**.
2. Put APG-20 on your table and **mount your sample** on it (exactly the same procedure as for APG-10). Loose the screw on the copper plate above the sample position using a screwdriver (see below left). Place the TEM grid to the recess on the carousel (see below right). Put back the copper plate upon the sample and tighten the holding screw to fix it. Check if the sample is fixed by the plate in the position.

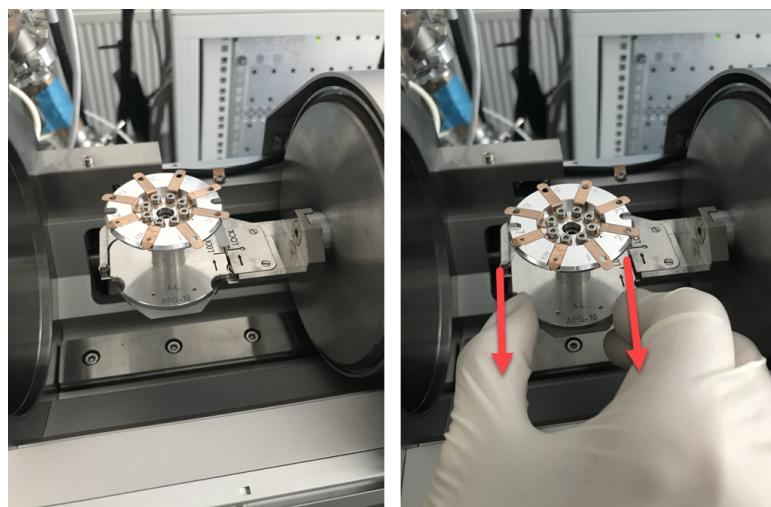


3. Ensure the standard carousel (or any other) is not located on the sample stage inside the chamber. If so, unload it using the Load Lock (LL) and remove it from the LL exchanging arm.
4. Open the LL safety cover by pulling the slider gently away.
5. Load the holder with your sample into the LL exchanging arm.



6. Close the LL safety cover by pulling the slider gently towards the microscope.
7. Go to Essence SW and click the **Load sample** button. Wait until the automated loading procedure finishes.

To **unload APG-20**: in Essence click **Unload Sample**, open the LL safety cover and slide out the holder from the LL exchanging arm.



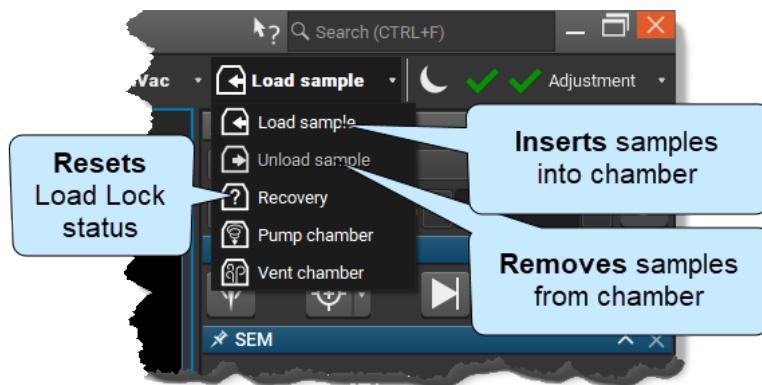
### 10.3 Standard Automated Load Lock

Standard Automated Load Lock is an optional accessory for TESCAN microscope systems which enables a **fast and easy automated specimen exchange** without the need of venting the microscope chamber. Load Lock is fully integrated into the automatic vacuum system of the microscope. Sample loading is proceeded using the Load Lock specimen exchange arm.

The loading chamber design makes it possible to exchange up to **7 samples at once**; it handle samples of **up to 500 g, 100 mm diameter and up to 4" wafers**. When using the Standard Automated Load Lock, a special sample holder is needed (**XMD-25-00**; see the figure below).



Load Lock is controlled through the **chamber control** toolbar icon:



**Need to restart Load Lock?** → [What To Do If ... You Need To Restart Load Lock? on page 117](#)

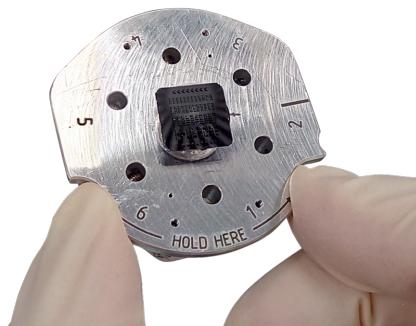


#### CAUTION

**Crush hazard when using Load Lock.** The moving part of Load Lock has several pinch point hazards. Keep hands clear when the Load Lock is moving and always use the cover to avoid this hazard! When the Load Lock is under operations, do not open the cover!

### 10.3.1 Loading a Sample

1. Prerequisites:
  - a. The microscope chamber is pumped properly.
  - b. Your sample is mounted on the special Load Lock (LL) sample holder (XMD-25-00; see the figure below). The holder is located on your table.

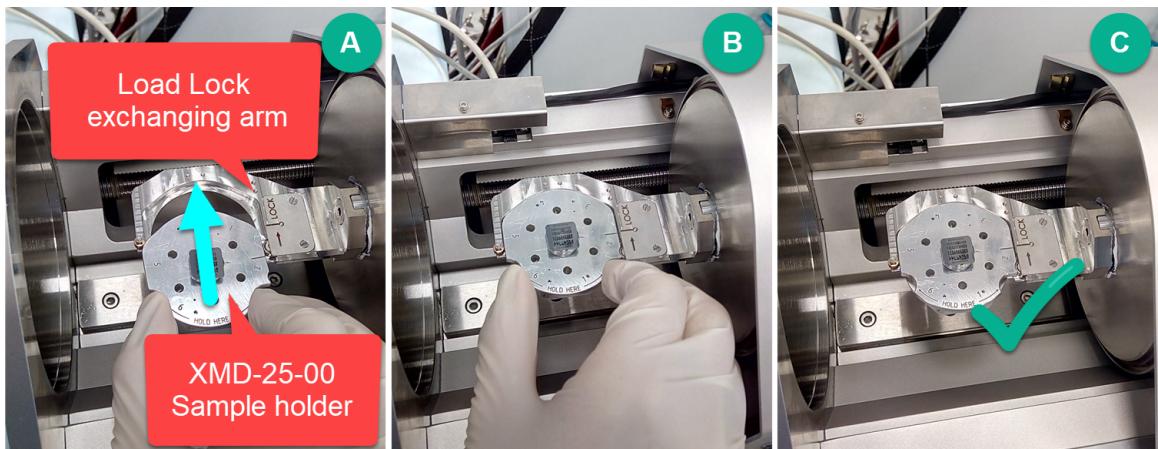


**Note:** Ensure that all screws holding the samples are screwed in and are **not protruding from the sample holder**.

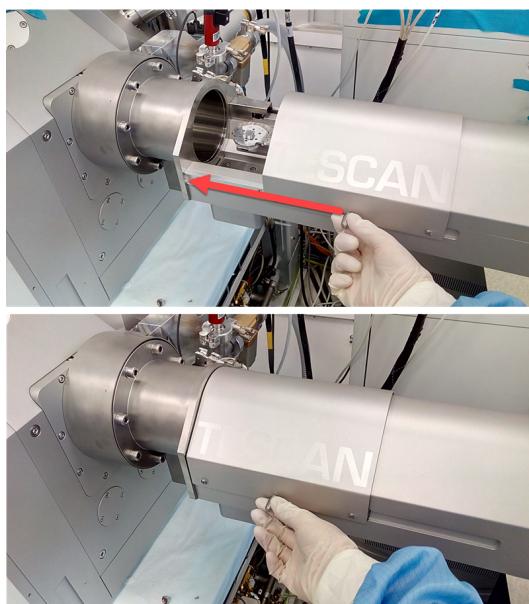
- c. For safety purposes, **Chamber View** should be open.
2. Put on **powder-free clean gloves**.
3. Open the LL **safety cover** by pulling the slider gently away from the microscope.



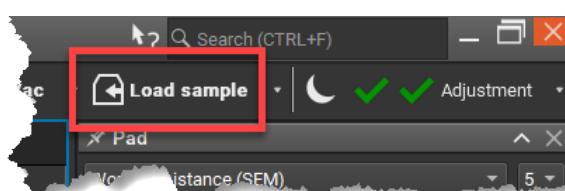
4. Grip the **XMD-25-00 holder** with your thumb and forefinger and slide it into the LL exchanging arm.



5. Close the LL **safety cover** by pulling the slider gently towards to the microscope.

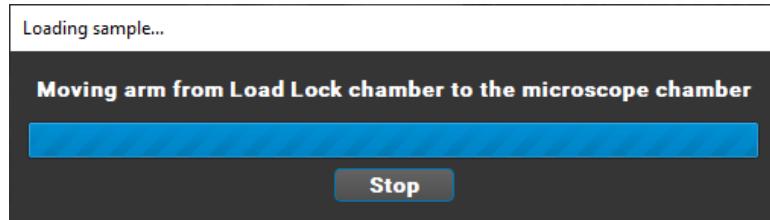


6. Go to Essence SW » toolbar » and click the **Load sample** button . Confirm with OK.



Now, the loading **proceeds automatically**. First the LL chamber is pumped. Then the sample stage inside the microscope chamber moves to the exchange position and the LL arm loads the holder on the sample

stage. In the end, the arm is retracted back into the LL chamber, the LL chamber is kept pumped. No further user action is required.



Once the dialog above disappears from the screen, the procedure is finished. Now you may start your work.

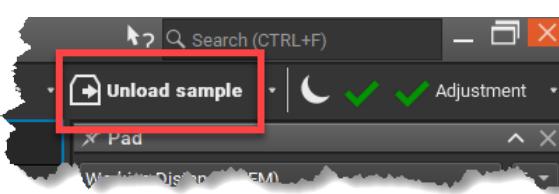


CAUTION
<b>EMERGENCY STOP.</b> In case a complication occurs during the process, click the emergency <b>Stop</b> button on the screen dialog (see the figure above). Once this button is clicked, you have to restart Load Lock → <a href="#"><u>What To Do If ... You Need To Restart Load Lock? on page 117.</u></a>
<b>CAUTION</b>
<b>Crush hazard.</b> When the Load Lock is under operations, DO NOT open the safety cover!

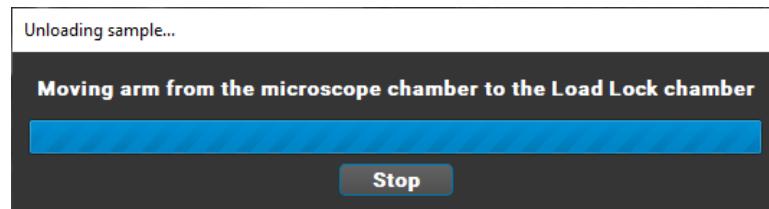


### 10.3.2 Unloading a Sample

1. Prerequisites:
  - a. The microscope chamber is pumped properly.
  - b. Sample is mounted on the special Load Lock (LL) holder XMD-25-00 and located on the sample stage inside the microscope chamber.
  - c. For safety purposes, Chamber View should be open.
2. Put on powder-free clean gloves.
3. Go to Essence SW » toolbar » and click the **Unload sample** button  **Unload sample**. Confirm with OK.



Now, the unloading **proceeds automatically**. The sample stage in the microscope chamber moves to the Exchange position and the LL arm unloads the holder from the sample stage. Then the LL arm with the holder retracts back to its Home position in Load Lock. In the end, the LL chamber is vented. In this step, no other user action is required.



Once the dialog above disappears from the screen, the procedure is finished.



#### CAUTION

**EMERGENCY STOP.** In case a complication occurs during the process, click the emergency **Stop** button on the screen dialog (see the figure above). Once this button is clicked, you have to restart Load Lock → [What To Do If ... You Need To Restart Load Lock? on page 117](#).



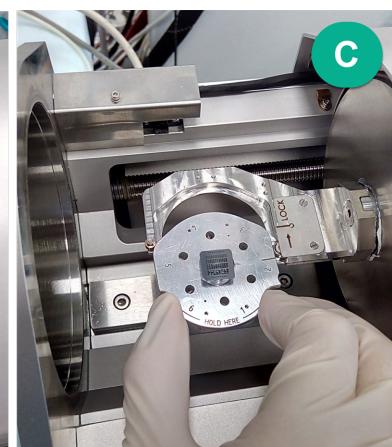
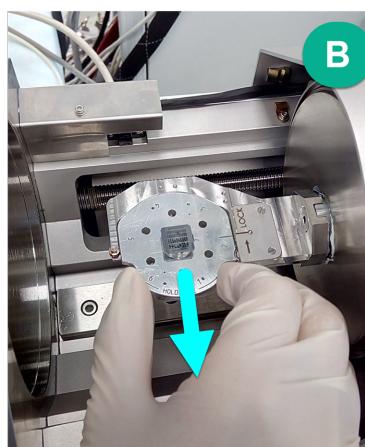
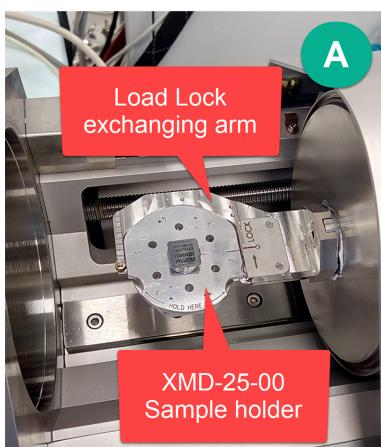
#### CAUTION

**Crush hazard.** When the Load Lock is under operations, DO NOT open the safety cover!

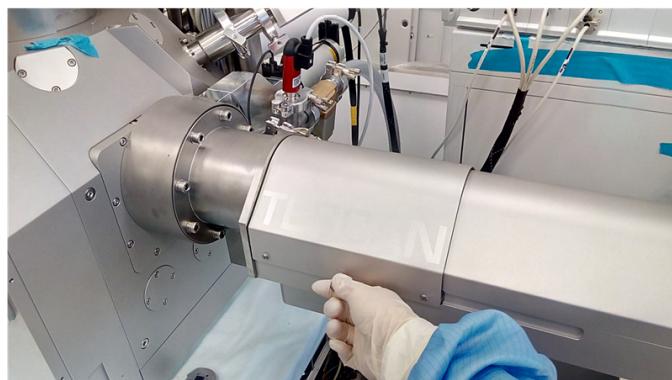
4. Open the LL **safety cover** by pulling the slider gently away from the microscope.



5. Grip the **holder** with your thumb and forefinger and slide it out from the LL exchanging arm.



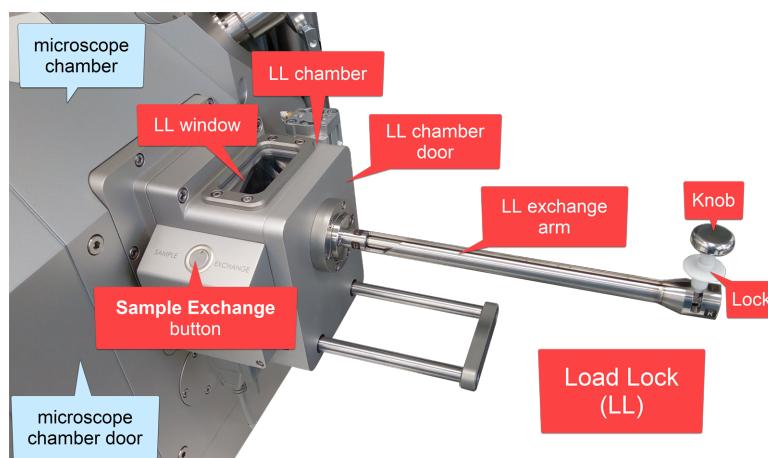
6. Close the LL **safety cover** by pulling the slider gently towards to the microscope.



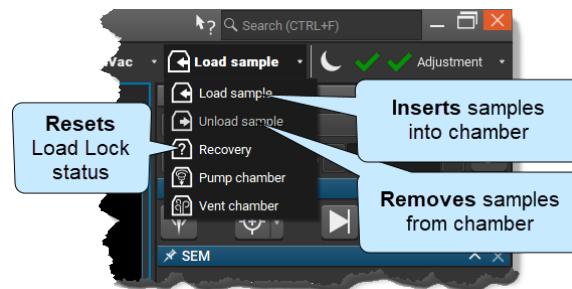
## 10.4 Manual Load Lock

Manual Load Lock is an optional accessory for TESCAN microscope systems which enables a quick and easy manual **specimen exchange without having to vent the microscope chamber**. Load Lock is fully integrated into the automatic vacuum system of the microscope. Sample loading is proceeded using the Load Lock specimen exchange arm.

The loading chamber design makes it possible to exchange up to **7 samples at once**, together up to **28 mm high** and **46 mm wide**.



Manual Load Lock is controlled through the **Sample Exchange** button located on the Load lock device (see the figure above) or through the **chamber control** toolbar icon:



To learn how to use the button **Sample Exchange** see *Essence Help*.

**Need to restart Load Lock?** → [What To Do If ... You Need To Restart Load Lock? on page 117](#)



### CAUTION

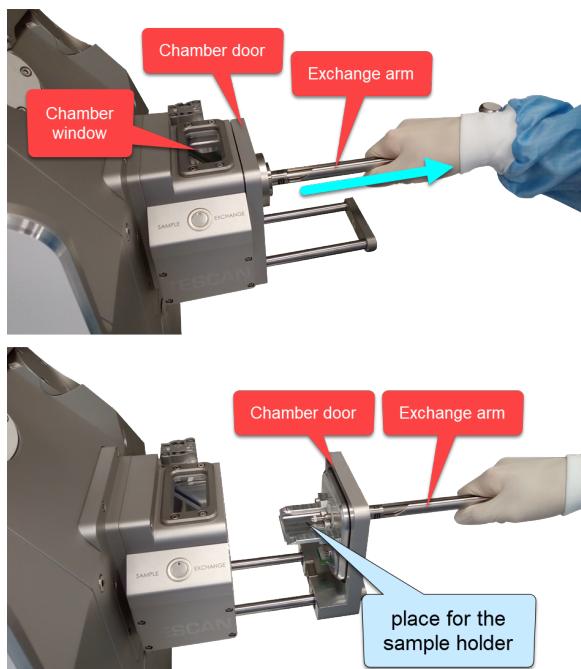
**Crush hazard when using Load Lock.** The moving part of Load Lock has several pinch point hazards. Keep hands clear when the Load Lock is moving and always use the cover to avoid this hazard!

### 10.4.1 Loading a Sample

1. Prerequisites:
  - a. The microscope chamber is pumped properly.
  - b. Samples are mounted on the sample holder, the sample holder is located on your table.
  - c. The knob is in the **P (parking) position** - see the figure below left.

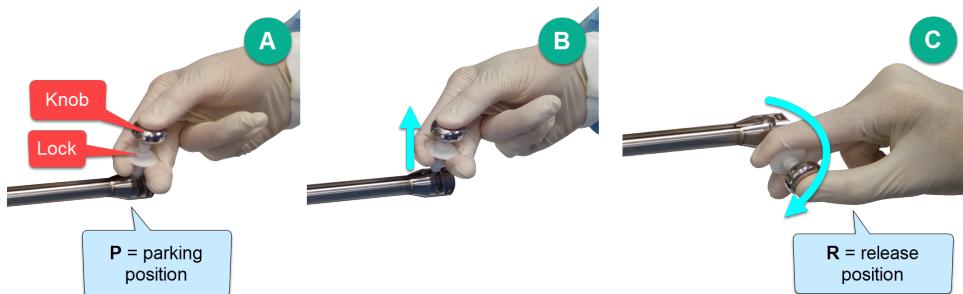


- d. The **Chamber View window** is open. It will be used to observe sample holder navigation inside the microscope chamber. It is recommended to keep the Chamber View window very large.
2. Put on **powder-free clean gloves**.
3. Open the **Load Lock (LL) chamber** by holding the LL exchange arm and pulling it gently away from the microscope.

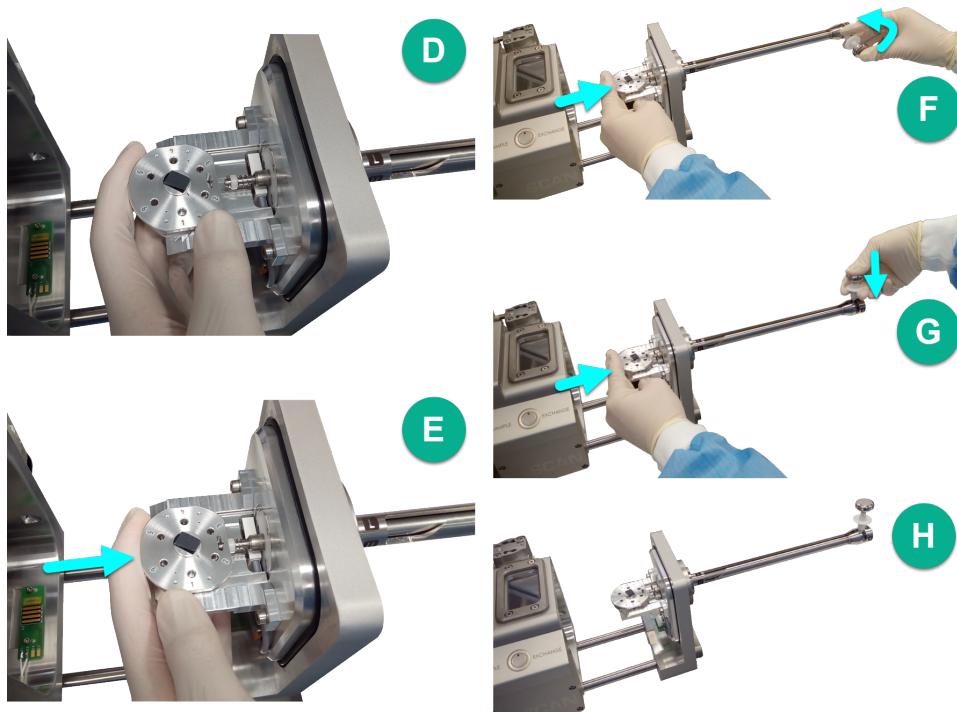


4. Place the sample holder into the LL exchanging arm as described below. You will need **both hands**.

- With your right hand, **unlock** the white plastic lock by pushing it upwards and holding it (see below A–B). Pull the whole knob **down** while still holding both the lock and the knob (C). The knob is now in the **R (release) position**. The spring for the sample holder located in the LL chamber door is now unlocked.

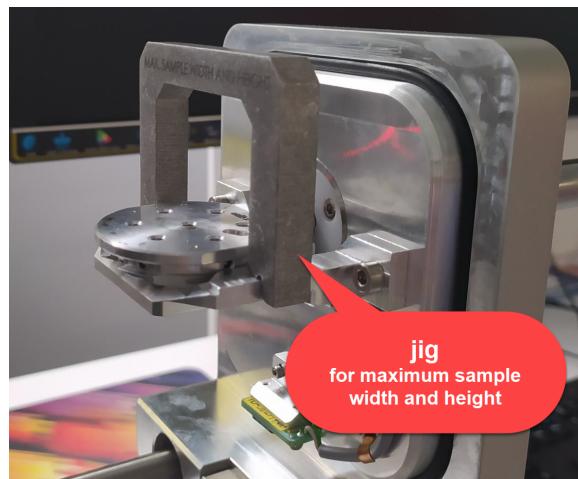


- With your left hand, place the sample holder on the screw and press the holder gently towards it (see below D–E). While still pressing the holder, pull the knob back to the P (parking) position (F) and release the lock with your right hand (G). Now the sample holder is properly fixed to the LL exchanging arm and the knob is in the **P (parking) position** (see below - H).

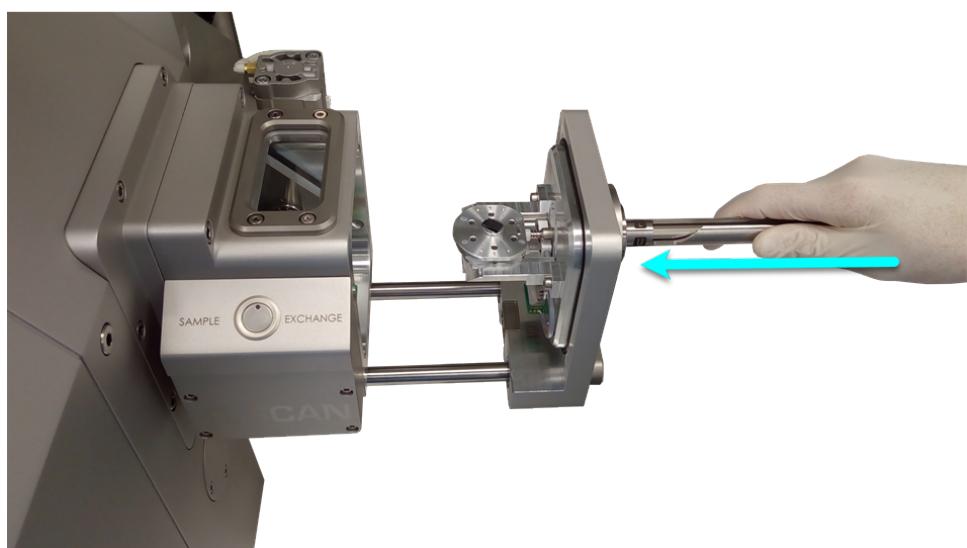


**Note:** Ensure that all screws holding the samples are screwed in and are **not protruding** from the sample holder.

- Put the special LL **jig** on the LL exchanging arm (see figure below) to make sure the sample **meets the maximum height and width**.



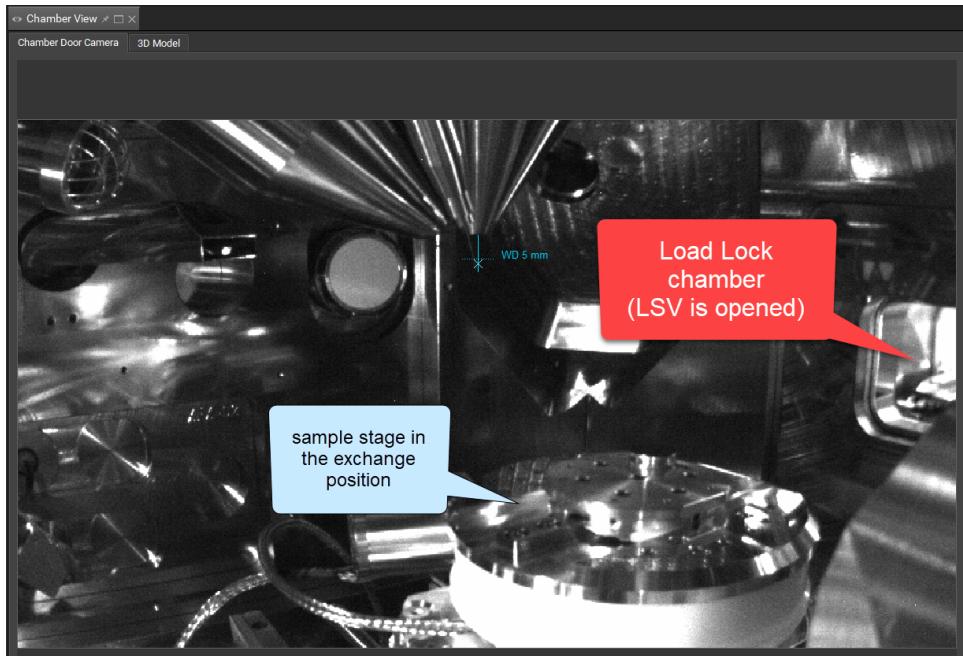
- Close the LL chamber** by pushing the LL exchanging arm gently towards the microscope. Once the LL chamber is closed properly, the button Sample Exchange lights up.



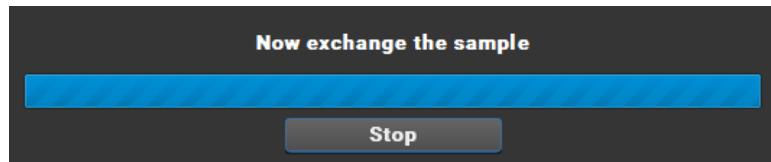
**DO NOT close the Load Lock door if the knob on exchanging arm is not in the P (parking) position.**

- Go to Essence SW » toolbar » and click the **Load sample** button . A confirm dialog appears. Press the door and confirm with **OK**.

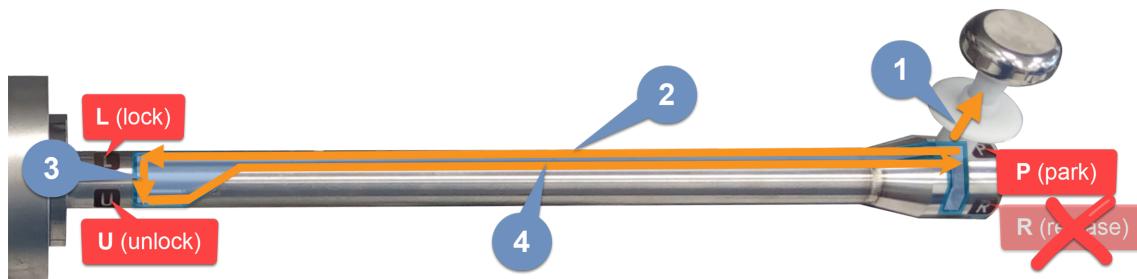
The semi-automatic procedure starts. First the LL chamber is pumped. Then the sample stage in the microscope chamber automatically moves to the exchange position and LSV opens (Load Separated Valve = the valve between the microscope chamber and the Load Lock chamber).



- Once you see "Now exchange the sample" in the loading dialog (see below), the valve is open and your action is required.



Load the sample on the sample stage using the LL exchange arm by following the scheme **PLUP** (Park-Lock-Unlock-Park). Do not forget to unlock the white plastic lock by pushing it upwards and holding it. Monitor movements in **Chamber view** throughout the whole PLUP operation.



**Note:** If you prematurely place the knob in the parking position before the sample holder is loaded, the software will assume that loading is complete.

**Note:** DO NOT use the R (release) position while loading / unloading a sample. Otherwise the sample holder will be dislodged from the exchanging arm.

When the knob is in the parking position again, the loading procedure **finishes automatically** - the sample stage in the microscope chamber automatically moves back, LSV closes and the LL chamber is vented. Once the dialog above disappears from the screen, the procedure is finished.



CAUTION
<p><b>EMERGENCY STOP.</b> In case a complication occurs during the process, click the emergency <b>Stop</b> button on the screen dialog (see the figure above). Once this button is clicked, you have to restart Load Lock → <a href="#">What To Do If ... You Need To Restart Load Lock? on page 117.</a></p>

#### 10.4.2 Unloading a Sample

1. Prerequisites:
  - a. The microscope chamber is pumped properly.
  - b. Samples are mounted on the sample holder, the sample holder is located on the sample stage inside the microscope chamber.
  - c. There is no sample mounted on the Load Lock (LL) exchanging arm.
  - d. The knob is in the **P (parking) position** - see the figure below left.

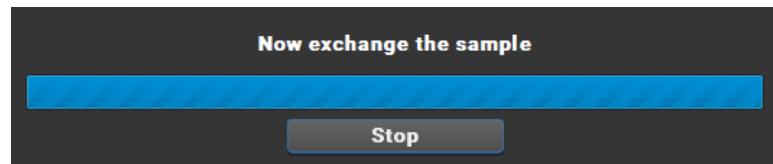


- e. The **Chamber View** window is open. It will be used to observe sample holder navigation inside the microscope chamber. It is recommended to keep the Chamber View window very large.
2. Put on **powder-free clean gloves**.

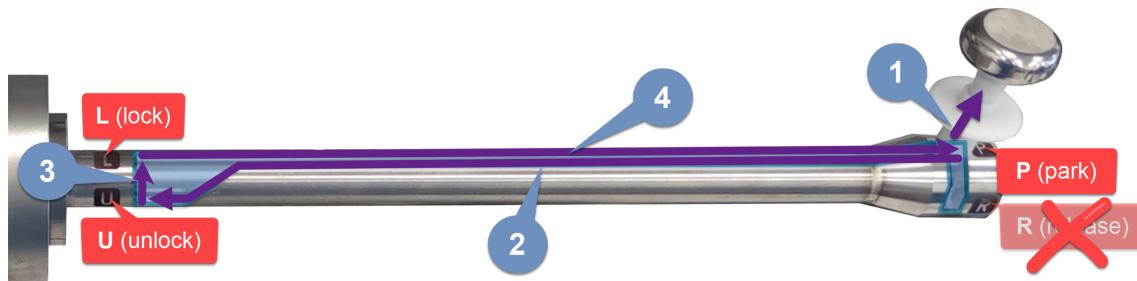
3. Go to Essence SW » toolbar » and click the **Unload sample** button . Confirm with OK.

The semi-automatic procedure starts. First the LL chamber is pumped. Then the sample stage in the microscope chamber automatically moves to the exchange position and LSV opens (Load Separated Valve = the valve between the microscope chamber and the Load Lock chamber).

4. Once you see "Now exchange the sample" in the loading dialog (see below), the valve is open and your action is required.



Load the sample on the sample stage using the LL exchange arm by following the scheme **PLUP** (Park-Lock-Unlock-Park). Do not forget to unlock the white plastic lock by pushing it upwards and holding it. Monitor movements in **Chamber view** throughout the whole PULP operation.



**Note:** If you prematurely place the knob in the parking position before the sample holder is unloaded, the software will assume that unloading is complete.

**Note:** DO NOT use the R (release) position while loading / unloading a sample. Otherwise the sample holder will be dislodged from the exchanging arm.

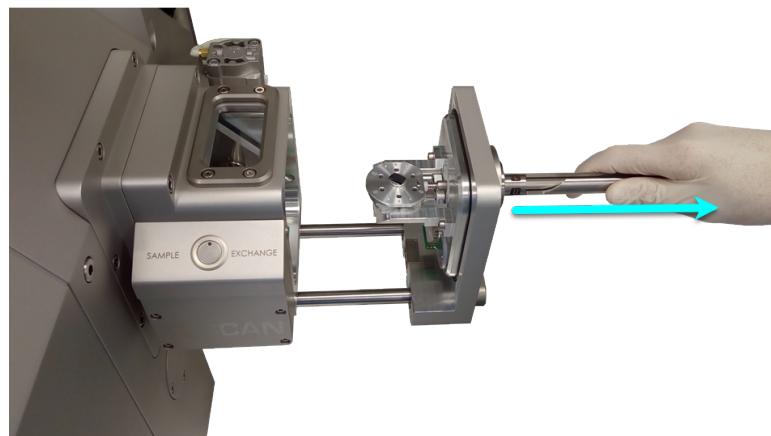
When the knob is in the parking position again, the loading procedure **finishes automatically** - the sample stage in the microscope chamber automatically moves back, LSV closes and the LL chamber is vented. Once the dialog above disappears from the screen, the procedure is finished and you can go on.



#### CAUTION

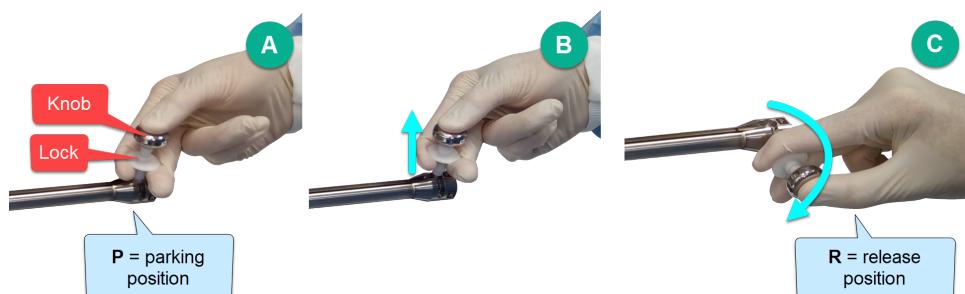
**EMERGENCY STOP.** In case a complication occurs during the process, click the emergency **Stop** button on the screen dialog (see the figure above). Once this button is clicked, you have to restart Load Lock → [What To Do If ... You Need To Restart Load Lock? on page 117](#).

5. Open the Load Lock (LL) chamber by holding the LL exchange arm and pulling it gently away from the microscope.

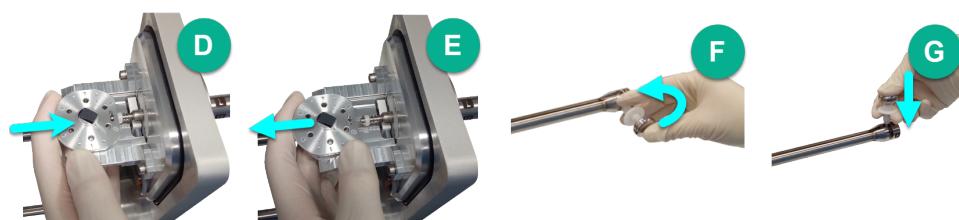


6. Remove the sample holder from the LL exchanging arm as described below. You will need **both hands**.

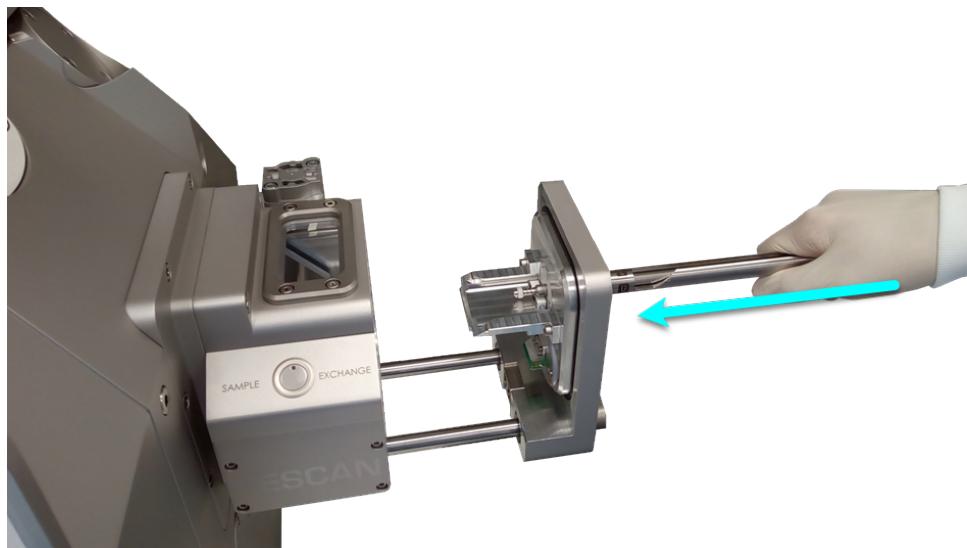
- With your left hand, **press the sample holder gently** towards the exchanging arm so that the holder does not spring out (see below - D). From now press on it all the time.
- With your right hand, **unlock** the white plastic lock by pushing it upwards and holding it (see below A-B). Pull the whole knob **down** while still holding both the lock and the knob (C). The knob is now in the **R (release) position**. The spring for the sample holder located in the LL chamber door is now unlocked.



- With your left hand, you are still pressing the sample holder gently towards the exchanging arm so that the holder does not spring out (D). Carefully remove the holder to the left (E). Pull the knob back to the **P (parking) position** (F) with your right hand and release the lock (G).



7. **Close the LL chamber** by pushing the LL exchanging arm gently towards the microscope. Once the LL chamber is closed properly, the button Sample Exchange lights up.



**DO NOT close the Load Lock door if the knob on exchanging arm is not in the P (parking) position.**

## 10.5 Keyboard Shortcuts

Keyboard shortcuts are **keys or a combination of keys** you can press on your keyboard to perform a variety of tasks. In TESCAN Essence there are three types of keyboard shortcuts:

1. **Common keyboard shortcuts.** These shortcuts are common for all users and cannot be changed. You can find them in the TESCAN Essence software » main Menu » Help » Keyboard shortcuts. To help you with their use, we created keyboard shortcuts cheat sheets (see the following pages).
2. **Customized keyboard shortcuts.** Each user can customized function of F2 - F10 keys for his / her needs (does not affect other users) → go to ***Function Keys*** in *Essence Help*.
3. **(Optional) Customized Control Panel.** Some buttons and knobs on your Control Panel (optional device) can be customized for user's needs (does not affect other users) → go to ***Control Panel Setup*** in *Essence Help*.

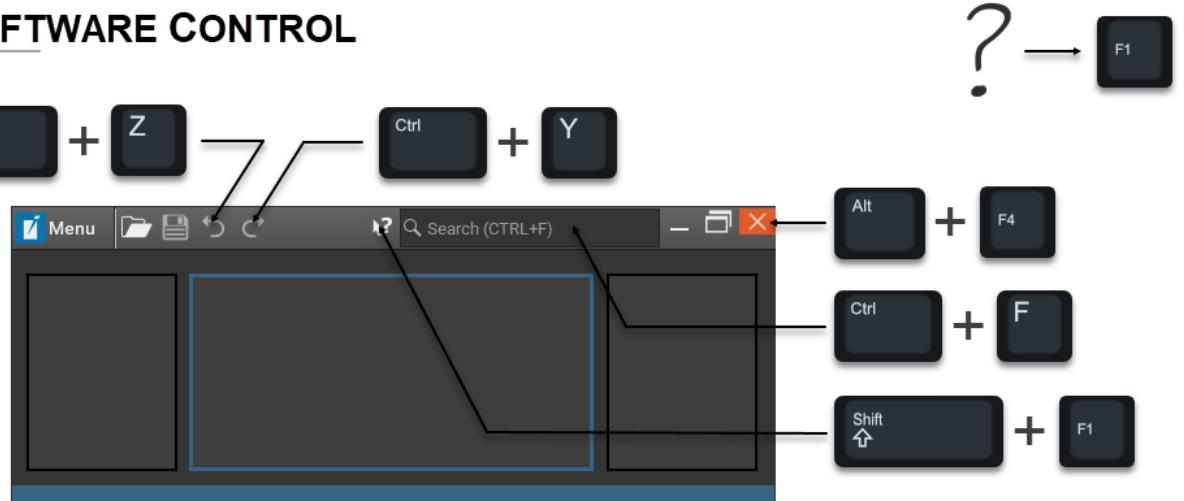
On the following pages you can find **cheat sheets** for **common keyboard shortcuts**.



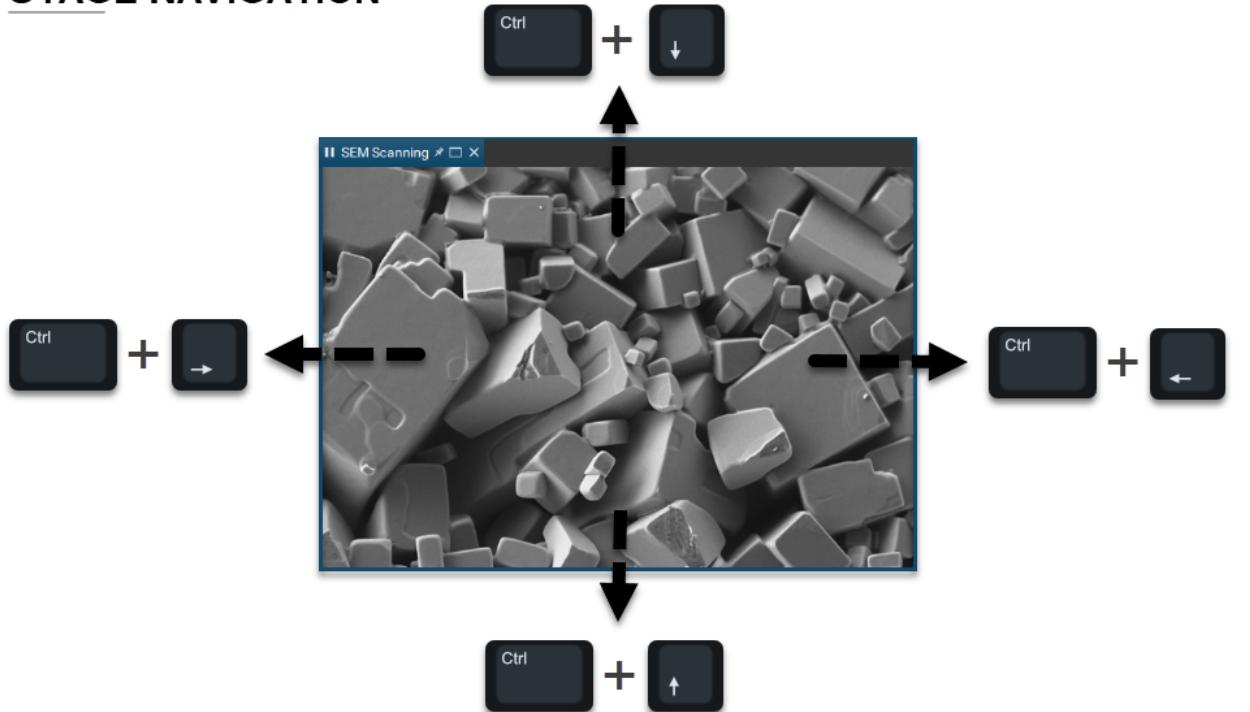
# KEYBOARD SHORTCUTS

CHEAT SHEET

## SOFTWARE CONTROL



## STAGE NAVIGATION



For **fast** movement press also **Shift + Up/Down** e.g. **Ctrl + Shift + Up + Down**.





# KEYBOARD SHORTCUTS

## CHEAT SHEET

### SCANNING

The screenshot shows the SEM software interface with several floating windows and toolbars. Key components include:

- Field of View**: A window with controls for zooming and panning.
- Working Distance**: A window with controls for working distance.
- Scan Speed**: A numeric keypad for setting scan speed from 1 to 10.
- Beam Current**: A window with controls for beam current.
- Degauss**: A progress bar for degaussing.
- SEM Scanning**: A main toolbar with icons for BSE, AF, and other functions.
- Accumulation**: A status message indicating accumulation.
- SEM Objective Centering**: A small window for objective centering.
- Pad**: A window for objective centering.

**Keyboard Shortcuts:**

- Field of View:**
  - V
  - Shift + Up + +
  - Shift + Up + -
  - Shift + Up + M
- Working Distance:**
  - W
  - Shift + Up + /
  - Shift + Up + \*
- Scan Speed:**
  - 1, 2, 3, ..., 9, 0, 10
- Beam Current:**
  - I
  - Ctrl + Up + +
  - Ctrl + Down + -
- Degauss:**
  - B
  - Shift + Up + B
  - Shift + Up + W
- SEM Scanning:**
  - A
  - Ctrl + Up + Page Up
  - Ctrl + Down + Page Down
  - Ctrl + Left + Home
  - Alt + Up + Enter
- Accumulation:**
  - Ctrl + Up + W
- SEM Objective Centering:**
  - O

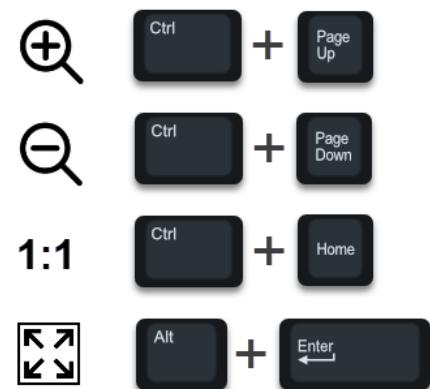
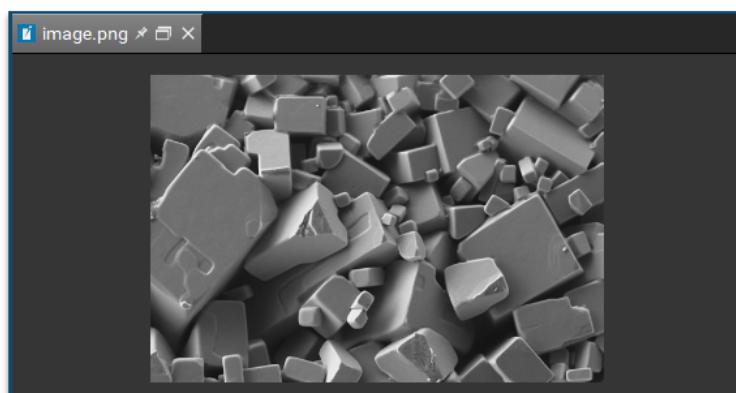
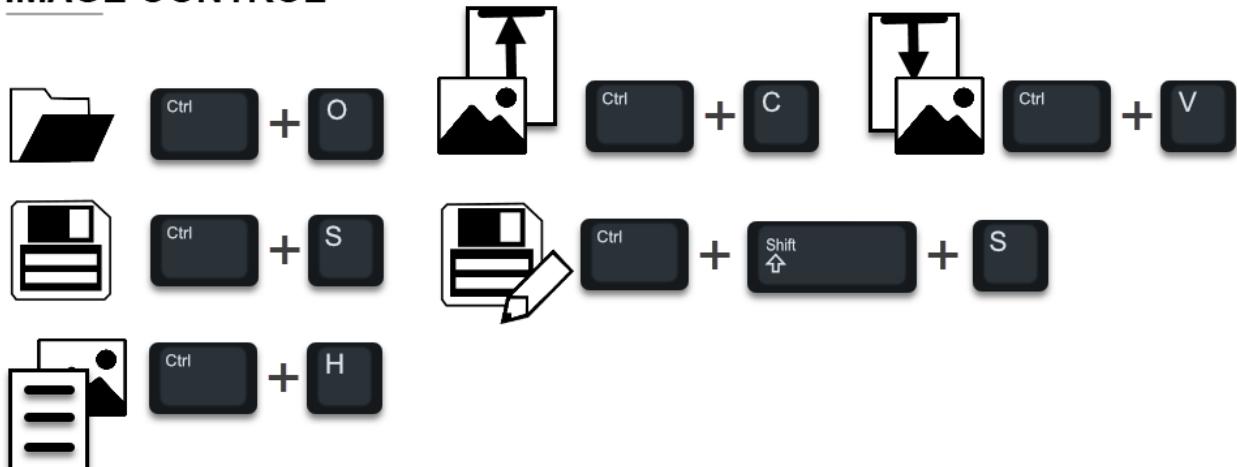




# KEYBOARD SHORTCUTS

CHEAT SHEET

## IMAGE CONTROL



## PAD

