EM-40

Operation Manual

Apr. 23, 2024

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Document Number	EM-40 Operation Manual – EN – 001 – B

Revision History

Rev.	Date	Name	Changed pages	Comment
A	Mar. 12, 2024	Park Young-ju		
B	Apr. 15, 2024	Park Young-ju	17	Add 2. HW component
			41	Modifying Sample holder content, adding Holder type content
			58	Modify the holder height to 11.5
			74	6) Add Holder Type Content
	Apr. 22, 2024	Park Young-ju	66	Modifying WD setting
			69	Modifying 'Sample Height' Input
			134	Modifying Electronic Gun Alignment

COXEM

Scanning Electron Microscope

EM-40 Operation Manual

NanoStation 5 Version (Apr. 2024)

COXEM Co., Ltd.

Precautions

- The product must be used only after thoroughly reading the user manual and fully understanding how to use the product.
- Keep the user manual in a place where it is accessible at all times.
- When the product is used without following the guidelines, caution, and warning in the user manual, the user shall assume responsibility for any issues that may arise.
  Since OL collision and damage to EDS & BSE Sensor frequently occur because the sample height was not measured or entered, please use the product after entering the measured sample height value. The user shall assume responsibility for any issues arising from failure to follow the foregoing.
- Some devices or functions described in the user manual may not be provided and may be different depending on the optional items or options.
- The image used on the cover and main body of the user manual are intended to aid in understanding and may be different from the actual product.
- The function or performance of this product and the user manual are subject to change without prior notice.

Precautions Before Use

Handling

Fine dust or foreign substances entering the electron microscope may degrade its performance. Thus, the microscope must be handled only after wearing sanitary gloves.

Example of worn sanitary gloves

CAUTION

The user must wear sanitary gloves to use the electron microscope except for the task of operating NanoStation as guided in the manual after this page.

Use Rights by Task

The use rights must be given and managed according to the details of tasks when operating the electron microscope.

Task classification	Details of the implementer
General operation & microscopic imaging	Operator
Calibration	Dealer or person who completed calibration training
Hardware replacement	Dealer or person who completed maintenance training
Software Upgrade & installation	Dealer or person equipped with knowledge on software installation
Hardware dismantling & maintenance	Dealer or person who completed maintenance training

Safety Precautions

The following are the safety precautions you must be aware of before using EM-40:

Item	Description
WARNING	Death or serious injury may occur if the instructions are not followed.
CAUTION	Injury or property damage may occur if the instructions are not followed.

WARNING

- Since high voltage is flowing through the electron gun, electric shock or burns may occur if it is touched with bare hands without safety equipment. Do not connect or disconnect the cable during electron gun operation.
- Do not touch the electron gun with bare hands when the microscope is turned on. Repair services must be requested when there is an abnormality of the electron gun.
- If mechanical pressure is applied to the electric cable, electric shock or fire may occur. Do not pull, bend, or twist the cable.
- If the electron gun chamber section falls off due to the loosened screws of the microscope, you may sustain an injury. Fasten the electron gun aligning screw before opening the electron gun chamber.
- You may sustain burns if you touch the hot surface of the electron gun cartridge with bare hands. Do not touch the cartridge until its surface has completely cooled down.
- Shifting to vacuum state while the chamber or electron gun of the microscope is open, i.e., not sealed, may cause fire due to the overheating of the rotary pump.

- You must check the oil gauge of the rotary pump to ensure that the oil level is maintained between MIN and MAX before activating the product. If the microscope is activated without oil, fire may occur due to defect or overheating of the rotary pump.

Precautions

- If the microscope is exposed to excessively high temperatures or overheating, abnormality or breakdown may occur. An appropriate indoor environment must be maintained to prevent product breakdown.
  (Normal operating environment: temperature of 20±5°C, humidity below 70%)
- If the microscope is stored at an excessively low temperature, the viscosity of the rotary pump oil may change significantly; thus causing failure of equipment vacuum performance, onboard electronic components, and stage.
  It must be stored at temperatures above an appropriate level.
  (Normal operating temperature: 20±5°C)
- When storing the rotary pump in an environment below 15°C for a prolonged period of time or using it for the first time, you must turn the gas ballast counterclockwise to activate, and then close the gas ballast again to enable smooth operation of the pump.
- Do not install or store the product in a place with excessive vibration of the floor where the product is installed.
  (Recommended vibration level: below 35dB; below 50dB is OK for medium or low magnification below 50K)
- If the rotary pump of the product operates, the surface temperature rises. Do not place ignitable substances or combustible substances around the rotary pump when the product is operating.
- Avoid suddenly standing up or sitting near the part where the product is protruding like the product stage or aperture. You may collide with the product and sustain injury or damage the relevant parts.
- When opening or closing the sample chamber or electron gun chamber, you must do so slowly with both hands since there is risk of injuring your hands.
- Use the equipment according to the method described in the user manual. If you do not follow the method described therein, the equipment may malfunction or break down.
- Request services when moving the equipment. Moving or installing the equipment arbitrarily may cause equipment breakdown or damage.
  A separate after-service fee applies in case of breakdown caused by the user's arbitrary movement or installation of the equipment.
- The user must not modify the hardware or software arbitrarily. Modifying the equipment arbitrarily may cause accidents such as fire or electric shock.
  When there is breakdown due to arbitrary modification by a user, a separate after-service fee applies.

- When connecting to the equipment using PC-USB, you must regularly scan the equipment for any computer virus. The software may malfunction if infected by a computer virus. (An equipment malfunction caused by a computer virus is subject to paid repair service.)

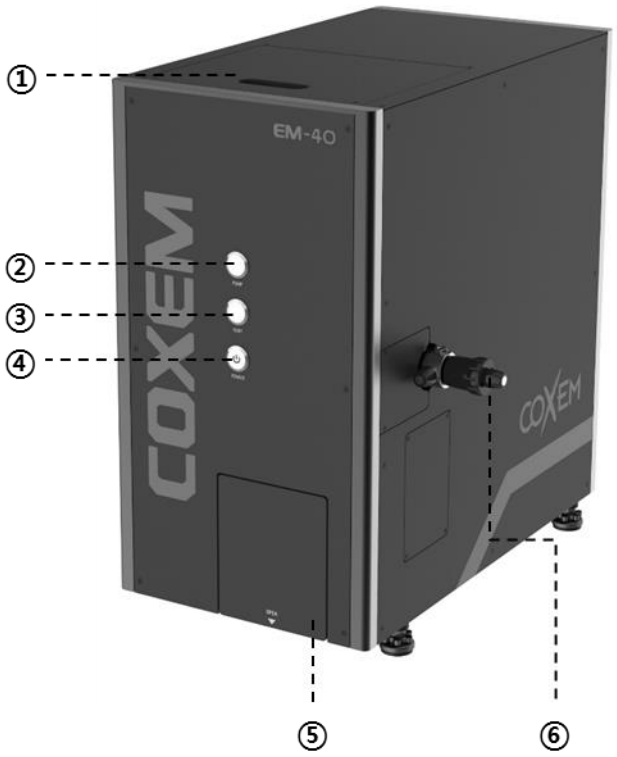
Table of Contents

1 Introduction

1.1 Description of Product Parts

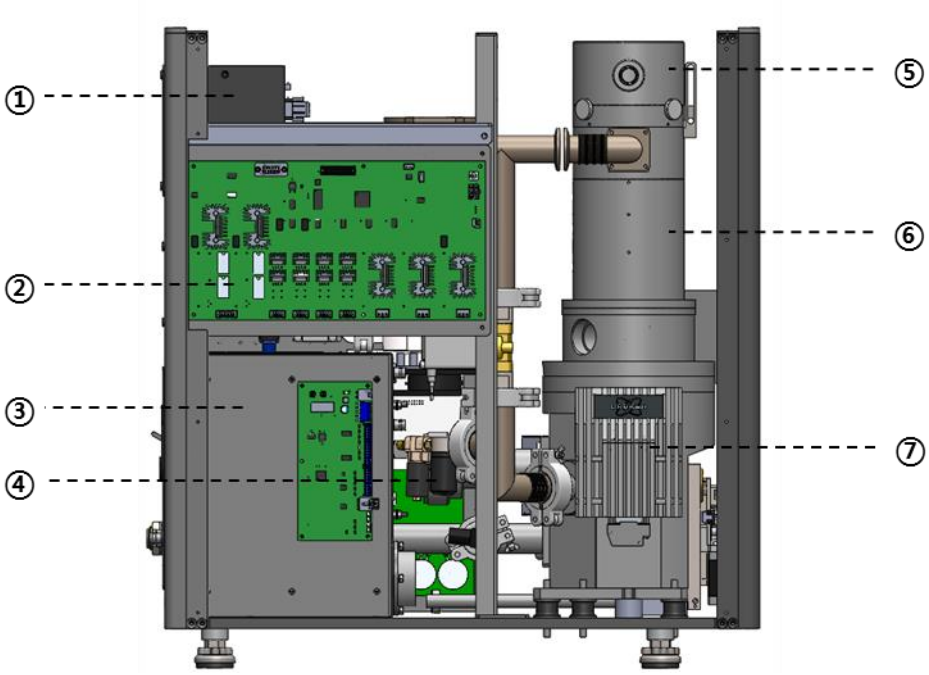
The names and functions of EM-40 product parts are as follows:

1.1.1 EM-40 Body

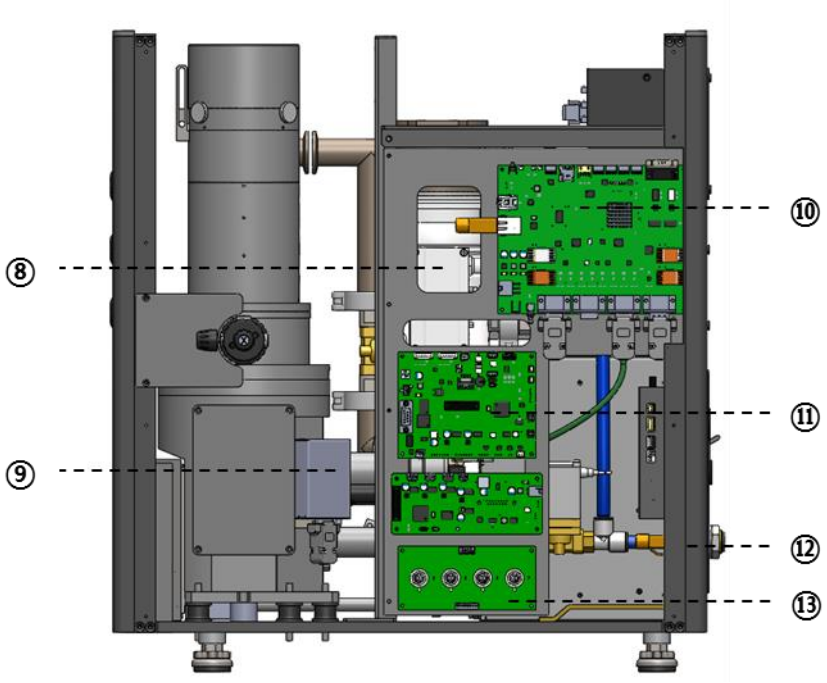


No.	Item	Description
①	Electron gun cover	It is a cover for protecting the electron gun.
②	Pump button	it switches to vacuum state.
③	Vent button	It releases the vacuum state.
④	Power switch	It is used to turn on power of the product.
⑤	Chamber door	It is the door of the chamber where a sample is placed.
⑥	Variable Aperture	It is a handle used when adjusting the aperture.

1.1.2 Inner Side of EM-40



<Image of left inner side of EM-40>



<Image of right inner side of EM-40>

No.	Item	Description
①	SMPS (24V)	It supplies power to the turbo pump.
②	KLDU	It is the lens driver board.
③	HV Power Tank	It provides high-voltage power.
④	LV Valve	It is a low-vacuum valve. (Optional)
⑤	Electron Gun	It radiates an electron beam.
⑥	Focusing lens	It is a lens that focuses an electron beam.
⑦	EDS	It is an EDS detector. (Optional)
⑧	Turbo Pump	It maintains a high-vacuum state.
⑨	BSE Board	It is the BSE board.
⑩	KSGU	It is the scan generator board.
⑪	KVCU	It is the vacuum control board.
⑫	Power and cable terminal	Power and cable terminals.
⑬	KSCU	It is the stage control board.

1.2 Equipment Operating Procedure

The operating procedure of the EM-40 electron microscope is as follows:

Step		Details of implementation
1	Sample preparation	3.2 Stub type
		3.3 Material type
		3.4 Sample fabrication
		3.5 Sample mounting
2	Power ON	4.1 Turn power ON/OFF
3	Imaging preparation	4.2 Set the electron beam
		4.3 Move the sample position
4	Image acquisition	5.1 Observation mode setting 5.2 Acceleration voltage setting 5.3 Observation magnification/Spot size setting 5.4 Focus adjustment 5.5 Fine movement of image 5.6 Contrast, brightness adjustment 5.7 BSE Mode 5.8 LV Mode – Optional
5	Save image	7. Save the image

2 HW component

2.1 EM-40 main body

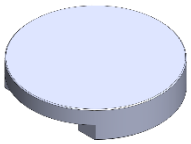
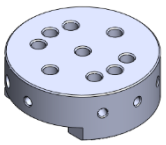
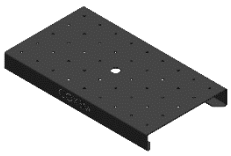
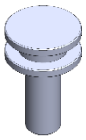
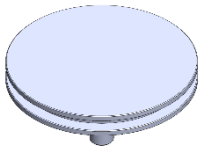
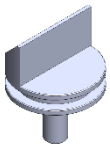
The EM-40 body shall be connected to the power cable, PC, and Rotary Pump.

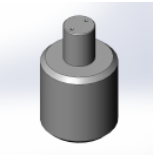
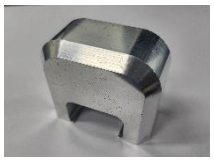
2.2 Confirming Product Components

After examining any flaws or damages, confirm if all the components shown below are included. The components included in the packing box are as follows:

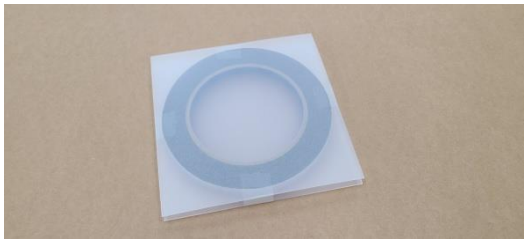
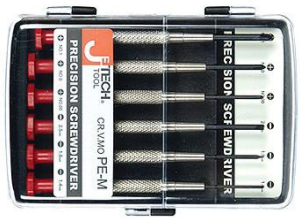
	
Main body of EM-40	Control PC & Monitor
	
Rotary Pump	Vacuum hose (Urethane)
	
Accessory box	

2.3 Holder set

Model	Image	Note
Standard Holder		Qty: 1EA
Multi-Holder		Qty: 1EA
Pin stub mount		Qty: 0EA
Pin stub (Φ6.35)		Qty: 7EA
Pin stub (Φ25.4)		Qty: 3EA
Pin stub (Φ12.7)		Qty: 3EA
Pin stub (Φ12.7, 45°&90°)		Qty: 3EA
Pin stub gripper		Qty: 1EA

Pin stub gripper		Qty: 각 1EA
Filament mounting fixture		Qty: 각 1EA
Wehnelt puller		Qty: 각 1EA

2.4 Accessories

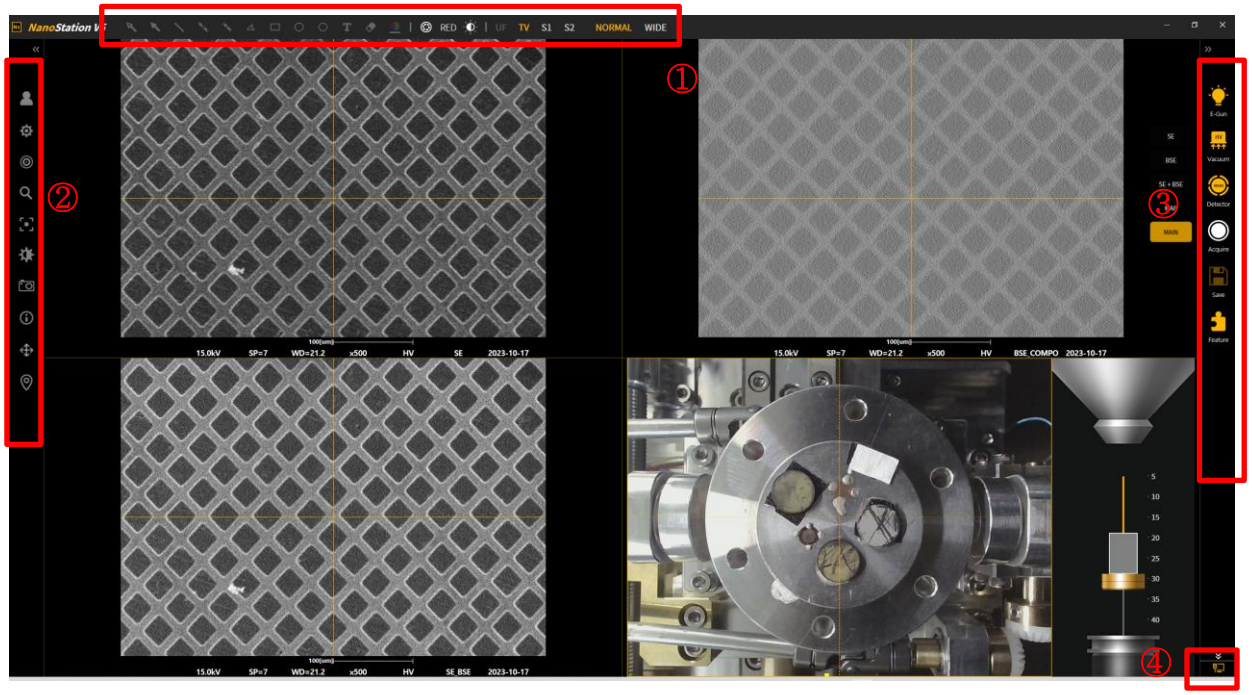
Model	Image	Note
Carbon Tape		Qty: 1EA
Hex key Wrench Set (7 PCS)		Qty: 1EA
Precision screwdriver		Qty: 1EA

Blower		Qty: 1EA
Silver paste		Qty: 1EA
Accessory box		Qty: 1EA

3 Screen Configuration

3.1 Main Screen of NanoStation

The configuration of the main screen of NanoStation is as follows:



3.2 UI Configuration

No.	Name	Description
①	Title Bar	Drawing tools, Wobble, RED mode, Auto BC, Live display, Mode
②	Menu Bar	Administrator, Setting, Alignment, Magnification, Focus, brightness/Contrast, Image Setting, Image Information, Image Shift, Stage
③	Operation Bar	Operation
④	Status Monitor	Connection status information

3.3 Drawing Tools & Quick Execution

3.3.1 Drawing Tools

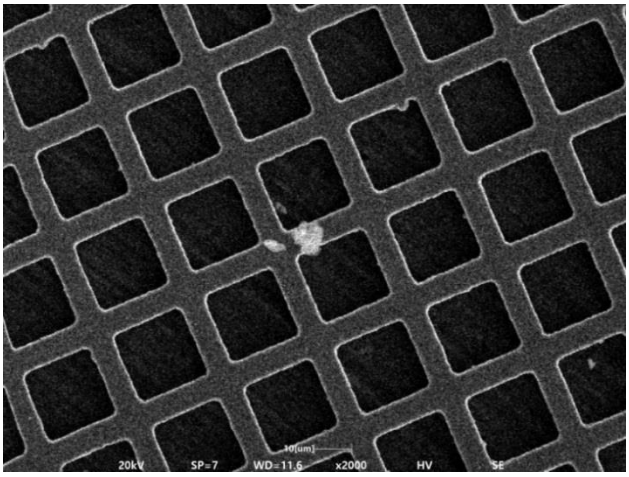
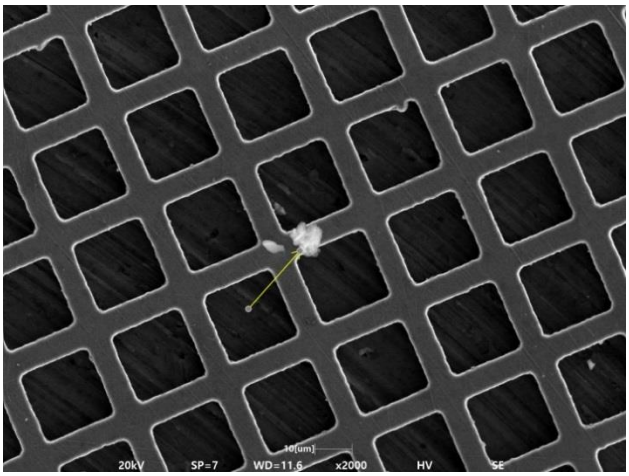
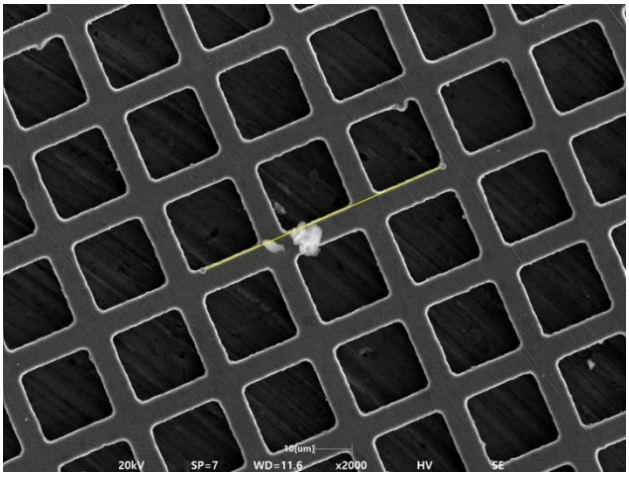
You can use shape tools to measure the length or width on the scanned image before or after saving the scanned image.

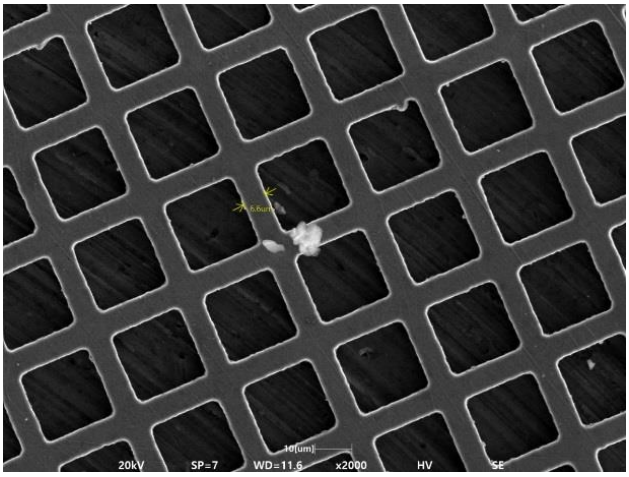
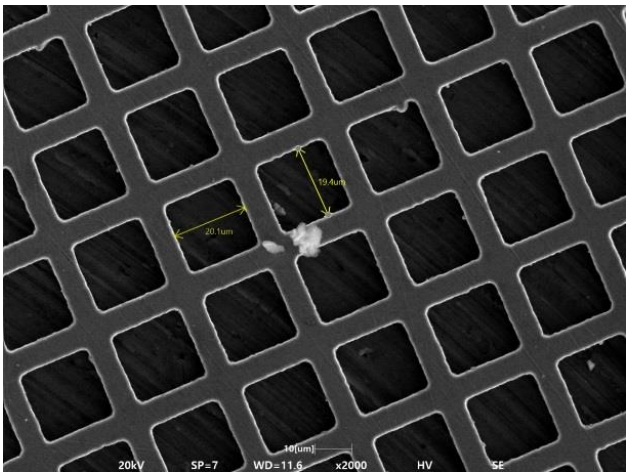
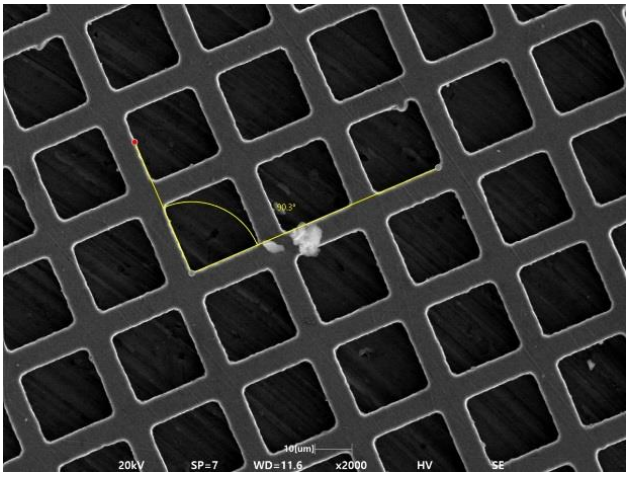
Drawing tools are activated in Single Viewer or Archive Viewer.

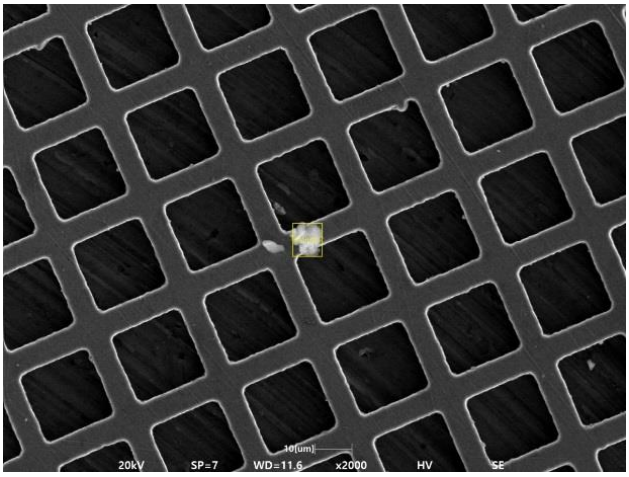
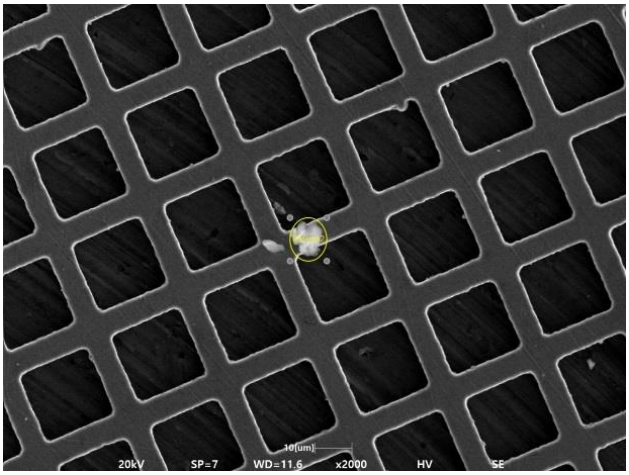
Wobble is activated in Single Viewer mode.

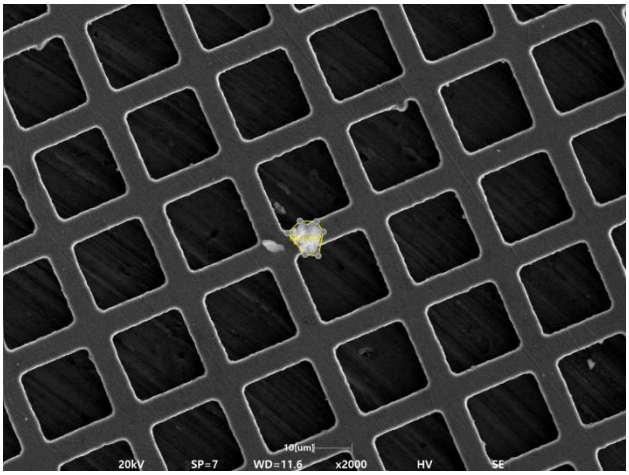
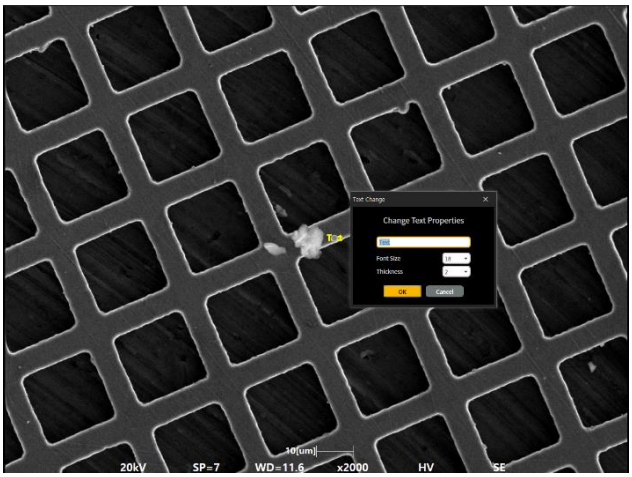
3.3.2 Add Shape

If a scanned image is displayed, you can use it by selecting a desired image tool at the top the screen.

Type	Screen
 Normal It is the basic cursor when moving the image.	
 Single Arrow It marks an arrow on one side of an image. Drag a mouse point from the desired starting point to the end point.	
 Drawing Line It draws a line on the image. • Drag a mouse point from the desired starting point to the end point.	

Type	Screen
 Distance It indicates the distance on an image. • Drag a mouse point from the desired starting point to the end point.	
 Length It marks the length on an image. • Drag a mouse point from the desired starting point to the end point.	
 Angle It marks an angle on an image. • Set the angle by right-clicking the desired point.	

Type	Screen
 Square It draws a square on an image. • If a mouse point is dragged, it draws a square.	
 Circle It draws a circle on an image. • It can draw two types of circles: a regular-size circle and an oval-shaped circle. • Dragging the mouse point for a short distance will draw a regular-size circle; dragging the mouse point for a long distance will draw an oval-shaped circle.	

Type	Screen
 Area It marks the width on an image. • Left-click to mark every corner of the shape whose width will be measured<?> according to the desired shape and finish by right-clicking the end point.	
 Text It marks texts on an image. • If a text input window pops up, enter the text and press [OK].	

You may be unable to draw a new shape near an already drawn shape.
In this case, draw the shape in another place and then move it by dragging.

3.3.3 Image Tool Color

It sets the color of the image tool.

3.3.4 Delete All

It deletes all texts and shapes recorded by a used image tool from the most recent ones.

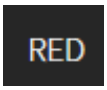
3.3.5 Wobble

It is a button used when aligning the aperture.

If the aperture is not properly aligned, it is difficult to adjust the focus when observing a sample, and the image quality deteriorates.

- When moving the image left and right or up and down while adjusting the focus, alignment of the aperture is required.
  In this case, calibrate so that there is no movement when observing an image by pressing the Wobble button and then turning the X, Y Knob of the aperture.

3.3.6 RED mode

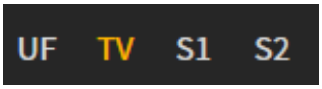


You can change the observation mode to RED mode.

3.3.7 Auto BC

Auto BC is the button for optimizing a video image by adjusting Brightness and Contrast.

3.3.8 Live display



The live display may be changed to a UF (ULTRAFAST), a TV, S1 (Slow1), and S2 (Slow2).

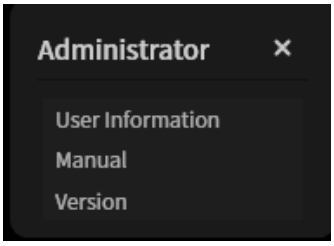
3.3.9 Mode

Image mode may be changed to NORMAL and WIDE.

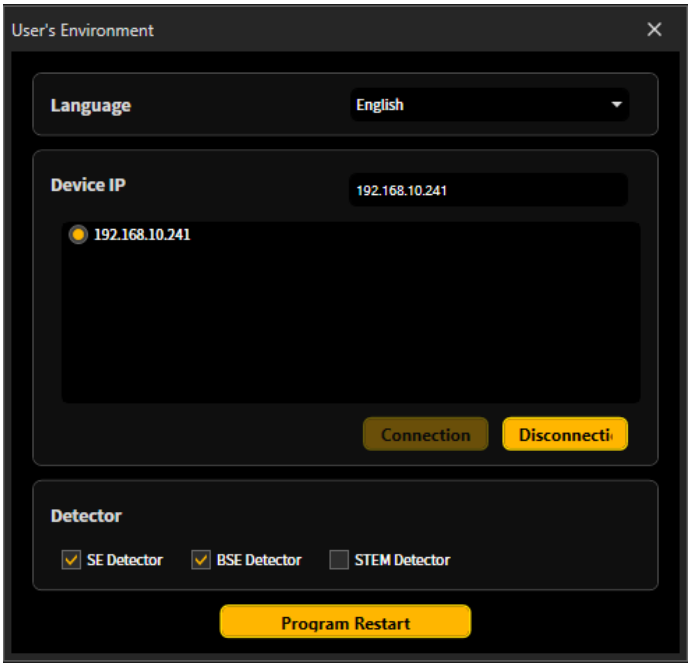
3.4 Menu

3.4.1 Administrator Mode

Menu - You can check the administrator mode through the  screen icon.



■ User's environment



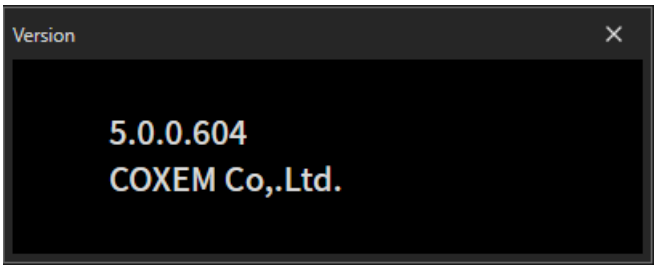
- Language: You can select the language of NanoStation.
- Equipment IP: It is used when connecting to a piece of equipment after selecting the IP of the equipment you wish to connect to.
- Detector: It checks whether each detector is used.
- Program Restart: It restarts NanoStation.

■ View Manual

You can view the equipment manual.

■ Version information

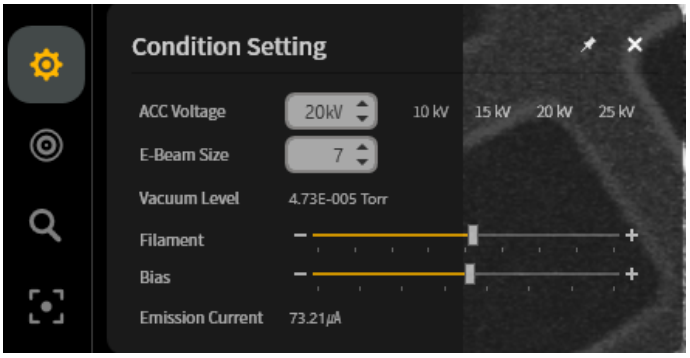
You can check the version information of NanoStation.



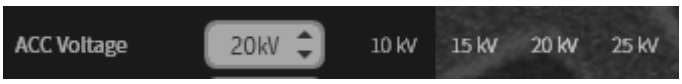
3.4.2 Setting

By selecting each operation button in operation mode, you can change the setting relevant to the operating mode in Menu - Setting.

■ When setting Detector



• Accelerating voltage



- You can set the required accelerating voltage depending on the purpose when observing a sample. (Default setting: 15kV) You can obtain the desired image only when you set a suitable accelerating voltage according to the raw material of a sample and the shape of the sample surface. (Accelerating voltage range: 1~30kV)
- High accelerating voltage (high voltage): If the accelerating voltage is high, the resolution increases, which is advantageous when measuring at high magnification. However, a high accelerating voltage is not suitable for viewing the sample surface, and it may damage the sample.
- Low accelerating voltage (low voltage): A low accelerating voltage is advantageous in measuring the shape of the sample surface since the beam current is lowered, but the luminance and resolution performance decrease.
- If the accelerating voltage is low, however, the resolution decreases, and the image becomes dim due to the reduced number of electrons.
- If you change the accelerating voltage, you must align the electron gun and perform aperture alignment (Wobble).
- The accelerating voltage can be changed by clicking the up and down button or using 4 fixed accelerating voltage buttons, or by entering a value.

NOTE For details, refer to 6.2 Accelerating Voltage Setting.

• E-Beam Size

E-Beam Size	Advantages	Disadvantages
If the E-Beam size is small	• Resolution is good. (Set when observing with high magnification)	• Lowers the luminance (brightness).
If the E-Beam size is large	• Raises the luminance (brightness) (Set when observing with low magnification)	• Resolution becomes worse.

NOTE

* The E-beam size has a significant effect on the resolution. A clear, accurate image can be obtained only when set according to the magnification. (Setting value: 1~12)
* If the E-beam size value is changed, the electron gun may become misaligned. Check the alignment of the electron gun after changing the E-beam size. (Refer to 8.2 Electron gun alignment method.)

Difference in resolution according to E-beam size

The E-beam size has high correlation with the resolution. Its characteristics are as follows:

- The smaller the E-beam size is, the higher the resolution, which is suitable for high-magnification image observation.
- The larger the E-beam size is, the better the image quality, which is suitable for low-magnification image observation.
- As the E-beam size becomes larger, the number of secondary electrons increases. This is advantageous in improving the image quality. Thus, it is used when observing with low magnification, which does not require high resolution.

• Filament

It indicates the voltage value applied to the filament.

- Filament must be used in line with the Operating Point. If the initial filament position is set, it will turn on as it sets the position to the filament value set afterward.

(Recommended Filament value: 2.0~2.2V)

CAUTION

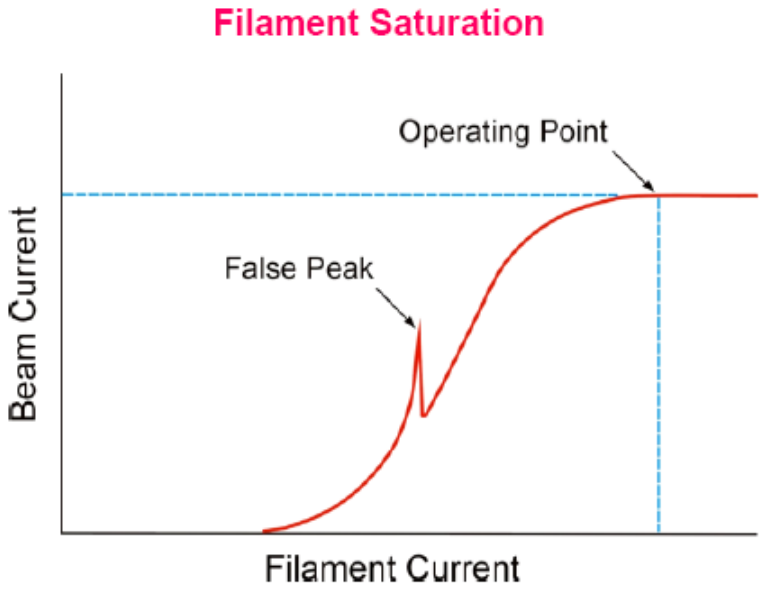
Entering a filament value of 2.2V or higher may cause the lifespan of the filament to be shortened or the performance of the E-Beam to be degraded.

NOTE

- How to Set the Filament Operating Point

If you gradually raise the minimum filament current value, the image will gradually brighten and then get dimmer as it passes the False peak.

Then, the image will grow brighter again and stop brightening further upon reaching a certain point as it is saturated. This point is the Filament Operating Point.



The life of a filament and the performance level of an electron beam are determined according to the filament current value. If you apply a wrong current value, the life of the filament may be shortened or the performance of the electron beam will degrade.

The microscope can be operated most efficiently only when the filament current value is set to a proper Operating Point.

- Bias

It controls the voltage pulling the electron beam occurring from a Filament towards the sample.

- Set the filament value and then adjust the bias value to match the emission current value.
  (Recommended emission current: 80±5uA)

• Emission current

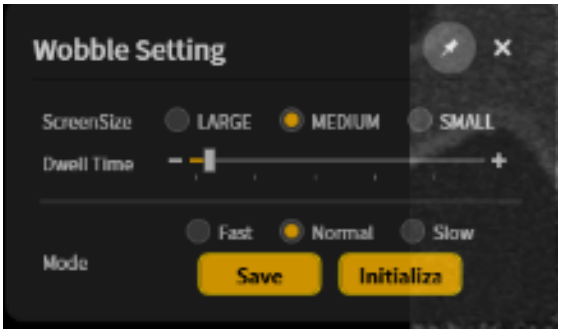
It displays the emission current value of an electron beam.

- Set the emission current value by adjusting the filament and bias value.
- (Recommended emission current: 80±5uA)

NOTE

If the emission current value is displayed as 0 even after the filament and bias values are adjusted, it means that the filament is broken; thus requiring the replacement of the filament.

■ Wobble Setting



• Reduction Ratio

You can adjust the size of the RED window.

• Dwell Time

You can adjust the scan speed of the RED window.

• Mode

FAST: Mode with the fastest scan speed

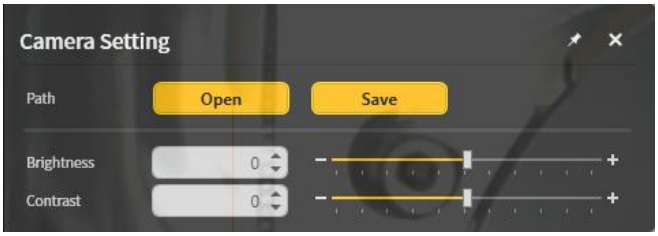
NORMAL: Mode with medium scan speed

SLOW: Mode with the slowest scan speed

Save: Each mode can be set to the user-defined value.

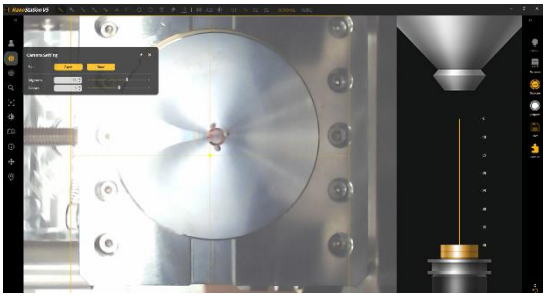
Initialization: User-defined values can be initialized to the initial values as shown in the table.

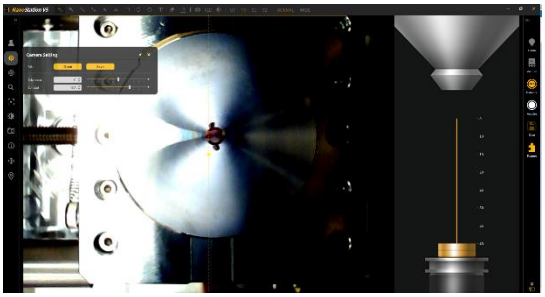
■ When Setting the Map



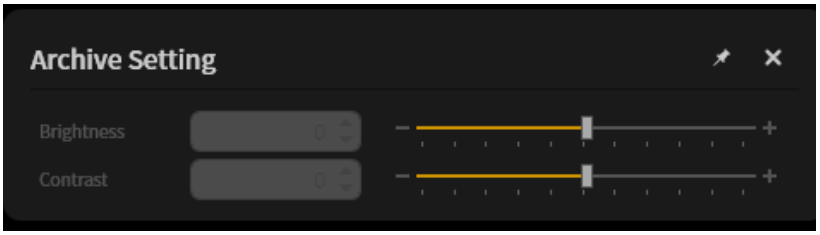
- Path
  - Open: You can check the saved Map image by opening the folder where you saved a map.
  - Save: You can save a Map.

- Brightness/Contrast
  - Brightness: You can change the brightness of a Map image.
  - Contrast: You can change the contrast of a Map image.





■ Archive Setting

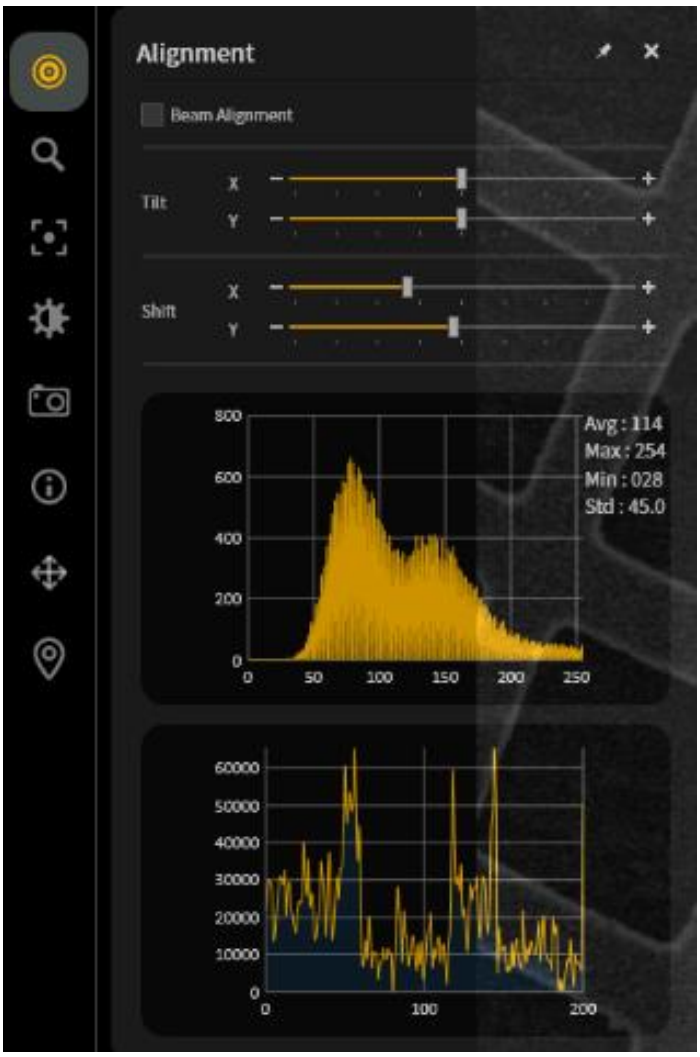


- Brightness/Contrast
  - Brightness: You can change the brightness of an image.
  - Contrast: You can change the contrast of an image.

3.4.3 Alignment

Menu - You can use the Alignment function through the  screen icon.

It calibrates the Gun Align Coil current value inside the lens system to align the position of the electron beam generated from the electron gun to the center of the lens more precisely.



- Gun Align must be performed when replacing a Filament or changing the accelerating voltage.

  Since the position of the Center does not mean the optimum state of the electron gun, move it to the center and then finely adjust it to the brightest position.
- Drag the button of the X-axis (or Y-axis) button or adjust the axes with the mouse wheel to find the position where the image is brightest.
- Beam Alignment: You can observe the shape and position of the electron beam through beam alignment.

  Operate the microscope while the position of the electron beam is moved to the center by using the align function.

WARNING	When adjusting hardware alignment, caution must be taken to prevent electric shock.

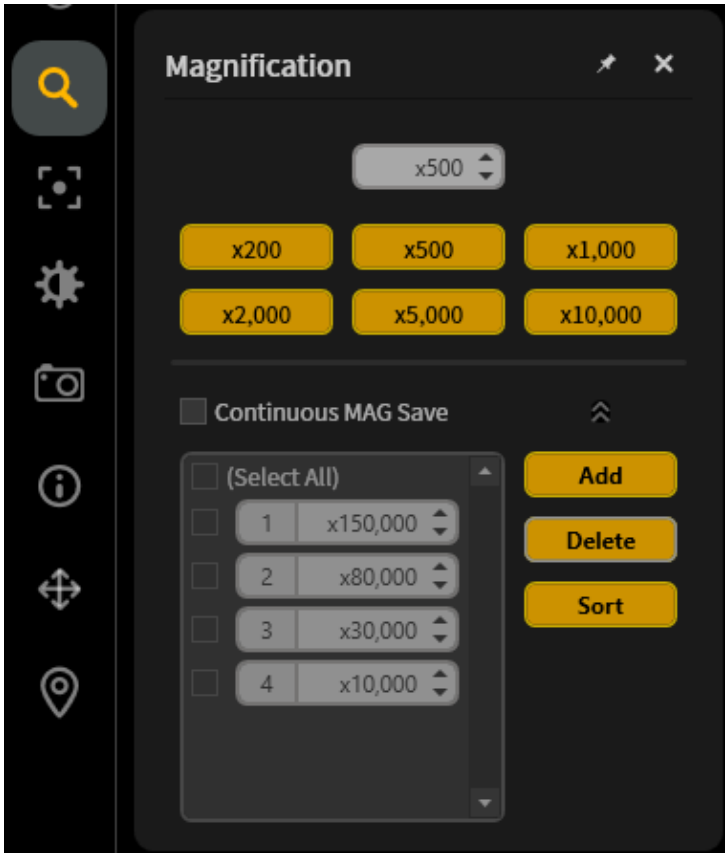
CAUTION	If the microscope is used while the alignment of the electron gun is excessively biased, the equipment can be damaged. When aligning the hardware electron gun at high voltage (over 25kV), communication can be lost. Thus, Gun Align must be performed in NanoStation at high voltage (over 25kV).

NOTE	After aligning the hardware electron gun, Gun Align must be performed in NanoStation.

3.4.4 Magnification Control

Menu - You can use the Focus function through the  screen icon.

You can select or enter the desired magnification when observing a sample.

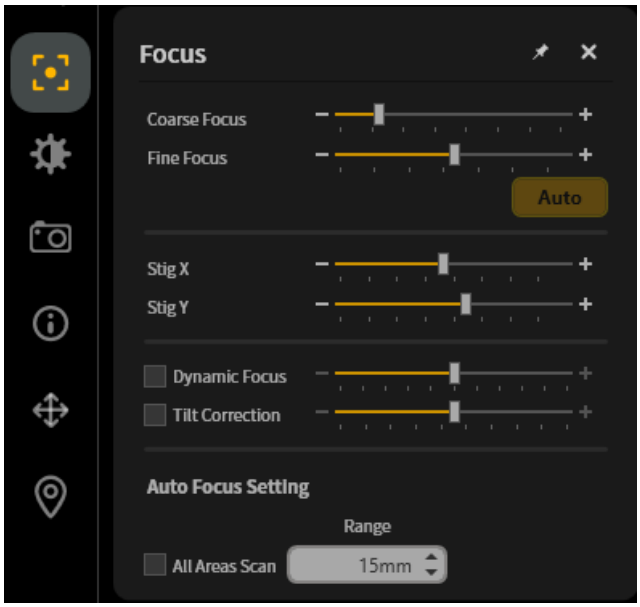


- Set the desired magnification by entering numbers.
  (The magnification setting range is x20~x250,000.)
  The minimum or maximum magnification varies depending on the Working distance (WD) and refers to a value that does not get any lower.
- The magnification is changed by clicking 6 Fixed Magnification buttons.
- Continuous magnification imaging: This is a function for continuously imaging with pre-entered magnification according to order.
  (It is used when imaging the same location with only different magnification.)
  - Add: You can add magnification. Click the Add button and then enter a desired magnification.
  - Delete: You can delete the desired magnification item by checking a magnification item.
  - Sort: You can sort the magnification in ascending order from a high magnification after entering the desired magnification.

NOTE For details on the magnification limit according to WD, refer to 5.3.1 How to select magnification.

3.4.5 Focus Control

Menu - You can control Focus through the screen icon.



■ Focus

An image can be focused by adjusting the strength of the current of an object lens.

- Coarse Focus: You can quickly find the closest focus in a wide area by coarsely adjusting the focus.
- Fine Focus: You can find an optimum focus by adjusting an adjacently focused image more finely.
- 

: You can automatically find the closest focus by pressing this button.

■ Stig

Stig. adjusts the Stigmator, which calibrates the circularity of an electron beam.

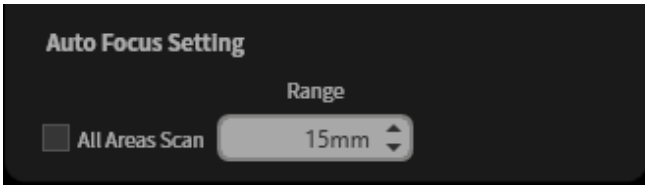
- Drag the mouse wheel or the Stig. X (or Y) bar, or click the - and + arrow key to move from the left end to the right end and position the button where the focus is best.

■ Dynamic Focus & Tilt Correction

You can obtain an image by calibrating the focus and depth using the Dynamic focus and Tilt correction option to observe a sample with an angle.

■ Auto Focus Setting

You can set the Range and Step based on the current WD to set up automatic focus.



- All Areas Scan: You can find an automatic focus based on all areas of the WD 5mm~40mm section.
- Range: You can set the range of the automatic focus from the current WD. (Range: 5~40mm)

- **Dynamic focus**

When measuring a sample with an angle, you can use Dynamic focus to change the focus at the center of a sample.

Grid with a 45° angle	
0%	+45%

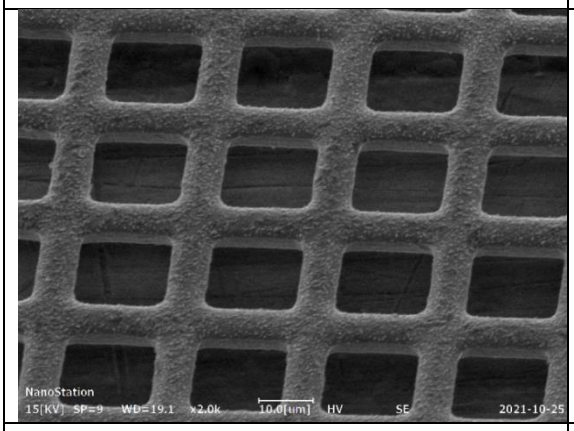
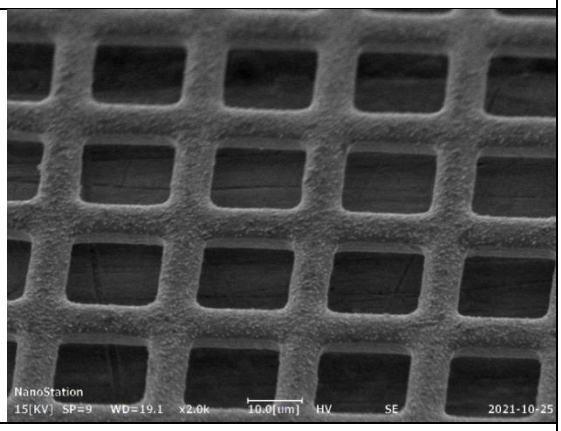

	

Image with overall focus	Image with focus at the center

- **Tilt Correction**

The tilt correction function can be used to compensate for the inclined angle and counteract the tilting effect on the deformed shape of the sample.

Grid with a 45° angle	
0°	+45°

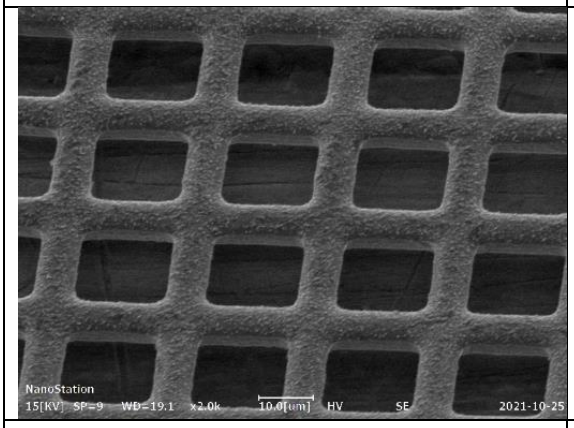
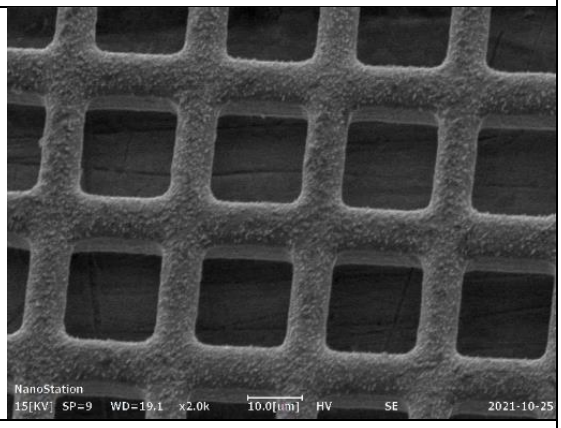
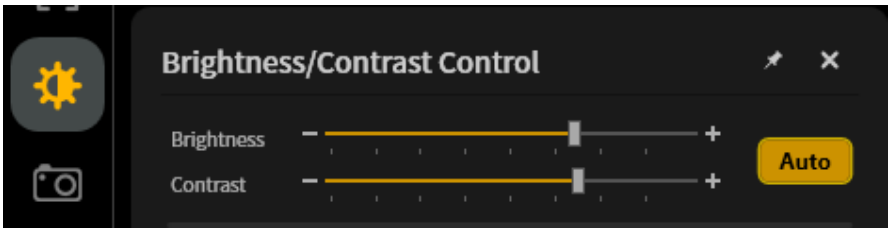

	

Image with shorter vertical length than horizontal length	Image with the same vertical and horizontal lengths

3.4.6 Brightness/Contrast Control

Menu - You can use image control through the  screen icon.

Calibrate brightness and contrast to obtain a good-quality image before imaging an image.



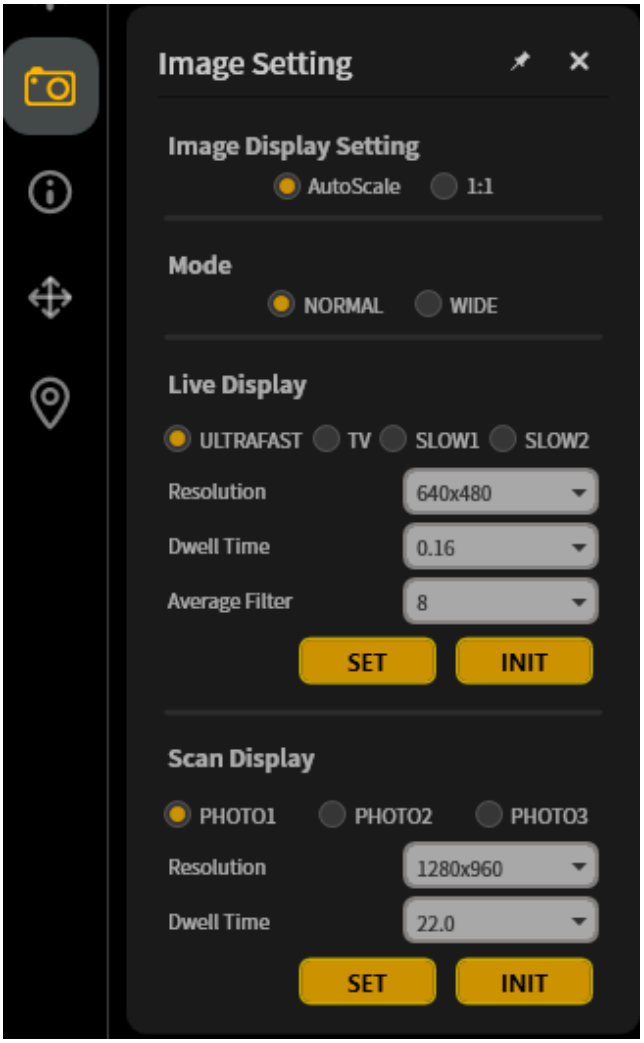
- Brightness: It adjusts the brightness of the electron microscope image screen.
- Contrast: It adjusts the contrast of the electron microscope image screen.
- 

: It automatically sets Contrast and Brightness.

3.4.7 Image Setting

Menu - You can use Image Control through the  screen icon.

You can adjust the image display ratio, resolution, and dwell time to obtain a good-quality image before imaging the currently displayed video and image.



- Image Display Setting: You can adjust the current image display ratio.
- Mode: You can adjust the current image display ratio.
- Live display: You can adjust the resolution, dwell time, and average filter value of the current image.
- Scan display: You can adjust the resolution and dwell time of the image to be saved after scanning.

Resolution	Dwell Time (us)
160x100	0.16
160x120	0.32
320x200	0.64
320x240	1.0
640x480	1.28
800x600	1.6
854x480	2.0
1024x576	2.2
1024x768	2.4
1280x720	3.2
1280x800	4.0
1280x960	5.0
1280x1024	6.0
1366x768	10.0
1400x1050	20.0
1440x900	30.0
1600x900	40.0
1600x1200	
1680x1050	
1920x1080	
1920x1200	

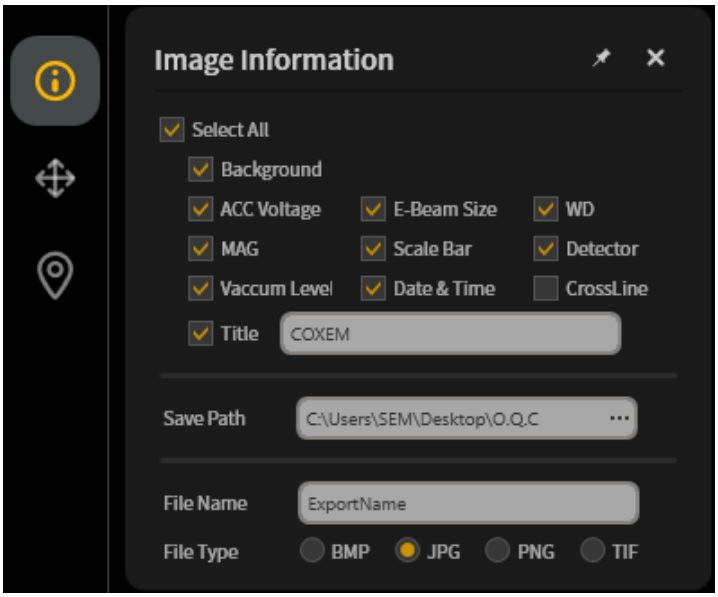
<Live display>

Resolution	Dwell Time (us)
5120x3840	0.16
2560x1920	1.6
2560x1600	3.2
2560x1440	5.0
2048x1536	10.0
1920x1200	18.0
1920x1080	18.28
1680x1050	18.60
1600x1200	19.0
1600x900	19.28
1440x900	19.6
1400x1050	20.0
1366x768	20.28
1280x1024	20.6
1280x960	21.0
1280x800	21.28
1280x720	21.6
1024x768	22.0
1024x576	30.00
854x480	40.00
800x600	

<Scan display>

3.4.8 Image Information

Menu - You can use the Image Information function through the  screen icon.



■ Select All

It selects/deselects all items displayed on the image.

- Background: It makes the text stand out by displaying the background of the image in black.
- ACC Voltage: It displays the accelerating voltage.
- E-Beam Size: It displays the E-Beam Size.
- WD (Working Distance): It displays the focus distance between an object lens and a sample.
- MAG: It displays the magnification.
- Scale Bar: It displays the scale bar.
- Detector: It displays the Detector Type in use.
- Vacuum Level: It displays the selected vacuum mode (LV or HV).
- Date & Time: It displays the date and time.
- Title: It displays the phrase randomly entered by the user. It is directly entered in the input box on the right.
- CrossLine: It displays or does not display the crossline on the screen.

■ Save Path

It sets the save path for an image.

- File Name
  It sets the filename of the image to be saved.

- File Type
  It sets the file type of the image to be saved.

3.4.9 Image Shift

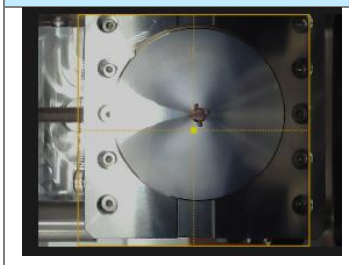
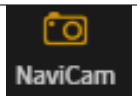
Menu - You can use the Image Shift function through the  screen icon.

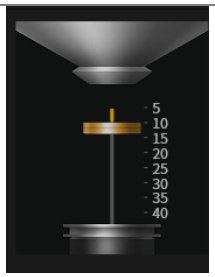
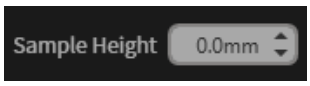
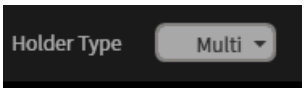
- Shift: It is a method of obtaining an image by moving the direction of the electron beam based on the X and Y-axes. It is used when slightly moving an image while a sample is zoomed in at high magnification.

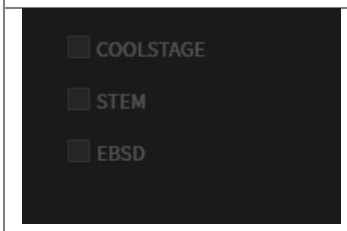
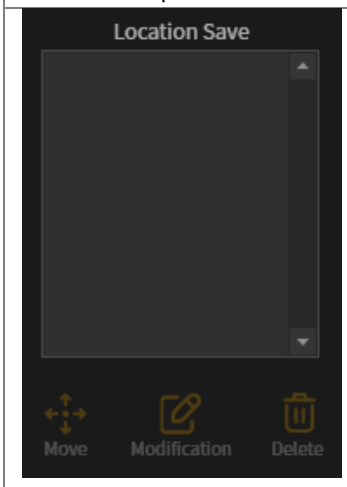
- Rotation: When observing a sample, you can rotate and view the image of an area you wish to view by rotating the electron beam. It moves in the opposite direction of stage movement depending on the image rotation angle.
  (Rotation range: ±180 degrees)

3.4.10 Stage

Menu - You can use the Stage Information function through the  screen icon.

Name	Description
 MAP	You can check the image shot with NaviCam.
 Home	It moves the Stage to the center(X=20, Y=20 position) of the chamber (Moves to the center after moving X=0, Y=0). (The maximum movable distance of the stage is X=40mm, Y=40mm)
 Center	It moves the Stage to the center of the chamber (X=20, Y=20 position).
 NaviCam	It moves the Stage to a position to be shot by NaviCam.
 Stop	It is used when stopping the movement of the Stage.

 Z Navigation	You can check the Z-axis position of the current sample stand. (The Z-axis position of the operable sample is 5~40mm.)
 Sample Height	Sample Height: When using Z-axis movement, you can enter the height of the sample holder to prevent collision. (The default multi-sample height is 5mm, The holder height up to the pin stub is 8.5mm, which is automatically entered when selecting 'Multi'. You can enter the sample height to be attached to the pin stub in 'sample height.') After selecting the holder type, the sample height must be input to enter the Z-axis value. The mountable sample height is 0 to 40 mm. (See [4.4.3 Measure WD] for more information on sample height.)
 Holder Type	Holder Type: If you change the holder type before putting the sample into the chamber, it is automatically applied to Z Navigation. When using Z-axis movement, you can change the holder type to prevent collision. (The default multi-sample height is 5mm, The holder height up to the pin stub is 8.5mm, which is automatically entered when selecting 'Multi'. You can enter the sample height to be attached to the pin stub in 'sample height.') After Vent is completed, you can change the holder type.
 Position info	Position info: You can know the current position, enter the desired position in the input window, and go to the position you entered. H.E (Home enable): When you want to home the X and Y axes respectively, you can home only each axis by clicking the HOME button. When unchecked, the HOME button is disabled and the

	X and Y axes cannot be homed respectively.
 Option	Option: Detector connected to the equipment in the Vent state By checking, you can use the functions of the detector. There are three types of detectors: COOLSTAGE, STEM, and EBSE.
 Location save	Location save: It is used when finding the position of an image shot with NaviCam later by saving its position.

NOTE

Since the sample height does not include the height of the sample stand, it must be used after entering the sum of the height of the sample stand being used and the height of the sample.

When a wrong sample height is entered, there may be a collision between the sample and the sensor.

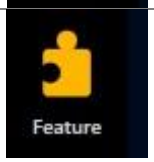
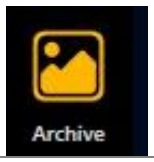
If a value lower than the minimum input table Z-axis value (5mm) is entered, an (x) mark will appear and the stage will not move. Thus, it must be used by changing to a value higher than the minimum value (5mm).

3.5 Operation

3.5.1 Operation button

It is used when turning the electron gun on or off.

Button	Name	Description
	E-Gun Power button	The button for turning E-Gun on or off. ※ Caution: If equipment power is turned off while E-gun is turned on, it may affect the Filament. You must first turn off E-gun power followed by equipment power. • Power Off state: Grey • Power On state: Yellow
 	Vacuum ON / Vacuum OFF button	The button for converting the inside of the chamber into vacuum state or atmospheric pressure state. ● Vacuum ON: It shows that the current state is a vacuum state. (If the Vacuum ON button is pressed, it switches to atmospheric pressure-state Vacuum OFF button.) ● Vacuum OFF: It shows that the current state is an atmospheric pressure state. (If the Vacuum OFF button is pressed, it switches to atmospheric pressure-state Vacuum ON button.)
	Detector button	The button for selecting the detector mode of the electron microscope.
  	Acquire button	The button for scanning and saving an image. ● Vacuum ON: It shows that the current state is a vacuum state. ● Vacuum OFF: It shows that the current state is an atmospheric pressure state.

Button	Name	Description
 	Save / Save(CS) button	The button for saving an image that has completed scanning. ● Save: It saves 1 currently scanned image. ● Save(CS): It saves an image at the magnification saved in the continuous magnification shooting.
 	Feature / Archive button	You can open a Panorama window by pressing the Feature button or check a saved image by pressing the Archive button. ● Feature: The function of automatically shooting multiple images according to the information entered by a user. ● Archive: You can edit or export a saved image.

3.5.2 Select Vacuum State

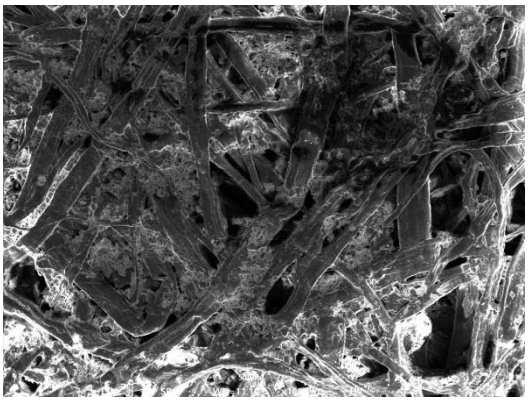
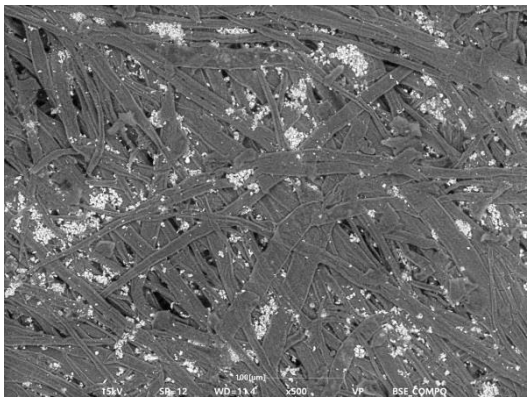
It is used when creating a vacuum state inside the chamber while observing a sample or when switching to an atmospheric pressure state while taking out a sample, and the vacuum level inside the chamber can be selected depending on the observation purpose or sample. The button below shows the current status of the equipment.

- Vent: Enables preparing a high vacuum state.
- HV (High Vacuum): Enables preparing a high vacuum state.
  Maintains the vacuum state inside the chamber below 10^{-4} torr.
- LV (Low Vacuum): Enables preparing a Low vacuum state.
  Maintained at the 20±5Pa level. **(Optional)**

NOTE

- LV mode is used when observing an uncoated sample such as wooden material, semiconductor, and biological sample or non-conductive sample.
  For reference, you can view a sample more effectively since the charging effect phenomenon is reduced when observing in BSE mode under an LV state.
  * The Vacuum Toggle button is visible only when the Setup screen is clicked, and you can switch the vacuum level only in Vent state.
  (Selection and switching are not possible in Pump state.)

Ex.: When observing an uncoated flexible printed circuit board (FPCB) in SE mode

High Vacuum	Low Vacuum
	

3.5.3 Select Detector Mode

The button for selecting the detector mode of the electron microscope.

- SE mode: It is usually used when observing a sample surface by displaying an image after receiving an input of the Second Electron signal.
  (It switches to SE mode if the BSE mode button is pressed.)
- BSE mode: You can observe the element composition of a sample by displaying an image after receiving an input of the Backscattered Electron signal.
  (It switches to BSE mode if the SE mode button is pressed.)
- SE+BSE (synthesis) mode: It observes an image synthesized from SE and BSE.
- MAP mode: It observes the image of a saved sample.
- MAIN mode: It observes all Detector modes.

3.5.4 Acquire Button

It scans an image with a value set in Map image or Scan Display.

- When scanning a Map image: Set after selecting a "Map" in the Detector button. Click Acquire button to scan a Map image after adjusting brightness/contrast in the Map setting.
  (Refer to 2.4.2 Setting item.)
- When scanning an image: Scan an image with the PHOTO mode, resolution and Dwell time values set to Scan display on the image setting window.
  (Refer to 2.4.8 Image Control item.)

- When scanning an image: It switches over so that the Acquire button can be stopped; if the button is pressed, a scan can be stopped.

- After stopping an image: It switches over so that the Acquire button can play a scan; if the button is pressed, a scan can be continued.

3.5.5 Save Button

The Save button is used when you wish to save a scanned image.

When you click the Save button, the image is temporarily saved and displayed as a small image at the bottom of the screen,

and is automatically saved in a designated path at the same time.

- Save: It saves 1 currently scanned image and 1 image containing image information.
- Save(CS): It saves an image at the set magnification value in the continuous magnification save mode shooting.

NOTE

When using Image Mode, an image is saved in the path designated in the Image folder of  image information, and the filename is set to the saved time and saved.

The default save path when shipping out the product is C:₩Snap Image.

3.5.6 Feature Button

You may use 'Archive' to edit or check a save image or execute Panorama function.

- Archive: It loads images saved up to the present, and it can edit and save an image.
- Panorama: This function creates a single large-area image by stitching together several images that have been scanned based on the set magnification. The scanning is performed within an area defined by two coordinates selected at the beginning of this operation.

3.6 Status Information

It displays the connection status of the network.

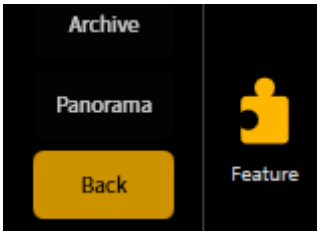
3.7 Archive

3.7.1 Archive

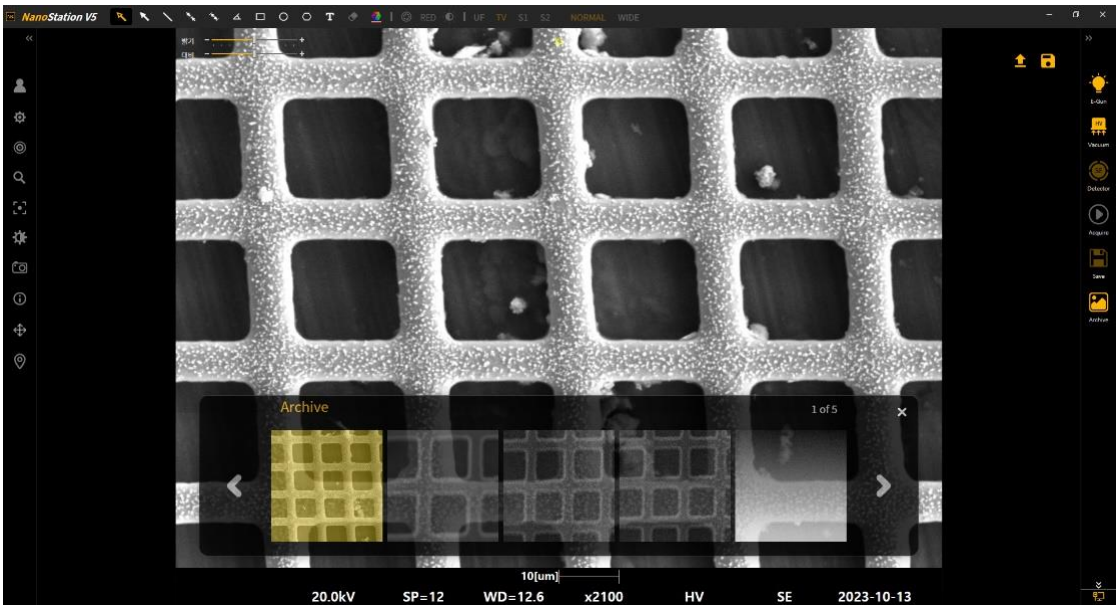
It is used when editing and saving a saved image.

Click the Archive button that appears after clicking the Feature button on the left.

(When going back to the previous menu, click the "Back" button.)



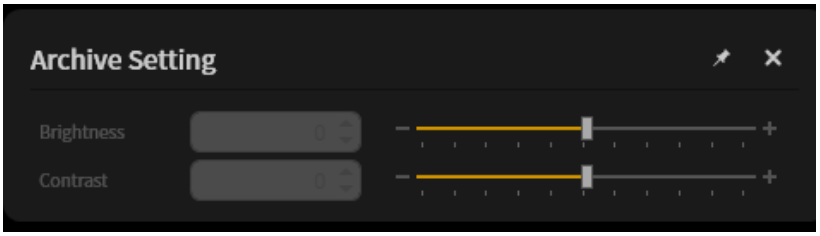
3.7.2 Archive Menu



Name	Description
 Export	It is used when saving an image modified using image adjustment and the draw menu in any internal or external space.
 Save	It is used when saving an image modified using image adjustment and the draw menu within the Archive.
 Save List	It is used when checking the list of images saved within the Archive.

3.7.3 Archive Setting Mode

It uses  when setting the Archive.



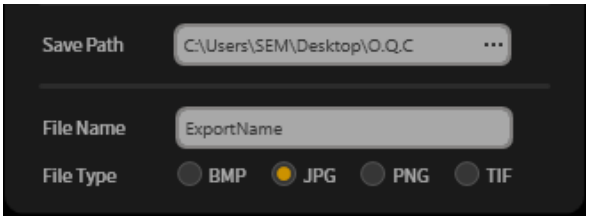
- Brightness: It adjusts the brightness of an image.
- Contrast: It adjusts the contrast of an image.
- Filter: It applies a filter effect to an image.


NOTE

For details on how to use the Drawing Tools from the Archive Image, refer to 2.3 Drawing Tools and Quick Launch.

3.7.4 Archive Filename Setting & Save Path

The default filename of an Archive image can be set in  image information.



- Filename: It sets the default filename when saving an Archive image.
- Save Path: It selects a folder from which an Archive image is loaded.


NOTE

You can check an image in the Archive only when an image file is in the "Image" folder within the save path.
When using the Archive function in another folder, the "Image" folder and files in the existing folder must be moved and used.

4 Sample Preparation

4.1 Overview

When observing a sample with an electron microscope, an accurate image can be obtained only after going through work such as pre-treatment according to the nature of a sample. If an unsuitable pre-treatment method is used, a sample may be damaged, or the user may make a wrong judgment after viewing a distorted image. If a sample is treated by a suitable pre-treatment method, a clear image can be obtained even from a sample that is difficult to measure.

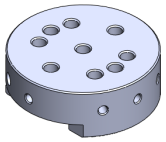
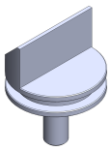
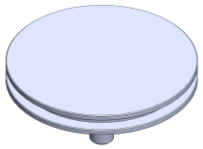
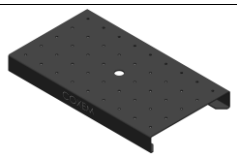
- Poly/Latex gloves must be worn throughout the process of handling samples.
  If a sample is handled with bare hands without gloves, contaminants from the hands or sodium elements may enter the electron microscope and pose the risk of degrading its performance.
- If there is risk of fragments flying everywhere when making a sample from glass materials or semiconductors, you must handle the sample while wearing safety goggles.
- Since there is a possibility of inhaling a sample in powder form, you must wear a mask.

4.2 Stub Type

4.2.1 Basic Stub Components

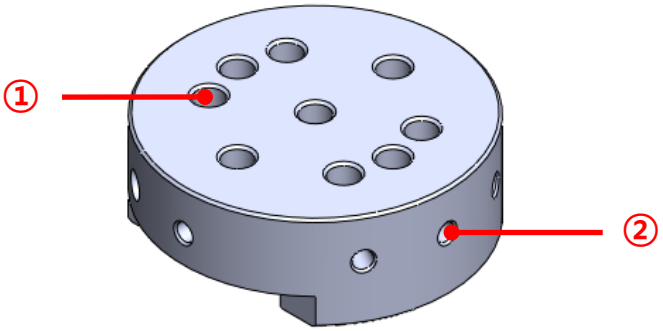
The following are the Stub components that are basically provided to purchasers of the EM-40 product:

(If a stub with different size or form is needed in addition to the basically provided Stub, it can be additionally produced and purchased.)

	Multi-Holder
	Stub #1 - Pin Stub (7mm dia)
	Stub #2 - Pin Stub (12.7mm dia)
	Stub #3 - Section/Tilt Sample Stand (12.7mm dia)
	Stub #4 25mm Basic Sample Stand (25mm dia)
	Stub Pin Mount

4.2.2 How to Use the Multi-Holder

Description of Each Part



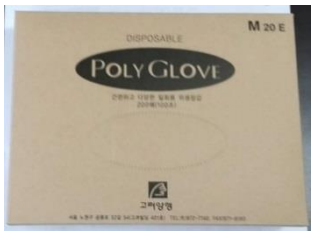
No.	Name	Description
①	Stub Loading Hole	Mount the Stub by inserting it into the hole.
②	Housing	This is a part of the body attached to the stage.

Mount a sample on a pin stub and insert the pin stub into the hole of the multi-holder, and then load it into the electron microscope for operation.

4.2.3 Stub Cleaning

If you repeatedly attach and detach samples to and from a stub, the stub will become dirty. If the stub becomes unclean, it may be difficult to fix a sample, or abnormalities may occur inside the chamber. Thus, the stub must be cleaned periodically.

Items to be prepared

		
Poly Gloves	Wiper	Acetone

The procedure for cleaning the stub is as follows:

1) If you repeatedly attach carbon tape to the stub, the surface of the sample stand will become dirty.

2) First, fold several wipers together and then spray acetone.

3) Make sure the surface of the sample stand faces downward.

4) Wipe the surface while pushing the stub left and right. If you wipe repeatedly, the carbon tape residue on the stub will be removed completely.

4.3 Material Type

If you wish to mount a sample on a stub for observation, select a stub with a suitable size and then consider the type and characteristics of the sample.

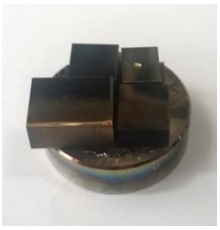
4.3.1 Classification by Height

Materials with low height

- Attach carbon tape to the surface of the stub plate and then mount a sample.
- Materials can be mounted even if they are slightly larger than the width of the stub plate.

Materials with medium height

- Attach carbon tape to the surface of the stub plate and then mount a sample.
- Materials can be mounted even if they are slightly larger than the width of the stub plate.



Materials with high height

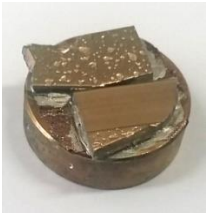
- Have the flattest part of a sample face downward and the observed part face upward, and then attach carbon tape and mount the material.

3.3.2 Classification by Material

NOTE For details on the sample pre-treatment method, refer to [3.4. Sample fabrication].

Plastic materials

- Because plastic materials have no conductivity, they must be coated. In some cases, silver paste is applied on the side of the sample to enhance conductivity.



Metal materials

- Because metal materials have good conductivity, they don't require coating. In some cases, they may be coated to enhance conductivity.

Molding materials

- In case of a sample that is difficult to cut, mold it first and cut it, and then analyze it after polishing.
  Ion coating must be performed on molding materials.

Glass materials

- You can view the cross-section by cutting these materials and obtain a tilted image by using a tilt holder.
  Ion coating must be performed on glass materials.

Powder materials

- Spray powder materials on carbon tape, and then use a blower to prevent powder from entering the microscope.
- Powder that is not properly removed with a blower can cause aging of the microscope.

4.4 Sample fabrication

Prior to observing a sample, a suitable sample preparation process is needed depending on the characteristic of a sample.

4.4.1 Matters to Check Prior to Sample Preparation

You must first check the following when preparing a sample:

1) Check the sample type and perform pre-treatment of the sample accordingly.

- Metal samples, polymer samples, semiconductor samples, biological samples, etc.

2) Check the purpose of sample observation, and select an analysis method that is suitable for the purpose.

- Surface analysis, cross-section analysis, BSE analysis, EDS analysis
- Sample preparation according to the purpose of observation

3) When observing with SEM, check the nature of a sample to prevent damage to the sample and equipment.

- Is the sample heat-resistant?
- Is the sample magnetic?
- Is the sample conductive or semi-conductive?
- How large is the sample?

4.4.2 Material Preparation

If the material is made by cutting or is small, a user can use it as a sample without further processing.

1. When observing a standard sample

A standard sample is needed to demonstrate the operation of the equipment when a material is not prepared.

- A standard sample can be purchased from a dealer or a website.
- The size of a standard sample is 25 x 25um (width x height). Since this sample is very thin and can be easily bent, pick it up and take it out carefully using tweezers, and then shoot the image after attaching it to the stub plate.

		
Sample material	**Taking out the material**	**Attaching to the Stub plate**

2. How to prepare the sample by material

The sample preparation method varies by material. Check the characteristic of a sample, and then prepare by referring to the following pre-treatment process:

1) Conductive sample such as metal

Cut a sample using various methods.

- When grinding, use low-speed cutter, grinder, wrapper, and tripod.
- When producing a fractured surface, use liquid nitrogen or diamond pencil.
- When etching, use the chemical method and heat etching.
- If there is corrosion or oxidation of the sample surface, perform etching or polishing. (When removing contaminants from the sample surface, use a Plasma Cleaner.)

2) Non-conductive samples such as non-conductive/fiber/polymer samples

A non-conductive sample must be coated with metal (gold, platinum) so that electricity flows through by using an ion coater.

Pre-treatment is usually done using an ion coater. This equipment prevents the charging effect of semiconductor samples and improves secondary electron efficiency generated from the sample.

3) Biological sample

Pre-treatment is very important for biological samples because deformation may occur when they are dried naturally. In addition, since there is a possibility of thermal damage when observing this sample, deformation or damage to the sample can be reduced only when observed at low accelerating voltage.

4) Semiconductor sample

For semiconductor samples, chemical etching is used depending on the observation area. The user must find an optimal pre-treatment method by comparing images before and after etching.

5) Sample in powder form

When normally mounting a sample in powder form, fixing it is important so that the powder does not scatter.

Large powder samples with size of several um or larger.

① Attach powder sample to carbon tape or CU tape.

② Compress with polyethylene film.

③ Fix with conductive adhesive.

- Or plant powder sample into silver paste.

Small powder samples with size of several um or larger

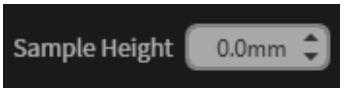
① Drop it on glass substrate or SI Wafer, and then disperse them.

② Cut the substrate/wafer where scattered samples are attached.

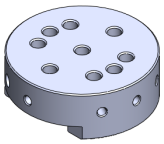
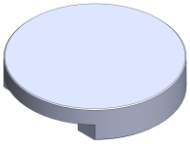
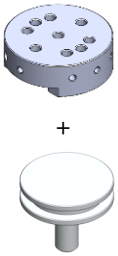
③ Fix with conductive adhesive.

4.4.3 WD Measurement

You must enter the sample height loaded from the floor surface of the stage in the sample height box.



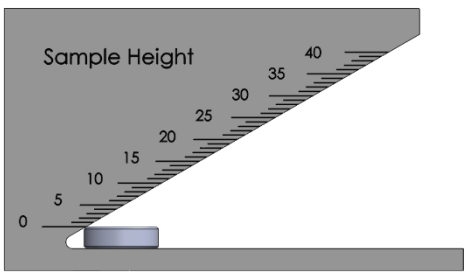
The names and WD of generally used holders and stubs are as follows:

Holder	 Multi-Holder	 Standard Holder	 Pin Stub	 +
Holder Height (mm)	8	3	3.5	12
Height when fastened (mm)	5	0	3.5	8.5
Available WD (mm)	10~35	5~40	-	13.5~31.5

1. When using a Standard Holder

   When mounting a high sample (approx. 20mm or higher), use the sample by attaching it to the Standard Holder. Measure the sample height using "Sample Height Ruler" as shown below.

(In this case, a sample with height of 0mm to 30mm must be used).



In this case, sample height = 0mm + actual sample height (mm).

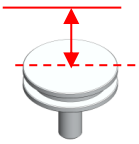
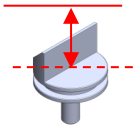
ex.) In case the actual sample height is 17mm, the sample height is 17mm (0mm + 17mm).

2. When using a Multi-Holder

Attach the sample to the provided Stub when using a Multi-Holder for mounting a low sample (approx. 20mm or lower) to measure the sample height by using the following "Sample Height Ruler"

(In this case, a sample with height of 0mm to 20mm must be used).

In this case, sample height = actual sample height (mm).

Holder	 Pin stub	 Pin stub (45°&90°)
Sample Height		

ex) If the sample is attached to the pin stub, enter 5mm in Sample Height if the sample is 5mm high.

ex) When a sample is attached to a single-sided/tilt specimen stand, measure the height of the sample from the flat part of the specimen stand using the "Sample height roller" and input it into the sample height.

WARNING

After mounting the Sample Holder, you must use it after entering the sample height.
If the sample height is not entered, or a wrong sample height is entered, issues such as OL collision and damage to the EDS & BSE Sensor may occur.
In addition, if the sample is larger than the holder due to its width, collision with SD Detector may occur.
The user shall assume responsibility for issues arising from failure to follow the instructions above.

NOTE

WD (Working Distance) refers to the focal distance between a sample and the object lens.

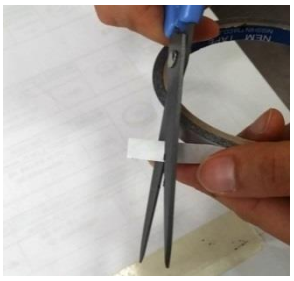
WD value	Advantages	Disadvantages
In case WD is set to high	Improved image depth	Decreased resolution
In case WD is set to low	Improved resolution	Reduced image depth

- When conducting EDS elemental analysis or aiming to obtain an image with high magnification, a height of around WD 7~10mm is recommended.
- When observing strongly magnetic samples such as Ni and Cr, it is difficult to observe the image due to constantly changing stig values caused by the magnetic properties of the sample. In this case, WD must be set higher so that the properties of the sample have less effect on the stig.

4.4.4 Mounting a Sample on the Stub

The order of mounting a sample on a stub is as follows:

1) Cut a carbon tape with scissors.
   The tape must be slightly longer than the size of the material.



2) Attach the tape to the stub plate.

3) Attach the material to the surface of the stub plate.
   At this time, you have to attach the material so that the direction of imaging direction upward.
   When attaching a sample to the stub plate, it must be fixed so that it does not waver and must be mounted without overlapping.

4) After attaching the material to the plate, use a blower to blow powder and dust off so that dust or contaminants do not enter the chamber.

CAUTION

- The size of the sample must be adjusted to enable entry into the inner side of the stub. Since an accurate image cannot be obtained if the sample shakes, the sample must be fixed on the stub with carbon tape to prevent movement.
- Dust and contaminants must be removed from all samples with a blower after fixing them on the stub.
  (If they are placed as they are into the vacuum chamber, the performance of the lens system or vacuum system may be degraded. Thus, you must prepare a sample from which contaminants are removed as much as possible.)

Marking of Sample Order

When you place several identical types of samples on the stub, marking their order makes observing the samples convenient.

- You can easily observe images since it appears in the same order when viewed from the electron microscope.

NOTE

In observing samples, remembering the order of the samples placed on the stub is efficient when looking for a sample.

4.5 Mounting of the Sample

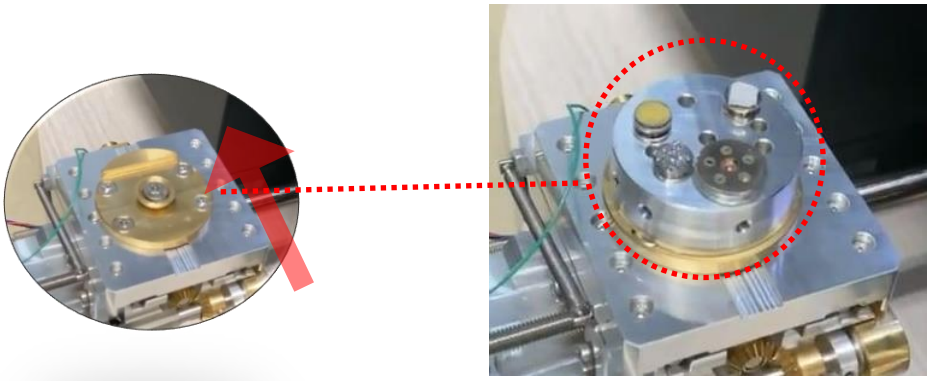
Once sample preparation is complete, insert or replace the multi-holder on the equipment.

4.5.1 Sample Preparation and Mounting

1) Press the [Vacuum] button in the NanoStation program, and then click the Vent button to cancel the vacuum state.

CAUTION When mounting a sample in the equipment, the vacuum state must be canceled.

2) Open the chamber door as widely as possible, and insert the Multi-Holder in the direction of the arrow in line with the groove of the part where a sample will be mounted.



WARNING If the final height of the sample is high, it may cause a collision between the object lens and the BSE sensor.
Thus, you must check the final height of the sample so that it does not exceed the height of the Housing Cover of the Multi-Holder.
The user shall assume responsibility for issues arising from failure to follow the instructions above.

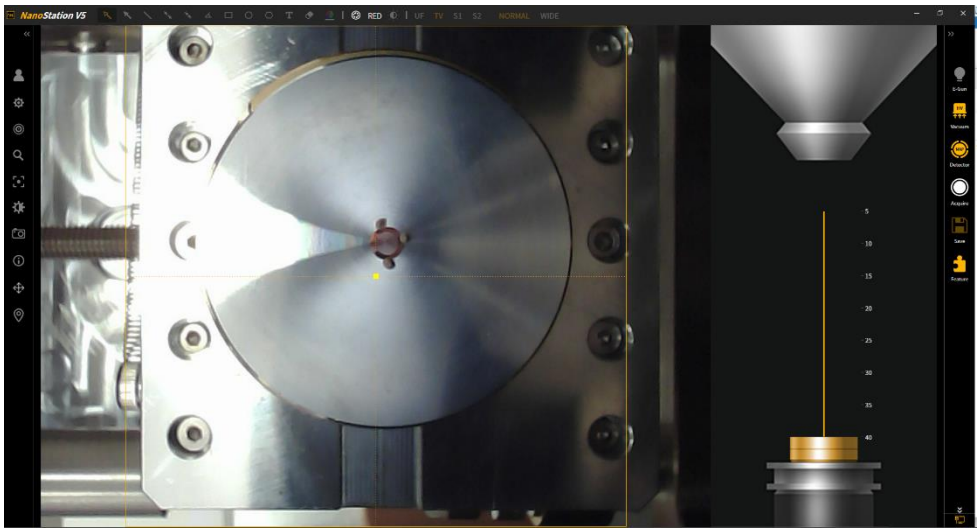
3) Push the chamber door until it is caught on the stopper.
(When it is caught on the stopper, it will make a "click" sound and stop.)

4) Click NanoStation- Operation Bar - 

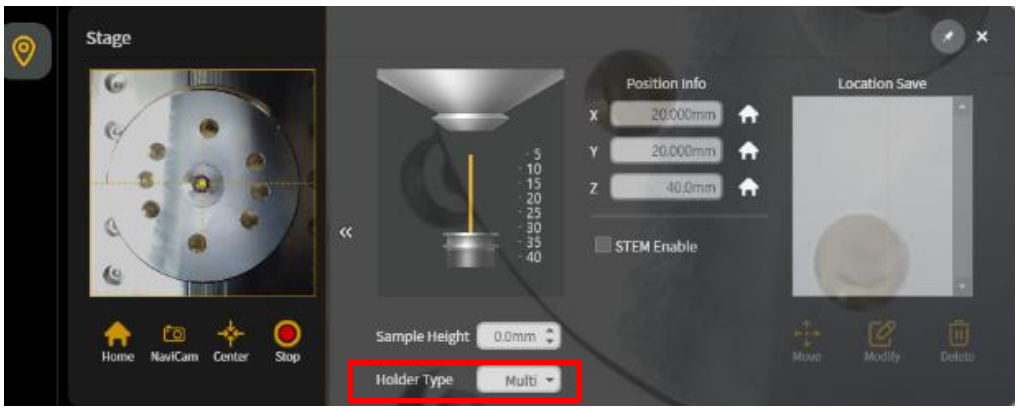
- Map button.

5) Click the Stage button, and then press the NaviCam button to shoot.

- If you press the button, the Stage coordinate will move to X: 20mm and Y: 40mm.
- Then, the CCD Cam located on top of the sample stand that finished moving will shoot the position of the Holder.
- Click the button to confirm the position of the Holder.

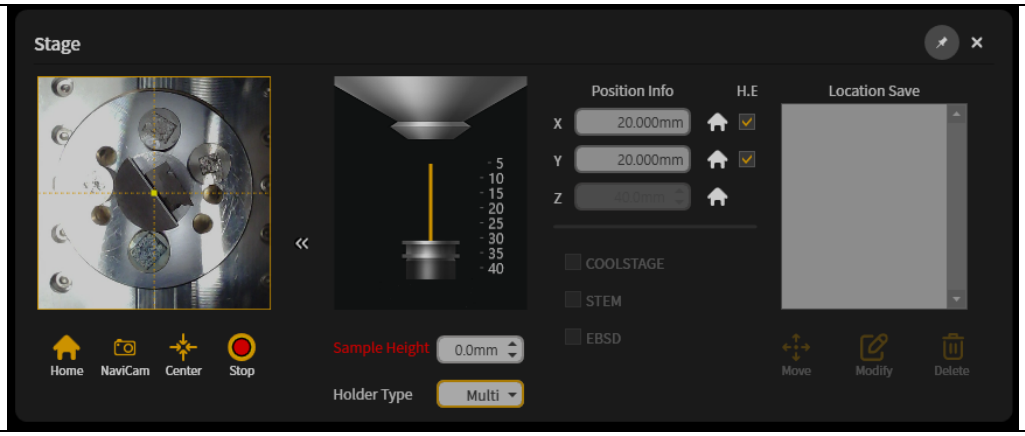


6) 스테이지 제어 – Holder Type - Multi 로 선택되어 있는지 확인한다. (자세한 내용은 [4.4.3WD 측정]을 참고한다.)

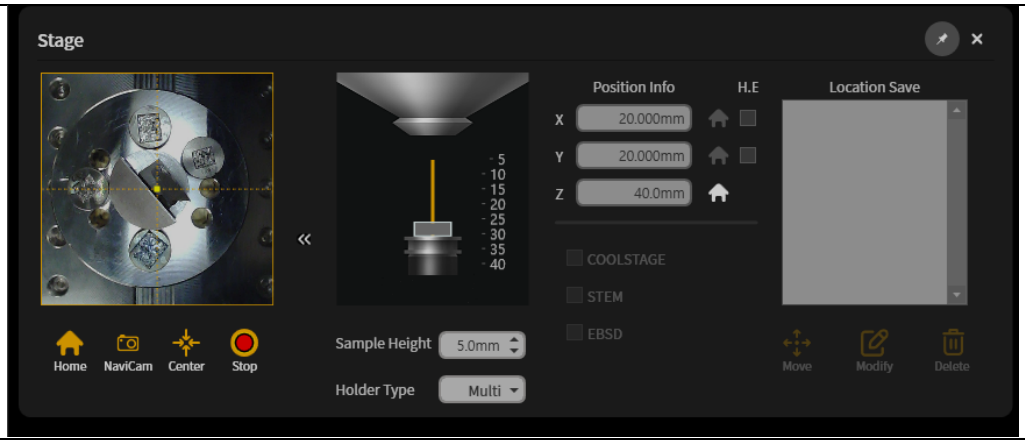


7) Enter the sample height and press the ENTER key.

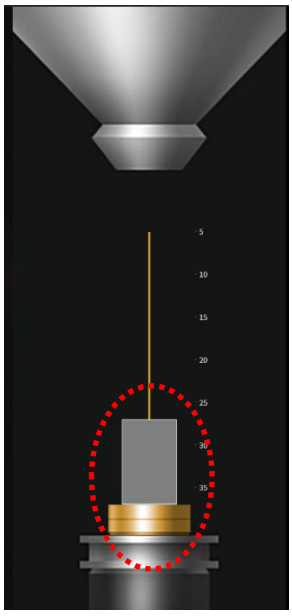
Before entering sample height



After entering sample height



8) Check whether the sample height is applied to Z Navigation.



9) Close the chamber door of the part where a sample is mounted.

CAUTION

When pumping, push the chamber door with your hand to ensure that the stage is in close contact with the chamber.
Since the rotary pump is activated at atmospheric pressure if the chamber door is left open for a long time after pumping, it strains the pump and causes it to fail. Therefore, you must make sure that the chamber door is closed when pumping.
(Check the LED on the front side of the equipment or NanoStation.)

10) If you enter the position in Menu – Stage – Z-axis or click the sample in Z Navigation, the Z-axis will move its position.

- When the mouse cursor is placed on the sample holder and adjusted with the mouse-wheel or double-clicked, the Z-axis will move by 1mm.
- If you click the WD number on the right, the Z-axis will move to the position of the relevant number

11) Press the [Vacuum] button of the NanoStation program followed by the HV button to switch to vacuum state.

CAUTION

To prevent a collision between the OL and the sample, you must enter the height of the sample stand and the sample.

4.5.2 Sample Storage

If camera shooting is finished, be sure to store the stub where the sample is attached in the Desiccator. If there is no storage box, it is ideal to keep it away from direct sunlight in a place where dust does not enter.

CAUTION

Since the adhesiveness of the carbon tape becomes very strong when exposed to air for a long time, it may become difficult to remove.

If the sample need not be stored for a long period of time, the carbon tape can be easily removed within a short period of time.

NOTE

In case of samples that may be oxidated such as metal or whose elements may be damaged, it is ideal to store them in a vacuum desiccator.

(Samples requiring vacuum storage: metal sample that can be quickly oxidated, semiconductor sample, biological sample, etc.)

5 Preparation for Camera Shooting

5.1 Power ON/OFF

5.1.1 Turning on EM-40

1) Turn on the main power switch on the back of the EM-40 product.
   - It must be turned on at all times.

2) Turn on the power switch in front of the EM-40.

NOTE

Vacuum completion generally takes approximately 2 minutes and 30 seconds until 100% vacuum state is reached from atmospheric pressure. (Based on High Vacuum) However, the time taken to reach 100% vacuum varies depending on the sample condition and operating status of the equipment.

3) It takes around 20 seconds for the equipment to turn on.

4) Double-clicking the Execute icon on the wallpaper of the control PC executes the NanoStation program.

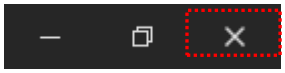
5.1.2 Turning off EM-40

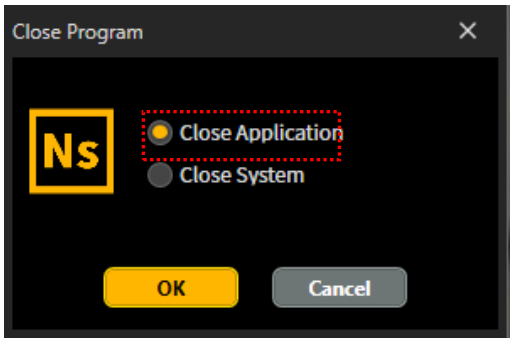
1) Turn off E-Gun in the NanoStation program.

NOTE

You must turn off the main power after waiting until the Filament, Bias, and Emission Current values become "0."

2) Close the NanoStation program.





3) Turn off the power switch in front of the EM-40.

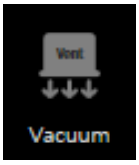
CAUTION

You must turn off product power in vacuum state.
(If in Vent state, you must turn off power after switching to vacuum state.)

5.2 Electron Beam Setting

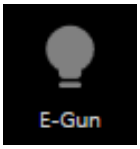
5.2.1 Turning on the Electron Beam

1) Press the [Vacuum] button of the NanoStation program if a sample is mounted followed by the HV button to execute vacuum.



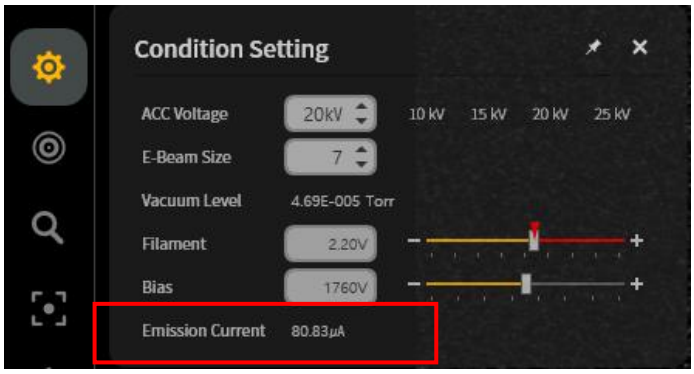
2) Check the vacuum state of the equipment.

3) If the vacuum level reaches 100%, press the [E-Gun] button to turn on E-Gun.

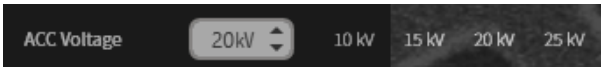


5.2.2 Filament Optimization

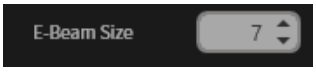
■ It optimizes the voltage value applied to the filament.



1) Enter the desired ACC voltage value or click the button to select.



2) Enter the desired E-Beam size.



3) Adjust the Filament value. (Recommended Filament value: 2.0V)

4) Adjust the Bias value to check the Emission Current value (Recommended Emission Current: 80±5uA)

CAUTION Entering a filament value of 2.2V or higher may cause the lifespan of the filament to be shortened or the performance of the E-Beam to be degraded.

NOTE For details, refer to [3.4 Setting].

NOTE You can place the mouse cursor on the ACC voltage, E-Beam Size, and Magnification value on the bottom of the screen and then change the ACC voltage value by scrolling the mouse-wheel.

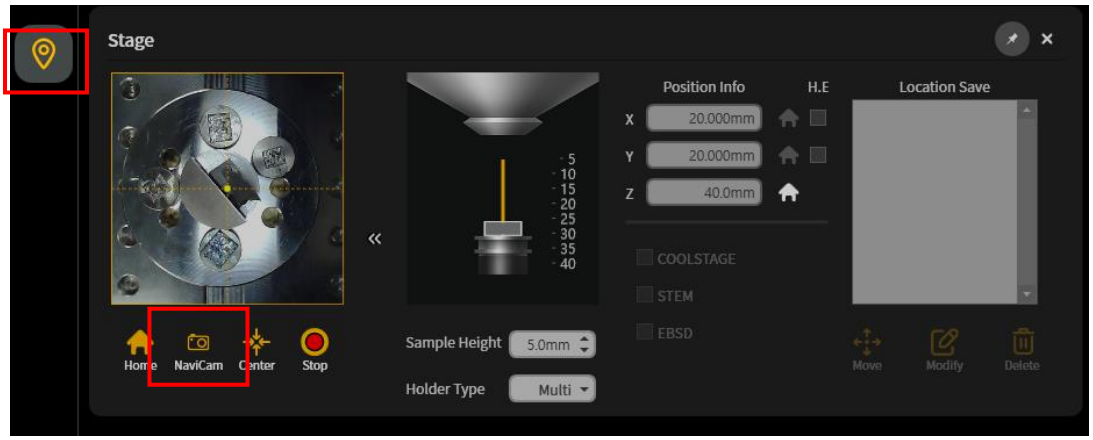
5.3 Sample Position Movement

5.3.1 Using NaviCam

NOTE

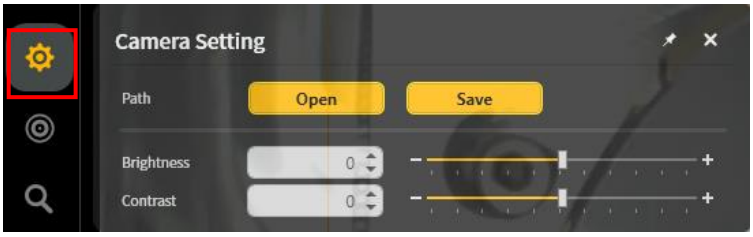
NaviCam is supported when using the CCD option. It is a supporting function of ensuring that a sample can be found easily by synchronizing the Stage coordinates and the Map function by selecting a stub to be measured among several Stubs.

1) Click Menu – Stage – NaviCam button to move the position of a sample.

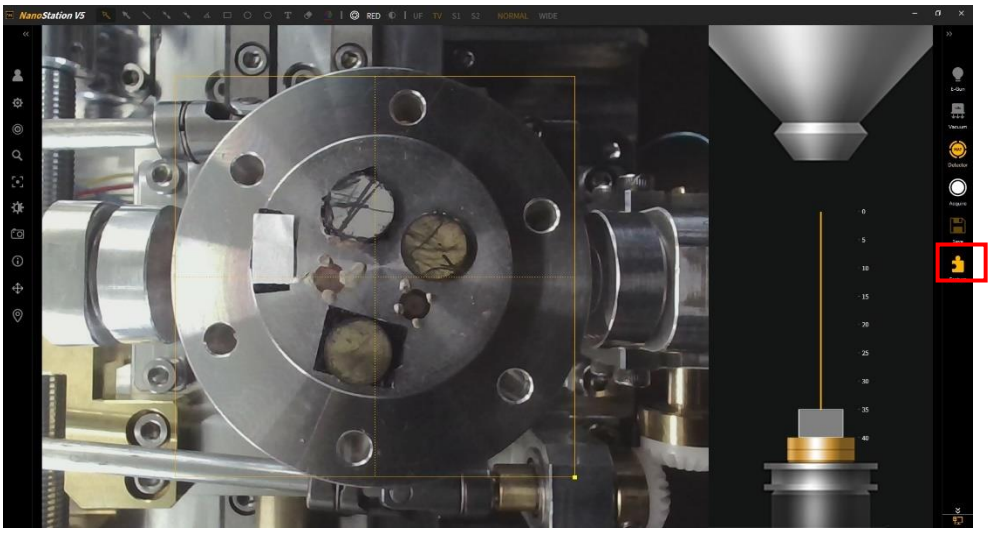


2) Click Detector – Map button from the Operation Bar.

3) You can change the brightness and contrast of the Map by clicking Menu – Setting.



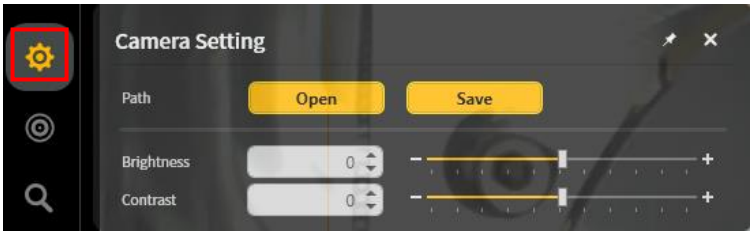
4) After checking the position of a sample from the map, click the Acquire button to save the Map image.



(Figure 4)

5) You can check the Map image by clicking Menu – Setting – Save button.

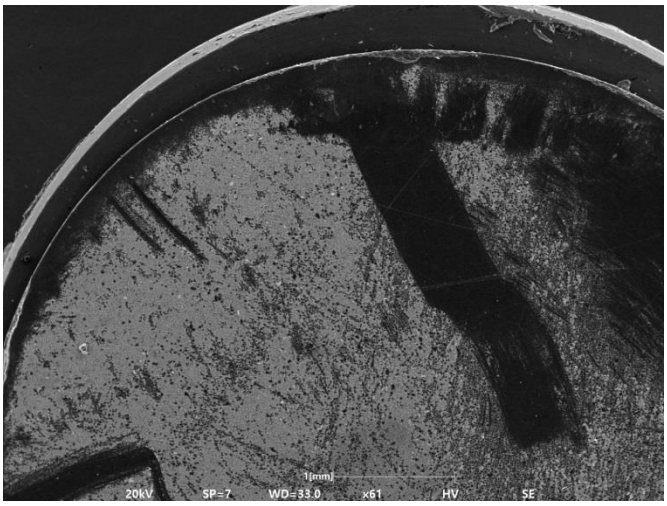
(It can be checked in *My Documents₩NanoStation₩maps*)



5.3.2 Minimum Magnification Adjustment

When observing a sample, you must first set the minimum magnification and then gradually increase the magnification.

When setting the minimum magnification, adjust with the mouse wheel on the magnification value window.



The minimum and maximum magnifications vary depending on the WD value and ACC voltage value. The minimum magnification limit by WD is as follows:

(ACC voltage: based on 20kV)

WD (mm)	Min. magnification	Max. magnification
5	252	250000
10	169	250000
15	128	250000
20	103	250000
25	86	250000
30	74	250000
35	65	250000
40	57	250000

CAUTION

When finding a sample at minimum magnification, use only a short amount of time. (Within approx. 10 minutes)

Maintaining the minimum magnification for a long time may cause the Scan coil and control board to overheat,

in which case the image may stretch.

NOTE

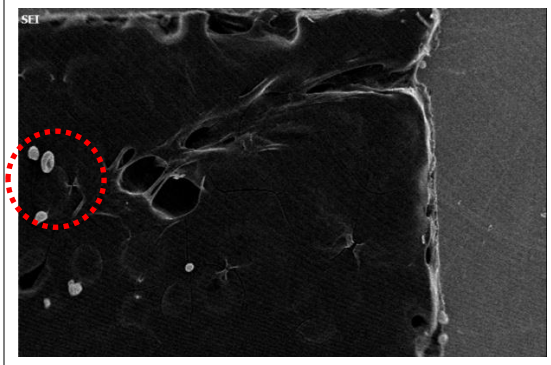
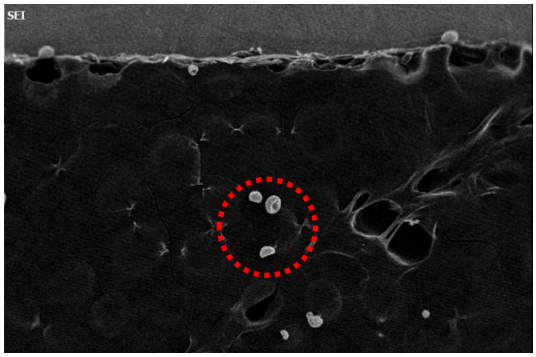
Minimum magnification refers to the value that does not go down any further when the magnification is lowered.

Minimum magnification varies depending on the WD (working distance) and ACC voltage setting value.

- The minimum magnification becomes lower if the WD value is high but becomes higher if the WD value becomes lower.

5.3.3 Selecting & Moving the Sample Using the Mouse

Double-clicking the direction you wish to move to moves to the direction you have clicked.

Before moving	After moving
	

NOTE

Or you can move by using the keyboard direction keys or entering a number for the stage coordinate value.
When moving by entering a number, however, the result of the movement may not be accurate.

4.3.4 Moving Using the Keypad

You can move 1mm at a time in the direction you wish to move by using the keypad.

Keypad

6 Image Acquisition

To acquire an image, follow the procedures below.

Procedure		Details
1	Observation mode setting	Set the observation mode and move to the area you wish to observe.
2	ACC voltage setting	Set an appropriate ACC voltage depending on the purpose of observing a sample.
3	Observation magnification setting	Move the position of a sample at low magnification, and then select the measurement position to zoom in at high magnification.
4	Spot size setting	Adjust to an appropriate E-Beam size depending on the magnification.
5	Focus setting	Calibrate the focus by controlling Coarse Focus, Fine Focus, and Stig X,Y. - Perform Wobble if necessary.
6	Contrast/Brightness adjustment	Set the desired Contrast and Brightness.

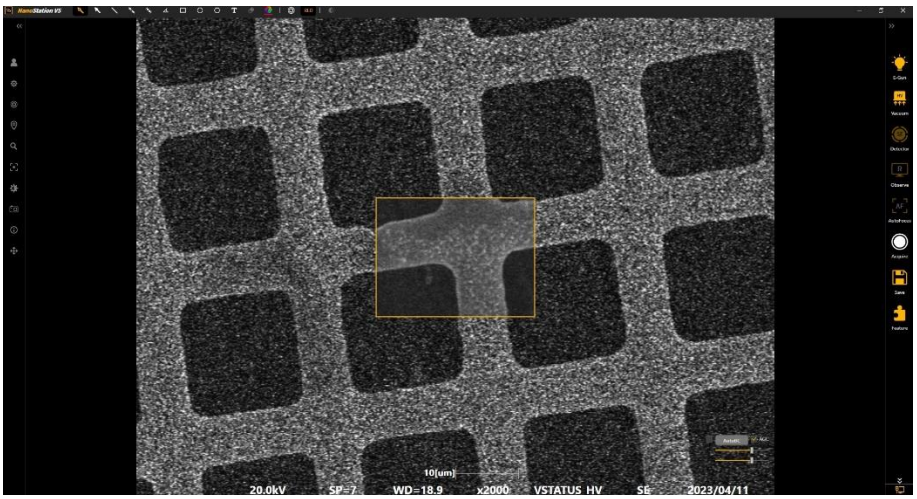
6.1 Observation Mode Setting

After finding the position of a sample, you have to set an accurate focus to acquire an image.

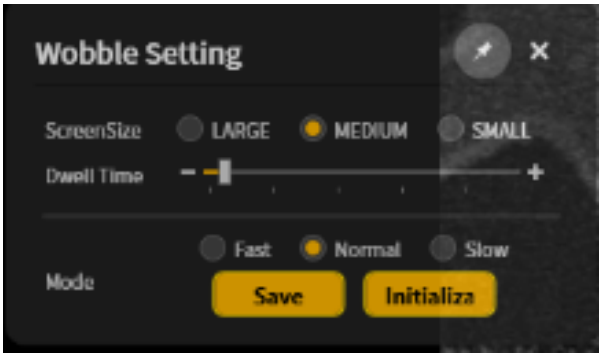
6.1.1 RED Mode

RED Mode 

If RED Mode is set, a small window appears on the image window as shown on the screen below. You can quickly control the image while viewing this window.
To move the RED screen window, drag the screen to the desired position.

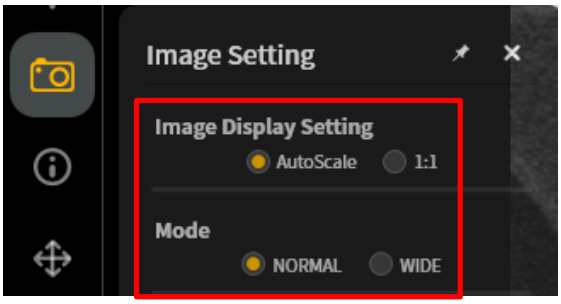


Click the Setting button () beside the screen. You can adjust Screen Size and Dwell Time.



6.1.2 Image Display Setting & Mode

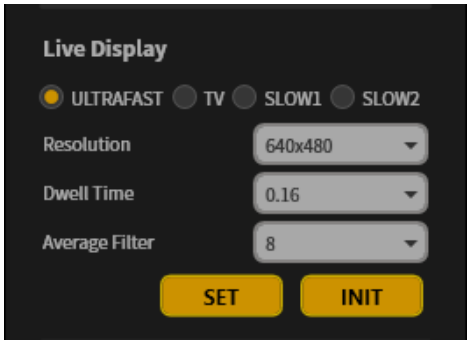
You can set the display ratio of the image you are currently observing.



In addition, you can observe a smooth image in connection to Dwell Time and Average Filter as shown below when using Live Display.

6.1.3 Live Display

You can adjust the Resolution and Scan Speed of the image you are currently observing.



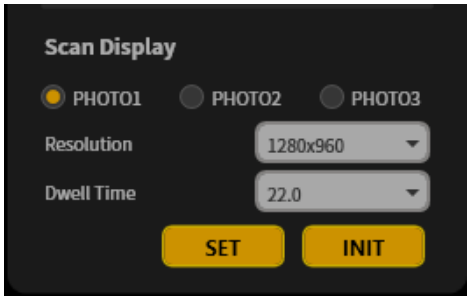
Scan mode	Resolution	Dwell time (us)	Filter
ULTRAFAST	640x480	0.16	8
TV	800x600	1.0	4
SLOW1	1024x768	4.0	1
SLOW2	1024x768	6.0	1

- Save: You can save the changed Resolution and Dwell Time in the currently selected scan mode.
- Initialization: You can restore the initial value of the currently selected scan mode.

In addition, you can observe a smooth image in connection to Dwell Time and Average Filter as shown below when using Live Display.

6.1.4 Scan Display

You can adjust the resolution and dwell time when saving an image of the currently observed video.



Scan mode	Resolution	Dwell time (us)
PHOTO1	1280x960	22.0
PHOTO2	2560x1920	10.0
PHOTO3	5120x3840	5.0

- Save: You can save the changed Resolution and Dwell Time in the currently selected scan mode.
- Initialization: You can restore the initial value of the currently selected scan mode.

6.2 Acceleration Voltage Setting

6.2.1 Acceleration Voltage Overview

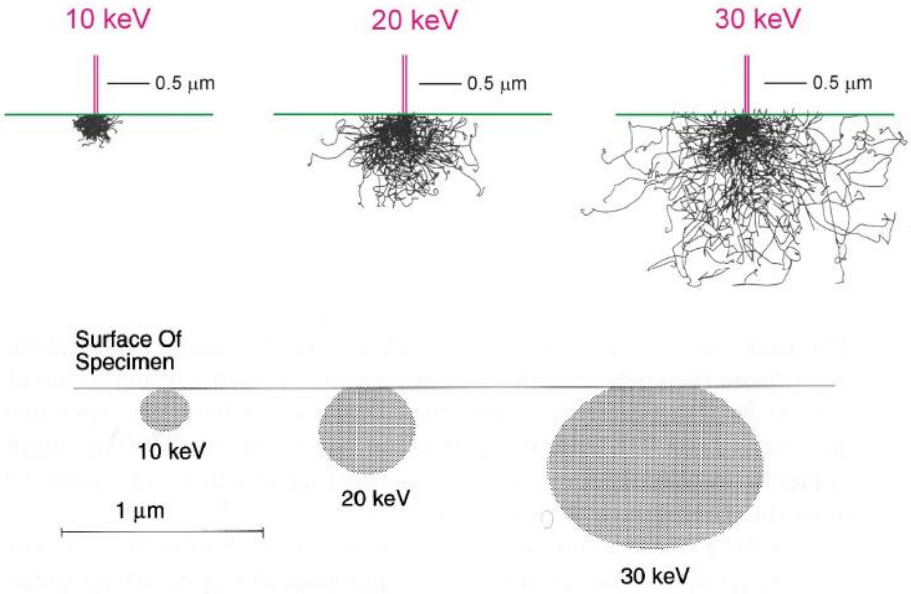
Accelerating voltage refers to the energy intensity of an electron beam. Select an appropriate value and use it according to the purpose of sample observation.

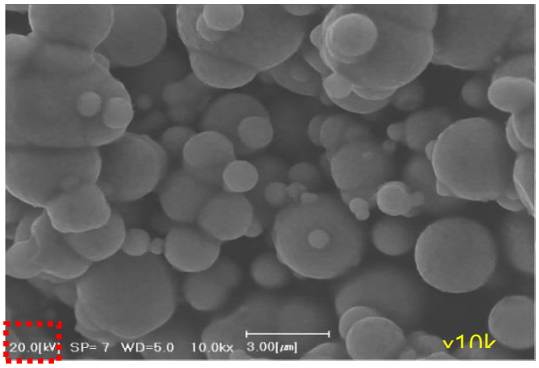
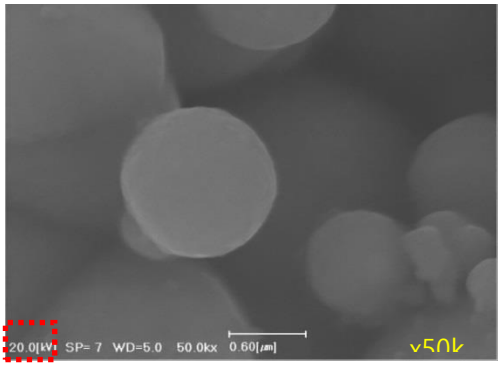
The advantages and disadvantages depending on the intensity of the accelerating voltage are as follows:

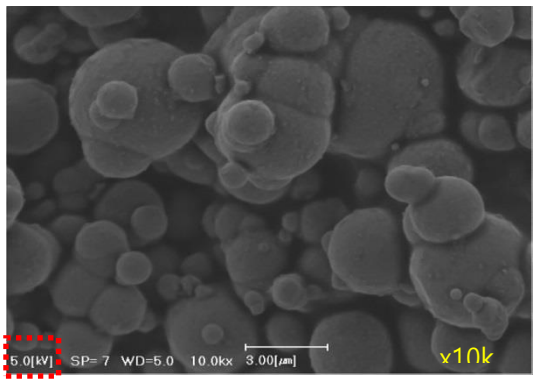
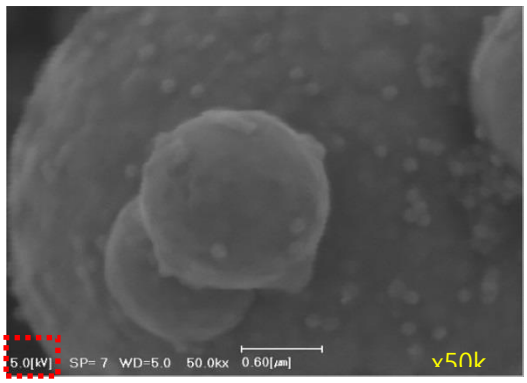
Accelerating voltage (Acc)	Advantages	Disadvantages
High ACC Voltage	• Increased resolution	• Unable to observe surface information • Edge Effect becomes intense • Charge Up becomes intense • Severe damage to the sample
Low ACC Voltage	• Able to observe surface information • Reduced Edge Effect • Reduced Charge Up • Less damage to the sample	• Decreased resolution • Reduced luminance • Degraded signal

Difference in Resolution According to ACC Voltage

As the ACC voltage increases, the resolution increases. It is easier to analyze the elements of a sample than its surface as the ACC voltage increases. A low ACC voltage value is suitable for observing the surface of a sample.

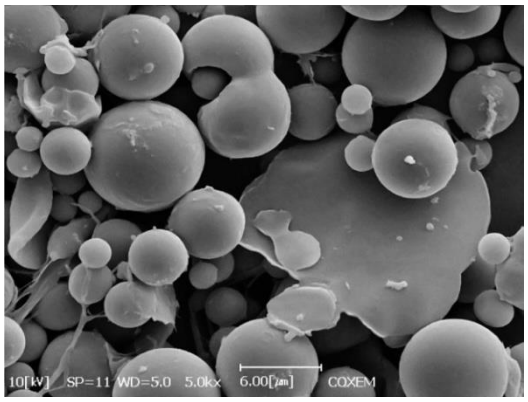
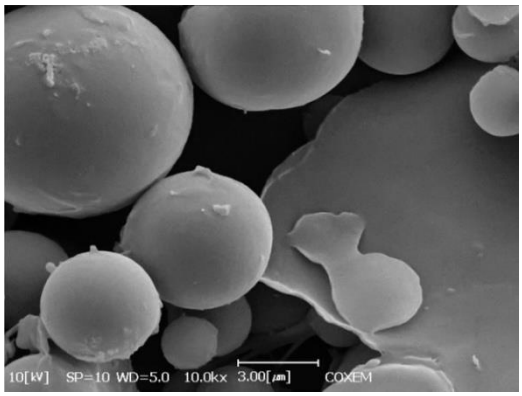


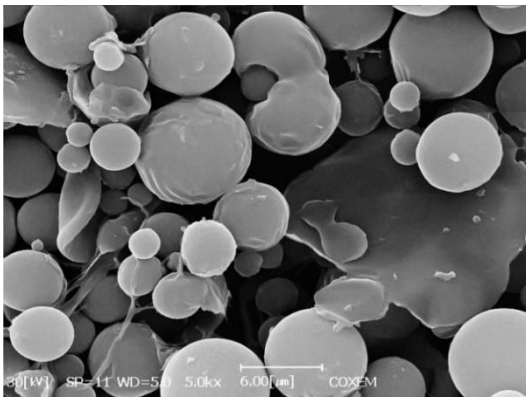
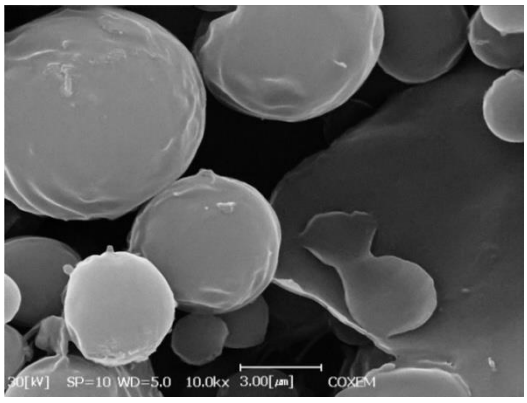
ACC Voltage: 20kV Magnification: 10K	ACC Voltage: 20kV Magnification: 50K
	

ACC Voltage: 5kV Magnification: 10K	ACC Voltage: 5kV Magnification: 50K
	

Occurrence of Thermal Damage According to ACC Voltage

As the ACC voltage becomes greater, the thermal energy of the electron beam increases. As a result, the sample image may be distorted due to thermal damage.

ACC Voltage: 10kV Magnification: 5K	ACC Voltage: 10kV Magnification: 10K
	

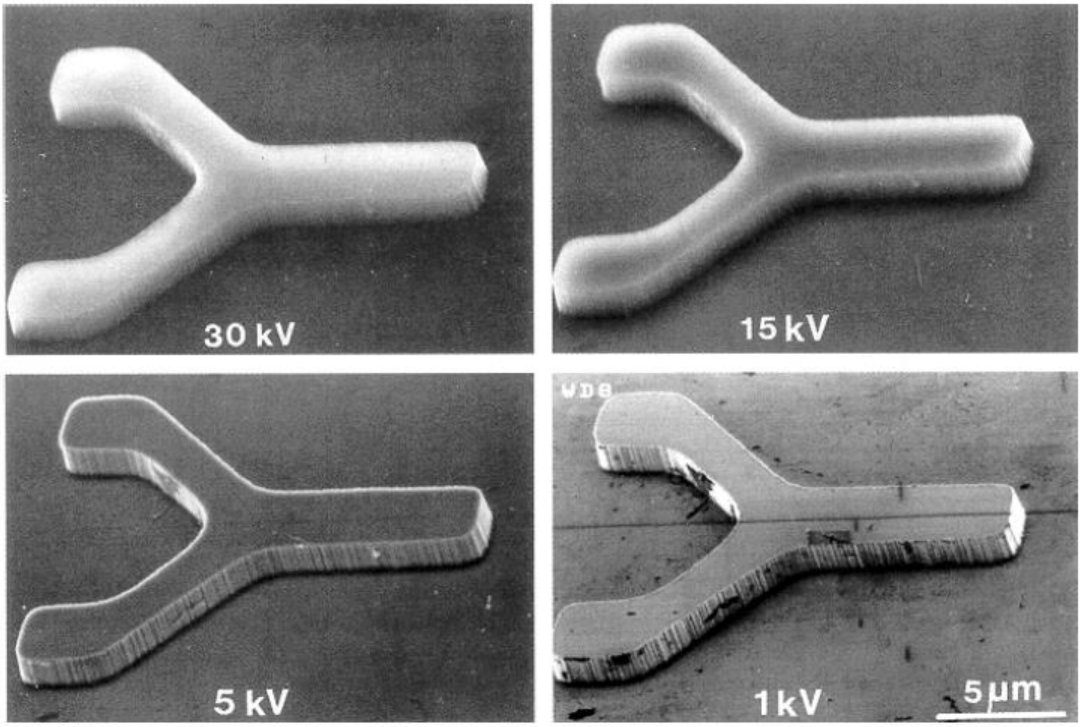
ACC Voltage: 30kV Magnification: 5K	ACC Voltage: 30kV Magnification: 10K
	

NOTE

To prevent damage to the sample, you must lower the ACC voltage value and reduce the E-Beam size and scan time of the electron beam. In addition, adjusting the coating thickness when pre-treating a sample can reduce image distortion by preventing damage to the sample.

Edge Effect According to ACC Voltage

The edge of the sample image looks blurry as the ACC voltage value increases but becomes sharper as the ACC voltage value decreases.

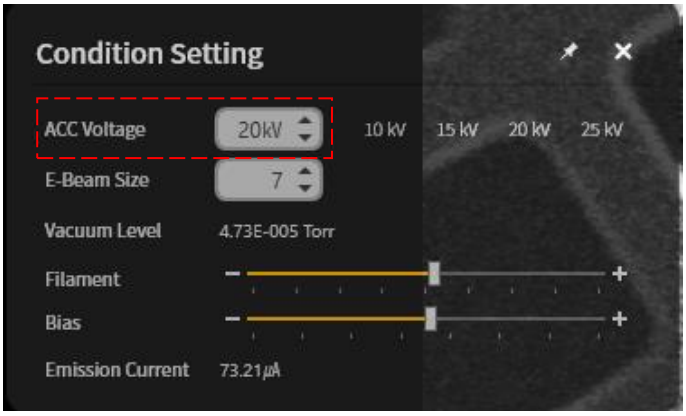


CAUTION	Since high ACC voltage causes greater electron consumption of the filament, it adversely affects the life of the filament compared to low ACC voltage. Therefore, you must use it only when necessary.

6.2.2 Acceleration Voltage Setting

Setting ACC voltage to low is suitable for observing the sample surface at low magnification, whereas a greater value is suitable for obtaining a high-resolution image. (Max. value: 30kV)

1) Select the desired ACC voltage value.
If you wish to select ACC voltage, use the up/down (▲/▼) button of the ACC voltage window or change it by selecting a fixed ACC voltage value.



2) After changing the ACC voltage, perform E-Gun Alignment and Aperture Wobble.

WARNING	When aligning E-Gun, be careful of electric shock.

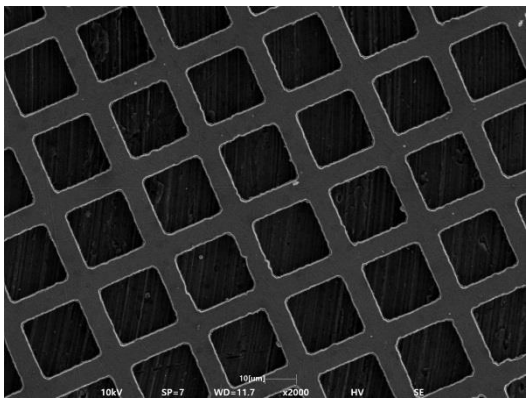
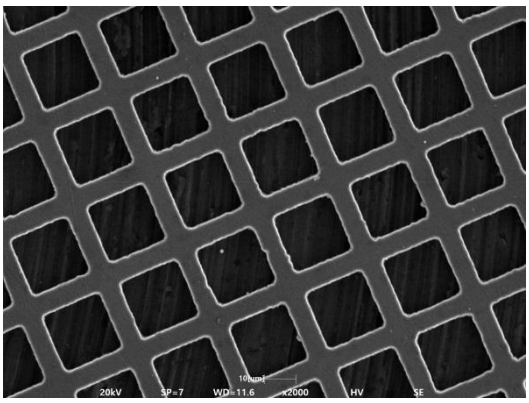
CAUTION	When ACC voltage exceeding 20kV was used, readjust the ACC voltage to below 20kV after measuring, and then turn E-Gun Off and close NanoStation. Closing immediately without adjusting the ACC voltage can have an adverse effect on the life of E-Gun.

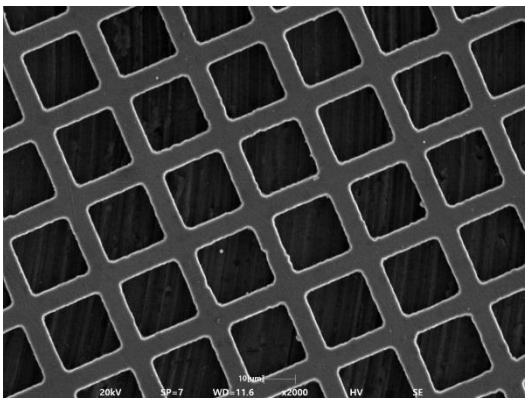
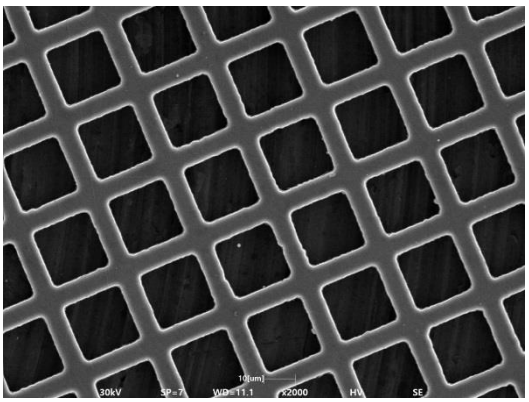
NOTE	When changing the ACC voltage value, perform E-Gun Alignment and Wobble again.

Change in Luminance According to ACC Voltage

As ACC voltage increases, the number of electrons reaching the sample increases, as a result of which the amount of generated signal increases and the luminance (brightness) becomes higher.

On the other hand, as the ACC voltage is reduced, the number of electrons reaching the sample decreases, as a result of which the amount of generated signal decreases and the luminance (brightness) becomes lower.

ACC Voltage 10kV	ACC Voltage 20kV
	

ACC Voltage 20kV	ACC Voltage 30kV
	

CAUTION

When a high ACC voltage is used for a long time, the electron acceleration of the filament becomes greater. Thus, be careful since it can cause filament breakage in a shorter time than its original lifespan.

6.3 Observation Magnification/Spot Size Setting

Select the desired magnification after selecting an ACC voltage suitable for the purpose. Set the E-Beam size suitable for the selected magnification and save the image.

Recommended value of Spot size by observation magnification

The appropriate E-Beam size value according to magnification is as follows:

Magnification	Spot size
50~100K	1
30~50K	2~4
10~30K	4~6
3~10K	6~8
3K or below	8~12

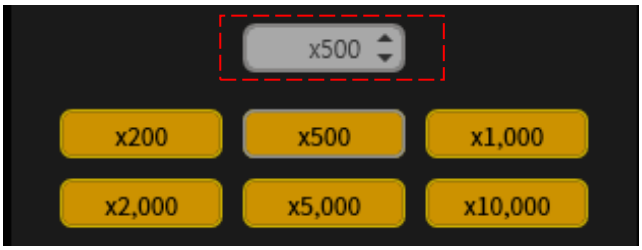
If the E-Beam size value increases, the image becomes brighter, and the signal value increases. Thus, the contrast value must be lowered.
If the E-Beam size value decreases, the image becomes darker, and the signal value decreases. Thus, set the contrast value to be relatively higher.

6.3.1 How to Select Magnification

In selecting the observation magnification, you can enter it in two ways.

1. Free Magnification

Place the mouse cursor on the Magnification window and select a magnification by scrolling the mouse wheel.

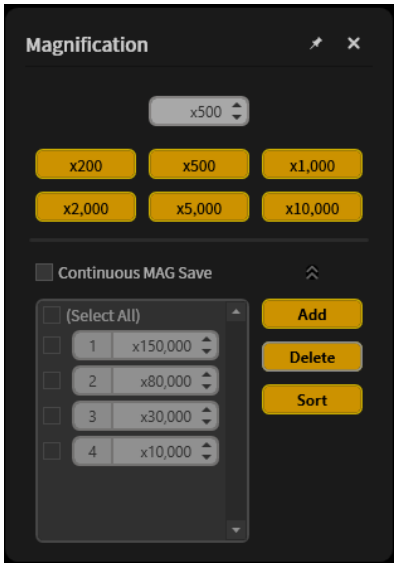


2. Fixed Magnification

You can select a set magnification (x200, x500, x1000, x2000, x5000, x10000) on the Magnification window.

3. Changing the Fixed Magnification

If you enter the desired magnification in continuous MAG shooting and then click the Save button, you can change the set magnification.



6.3.2 Spot Size Setting

Select the desired magnification, and then set a E-Beam size suitable for the magnification and save the image.

The characteristics according to changes in E-Beam size are as follows:

Spot size	Advantages	Disadvantages
When Spot size is small	• Resolution is good. (Set when observing at high magnification)	• Lowers luminance (brightness).
When Spot size is large	• Raises luminance (brightness) (Set when observing at low magnification)	• Resolution becomes worse.

NOTE

Spot size has a significant effect on the resolution. You can obtain a clear, accurate image only when the E-Beam size is set to suit the magnification. (Setting value: 1~12)
Since E-Gun can be misaligned if the Spot size value is changed, check the E-Gun Alignment after changing the E-Beam size. (Refer to 8.2 How to Align E-Gun)

Difference in resolution according to E-Beam size

Spot size is highly correlated with resolution, and its characteristics are as follows:

- With smaller Spot size, the resolution increases, which is suitable for observation of images at high magnification.
- With larger Spot size, image quality improves, which is suitable for observation of images at low magnification.
  With larger E-Beam size, the number of secondary electrons increases. This is favorable for improving image quality.
  Thus, it is used when observing images at low magnification, which does not require high resolution.

6.4 Focus Adjustment

A clear image can be obtained only when the focus is accurately set after setting the magnification to observe a sample.

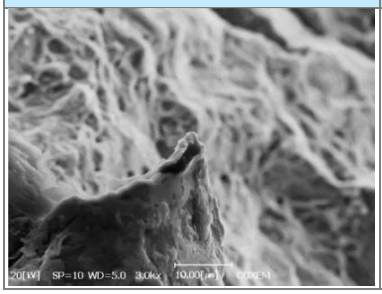
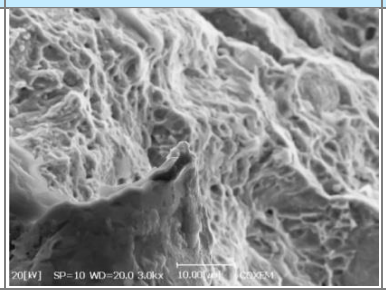
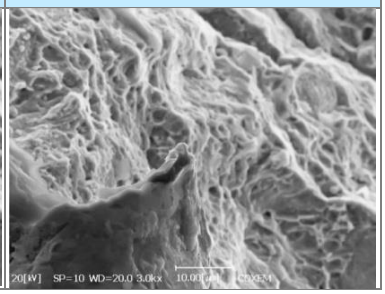
Aperture size

If the aperture becomes larger, image depth is reduced as more electrons flow in; if the aperture becomes smaller, image depth increases as the image becomes sharper.

WD (Working Distance)

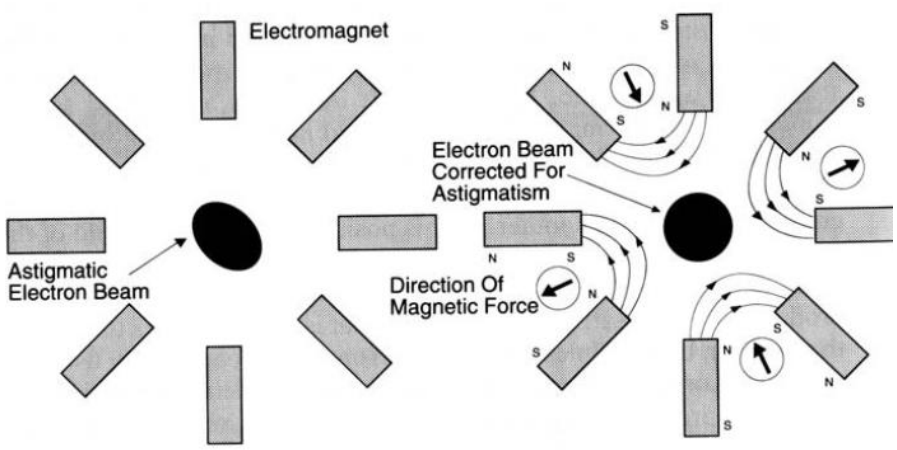
If the WD value increases, image depth increases and resolution degrades; if the WD value decreases, the image becomes clearer and image depth decreases.

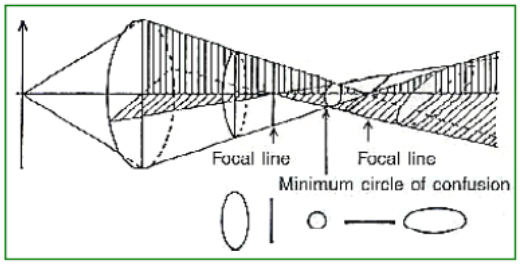
Ex.) Difference in depth according to WD when the aperture size is 30um

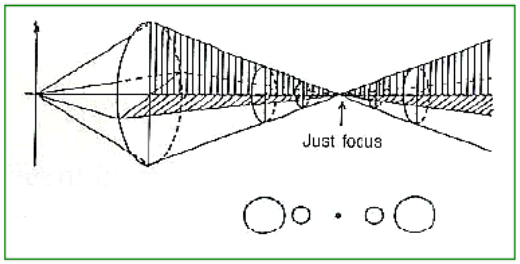
WD: 5mm	WD: 20mm	WD 30mm
		

Astig adjustment

When setting the focus, you can obtain a clearer image as you create a circular form of electron beam. When you focus by adjusting Stig, the clearest position is found as you adjust the X-axis and Y-axis.







6.4.1 Focus Setting

Click Menu -  (Focus Control) button.

- 

  : You can quickly find the closest focus in a wide area by coarsely adjusting the focus with a click of a button or mouse.

- 

  : It can fine-tune the focus on the image more precisely and find the optimal focus with a click of a button or mouse.

- 

: You can automatically find the closest focus by pressing this button.
If the focus is off by a large margin, focus may not be made properly.
(It generally takes about 3 seconds. If you wish to stop Auto Focus, click the button again to stop.)

NOTE

When using the Auto Focus function
When using the Auto Focus function, focus may not be made depending on the circumstances.
(When the sample does not have a clear boundary or when there is a great difference between the current focus value and the actual WD value.)
If focus is not made, try again by moving the position of the sample.

When setting the focus to obtain a clear image, calibrate the focus by adjusting the proximity focus, detailed focus and Astig.

NOTE

When setting the focus, it is easier to focus on the area with clear contrast such as the border of the sample.
If you make an accurate focus at high magnification, you need not make an accurate focus again when observing an image.
However, the sample may be damaged when observed at high magnification for a long time.

■ Manual Focus Setting

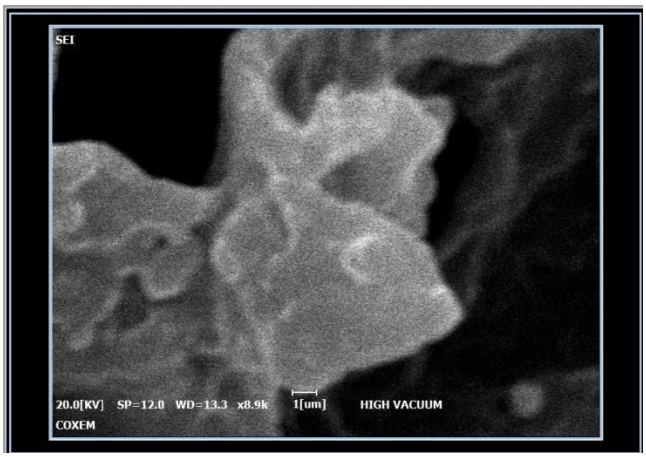
1) Move to the position you wish to observe on a mounted sample.

- When finding the position of a sample, set it to minimum magnification.

NOTE For details on moving the sample position, refer to [4.3 Sample Position Movement].

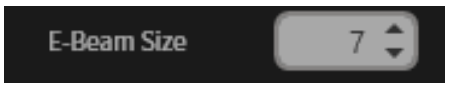
2) Find the accurate position for observation by zooming into the sample and then set it to a higher magnification than the desired magnification.

(Ex.: If you need to acquire a x5000 image, set the magnification to over x5000.)



3) Set the Spot size to suit the set magnification.

(Ex.: When you need to acquire x5000 image, set the E-Beam size to 6~8.)



4) Select Menu -  (Focus Control) icon followed by Coarse Focus and calibrate the focus by using the mouse-wheel.

- The WD value can be identified from the WD value at the bottom of the electron microscope image screen.

5) Select Fine Focus and calibrate the focus using the mouse-wheel.

6) Calibrate the focus by dragging Stig X and Y.

7) Find the optimal image by adjusting Fine Focus.

8) When recalibrating focus, readjust in order of [Astig -Fine Focus- Stig -Fine Focus].

9) Set the magnification at which you wish to acquire an image.

CAUTION

Observing for a long time in one position may cause thermal damage to the image.

NOTE

When setting the focus, it is ideal to start from high magnification and lower to the desired magnification.

If you have moved the stage position after completing focus setting, set the focus from the beginning once again.

Since focus is not made due to a different sample position as the stage moved, you have to set the focus again.

■ Automatic Focus Setting

If you wish to focus automatically, press the [] button of the Operation bar.

- Auto Focus can automatically find the image at the level of coarse focus at magnification below x5k.

  It is not as accurate as manual focus adjustment.

  It is better to focus manually to make a more accurate focus.

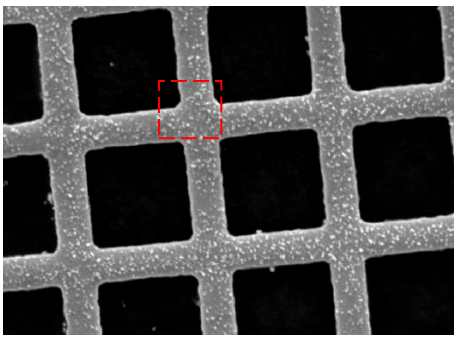
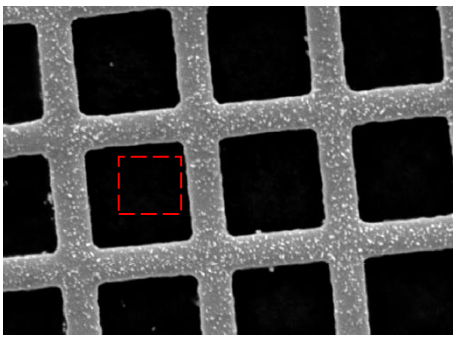
NOTE

When using Auto Focus in the following situations, focus may not be set properly:

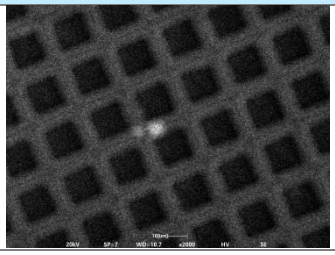
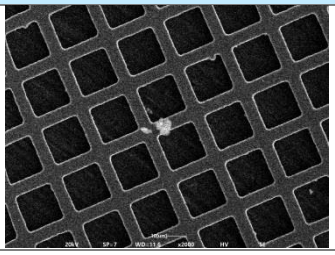
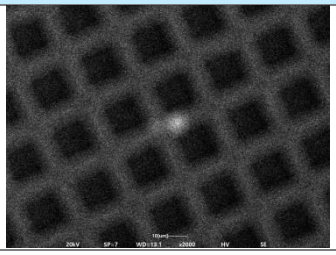
• When there is a big difference between the current focus value and the actual focus value of the sample

(ex. If the actual working distance is 7mm when the current focus is 30mm)

• If the image does not exist within the Focus mode screen between Auto Focus function implementation (at high magnification) or if there is a smooth surface without a significant difference in contrast

	
Correct Auto Focus area	Incorrect Auto Focus area

Example of Focus Setting Status

Before focus	Focus	After focus
		

b

NOTE

In case an image is not clear due to inaccurate focus even if the aperture is adjusted, you must perform Wobble.

For details on Wobble work, refer to 6. Aperture Adjustment.

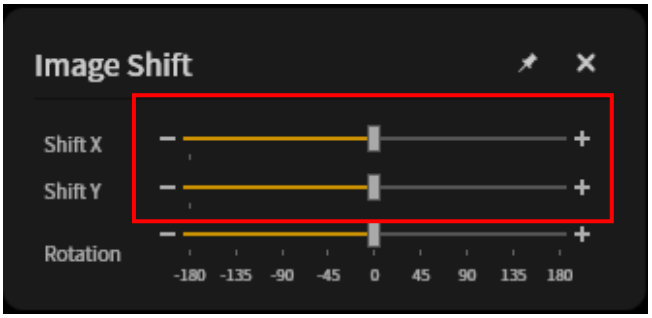
6.5 Fine Movement of Image

When you wish to adjust the image position after setting the focus at high magnification, you can use the fine movement function. The Fine Movement function moves the image by moving the direction of the electron beam.

6.5.1 Using Image Shift

When moving an image precisely after setting the focus zoomed in at high magnification, use the Image shift function in the left tab. In the case of Image shift, it observes a sample by moving the direction of the electron beam instead of the stage.

1) Move an image by adjusting the X/Y-Shift bar or entering a value while looking at the screen.



6.5.2 Using Beam Rotation

When rotating an image precisely after focusing at high magnification, use the Beam Rotation function in the left tab.

When observing a sample, you can rotate and view the image of an area you wish to view by rotating the electron beam.

- Rotate to the desired direction by adjusting the Rotation bar while looking at the screen.

If the electron beam has rotated a lot when using Rotation,
it may move in the opposite direction of that desired by the user.
Once measurement is complete, you must use Rotation by adjusting to its original point.

6.6 Contrast & Brightness Adjustment

If you have obtained the desired image after focus setting, prepare to obtain an image by adjusting contrast and brightness.

6.6.1 Contrast & Brightness Control

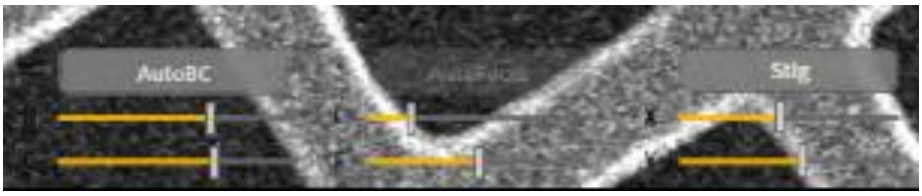
You can obtain a clear image by adjusting the contrast and brightness values.

1) Contrast: It adjusts the contrast of an image.

2) Brightness: It adjusts the brightness of an image.

3) Auto BC: Auto-adjust Brightness, Contrast

4) You can adjust contrast and brightness by clicking the Auto BC button at the bottom of the right side of the image.



5) If you place the mouse cursor on the AutoBC bar and adjust the mouse-wheel, contrast and brightness are adjusted.

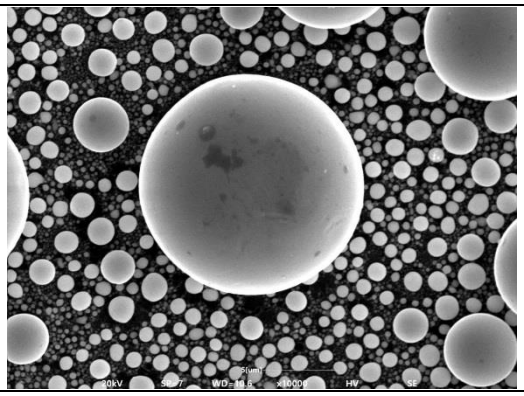
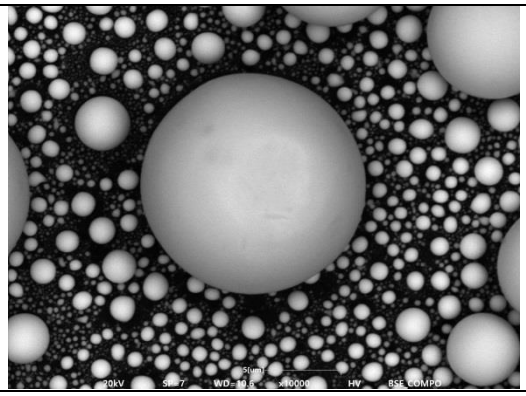
NOTE

The Auto Contrast function may display black or white screen due to a change of setting values or effects such as White Spot and Charging Effect.
Thus, if Auto Contrast does not work properly, you can create a normal image state by repeatedly clicking it 2~3 times.

6.7 BSE Mode

BSE Mode refers to an image detecting BSE (Back Scattered Electrons) occurring due to an incident electron beam on a sample by using the BSE sensor.

If the components of a material differ due to an expression of different luminance depending on the elemental composition of a material, BSE Signal can detect an image by showing a stark difference in contrast to SE image.

	
SE Image	BSE Image

6.7.1 Precautions When Using the BSE Sensor

■ Take care not to contaminate and damage the surface of the BSE sensor.

- Contamination and damage to sensors and cables can have an adverse effect on signal detection. Damaged sensors and cables due to negligence in use are subject to paid services. Thus, you must take caution in use.

■ Take note of the Sample Height

- The total sample height including the multi-sample stand is 22.5mm. When the sample height exceeds this, BSE may be damaged when moving the Z-axis. Thus, caution is needed when operating it. (Limited to a person who has completed training)

6.7.2 How to Use BSE Mode

■ Preparation before and after selecting BSE Mode

1) Since the amount of BSE signals changes rapidly depending on WD,
adjust the sample stand height to set the optimal WD. (Recommended WD: 7~10mm)

2) Since the Spot Size may vary greatly with SE Mode when using BSE Mode,
adjust Wobble and Gun Alignment so that the optimal electron beam can be lowered.
(Refer to 6.2.1 Wobble Work 1 and 8.2 How to Align E-Gun)

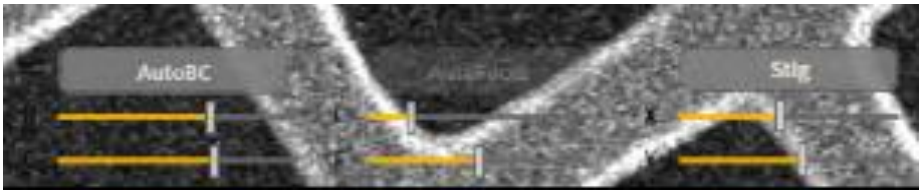
■ How to select SE and BSE modes

- You can observe the SE image if SE Mode is indicated and the BSE image if BSE Mode is indicated. (You can observe only when BSE Detector is turned On.)

■ BSE Image Optimization

1) Select an appropriate Spot Size in Menu – Electron Microscope Setting mode.

2) Optimize the image by adjusting the Brightness and Contrast values of AutoBC on the bottom right.



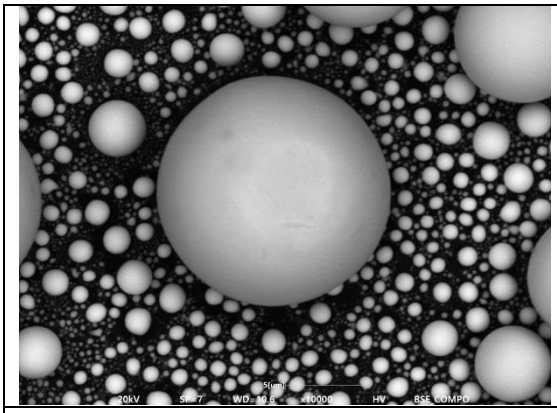
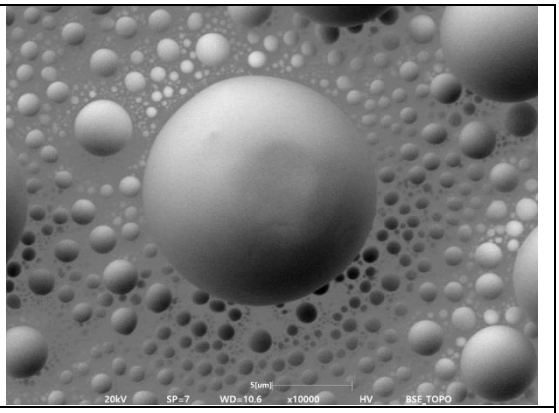
NOTE You can automatically adjust the image quality by clicking Auto BC.

■ BSE Compo & Topo

- The BSE sensor provides COMPO Mode and TOPO Mode.

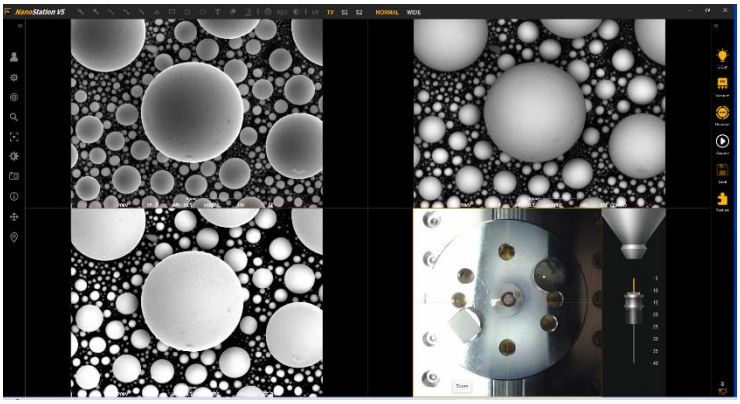
Compo Mode is a method of detection by applying +voltage to all 4 channels of the BSE sensor, which enables a user to observe the composition ratio of a sample easily.

Topo Mode is an observation mode wherein it is easy to observe the surface morphology of a sample by applying 2 channels of +voltage and 2 channels of -voltage.

	
Compo	Topo

■ SE/BSE Mode

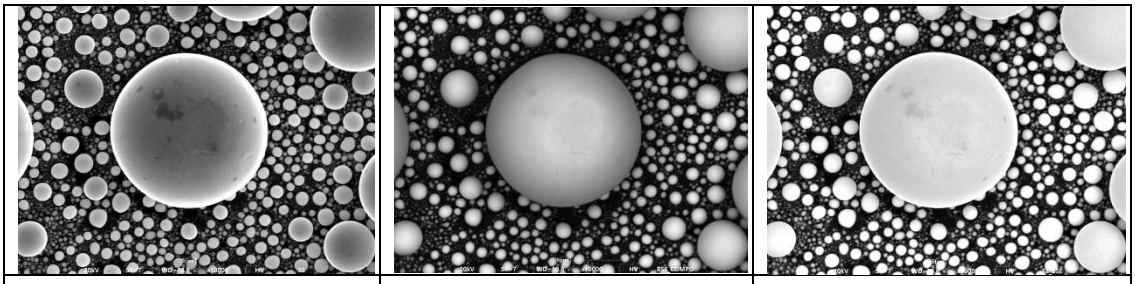
- This is a mode used when observing in both SE and BSE modes, which display an image by dividing the electron microscope image screen into two: SE and BSE. You can observe the characteristics of secondary electrons and Backscattered Electrons of the sample currently being observed.



■ SE+BSE Mode

SE + BSE

- It combines the SE and BSE signals and displays them as one image.



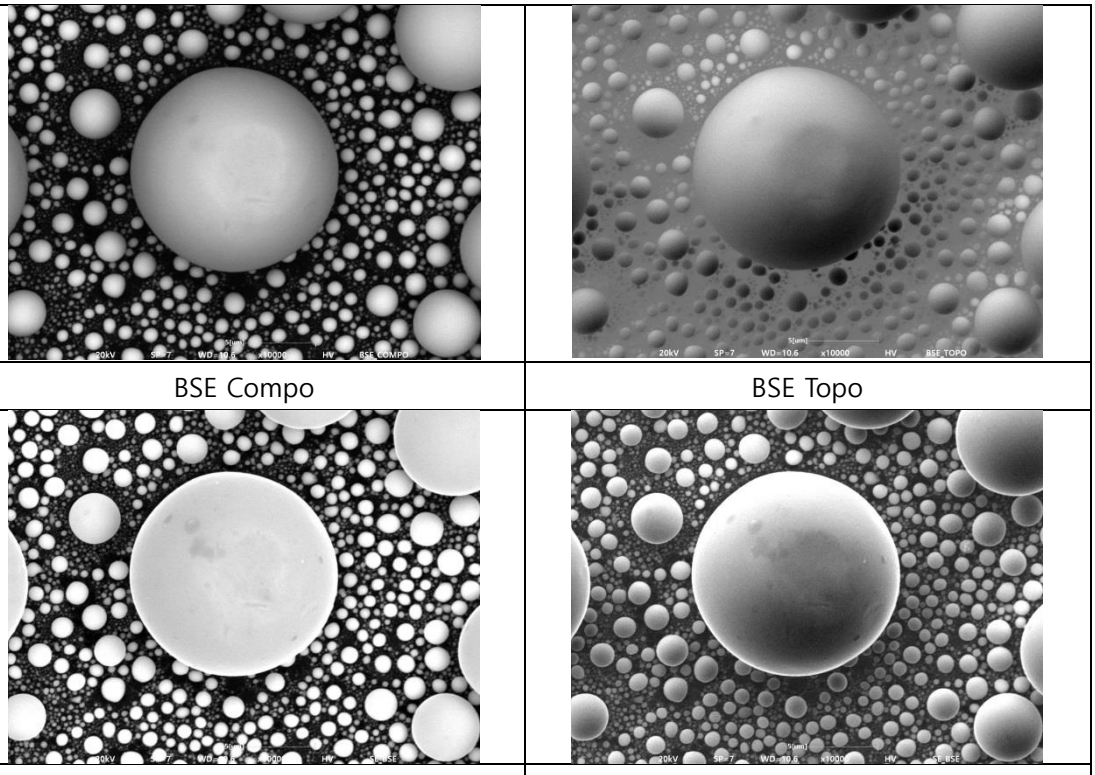
SE Mode	BSE Mode	SE+BSE Mode

- Diamond Ring compare on each Observation Mode -

NOTE

* When you wish to view SE/BSE, SE+BSE Mode
1) Set to appropriate image in SE Mode.
2) Set to appropriate image with the same Spot Size as when setting SE after selecting BSE Mode.
3) Select the desired Display Mode (SLOW or PHOTO), and then click SE/BSE or SE+BSE Mode.

Reference picture. 4 types of Image videos applied with BSE synthesis



BSE Compo	BSE Topo
SE+BSE Compo	SE+BSE Topo

6.8 LV Mode (Low Vacuum Mode) - Optional

EM-40 supports Low Vacuum Mode.

LV Mode converts the vacuum level of the chamber where a sample is loaded into a low vacuum level, and it is capable of eliminating unsafe elements due to the nature of the detector. It significantly reduces the charging effect phenomenon that occurs when observing the sample of a semiconductor in SE Mode, so it is able to create an image with no charging effect even without pre-treating the semiconductor sample and is capable of improving the quality of a BSE image.

NOTE

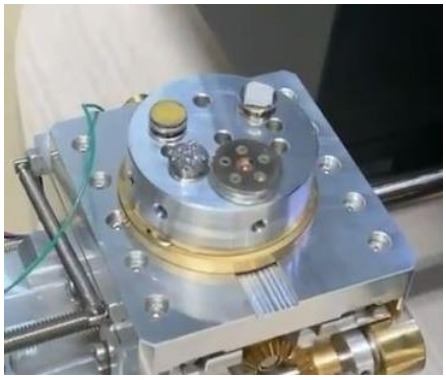
Low Vacuum of EM-30N has a chamber vacuum level of 20±5Pa, and High Vacuum has a chamber vacuum level of 10-4 Torr.

The LV Mode does not support the separated image of SE/BSE and synthesized image of SE+BSE.

■ How to Use LV Mode

1) Click the Vacuum button followed by the Vent button.

2) Mount the prepared sample on the Stage Holder.



3) Click the Vacuum button followed by the LV button.

NOTE

In LV Mode, it takes approximately 3 minutes until E-Gun is turned on after pumping.
When E-Gun is turned on within the relevant time even though a separate time is not displayed,
the remaining time is displayed and E-Gun does not turn on.

4) Observe the image by clicking the E-Gun Off button.

5) Finish image observation by clicking the E-Gun ON button.

6) Click the Vacuum button followed by the Vent button.

NOTE

The method for changing again to HV Mode is the same as how to use LV.
(Change to High Vacuum by pressing Vacuum Toggle after Gun off)
Since the amount of electron beam increases as the Spot Size is larger in Low Vacuum Mode, a great charging phenomenon may occur.
Therefore, use it in an appropriate Spot Size or smaller.
* The normal LV Mode does not work when closing NanoStation while using LV Mode or restarting after turning off equipment power.
If you wish to use LV again, proceed with the process of using LV mode again from the beginning.

6.9 Panorama Shot

Panorama Shot is a function of automatically shooting multiple images according to the information entered by the user.

6.9.1 Precautions When Using the Panorama Shot

■ Although the function can be implemented at low magnification (x200 or lower), it may produce a distorted image.

(x200 or higher is recommended.)

■ It is possible only if there is no Tilt. (T=0°)

- If there is a Tilt, an error occurs, and it can cause distortion after Stitching.

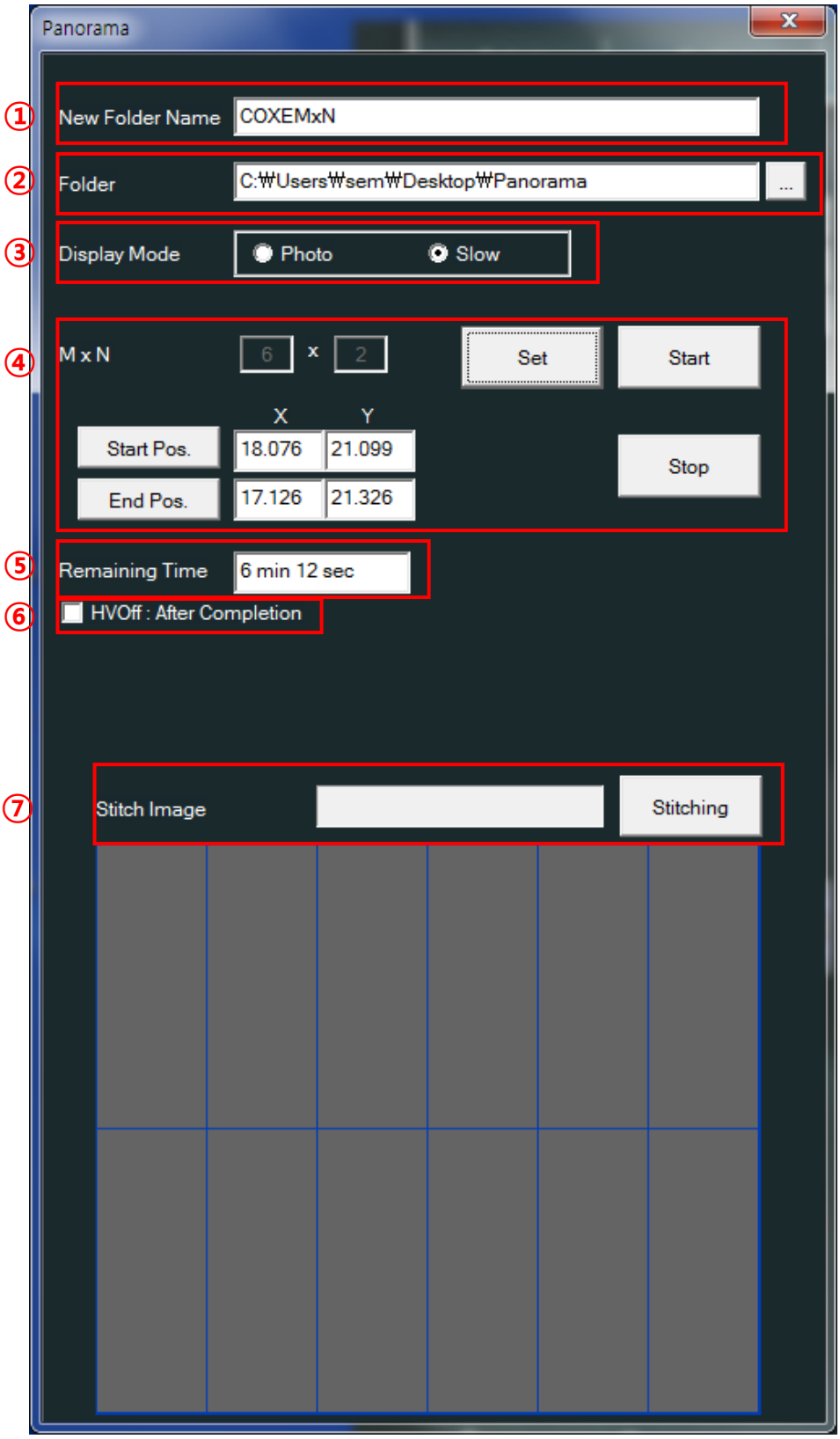
■ Other factors that may make the Panorama shot unsuitable

Sample with significant variation in height	Distortion may occur due to a difference in the focus area of the sample.
Unsuitable coupling of the holder	Take caution to prevent tilt when coupling the stub and holder.
Sample with flat surface	The stitching function is designed to connect images according to the distinct features of each edge of an image. If there are no bumps due to a flat surface, it misrecognizes the position of Stitching connection. (Glass Sample)

Some functions such as Image Info and Image Shift are automatically turned off during the Panorama Shot.
(They can be used again after the Panorama Shot is completed.)

6.9.2 Panorama Shot Configuration

Clicking Option - Panorama on top of NanoStation opens the following window:



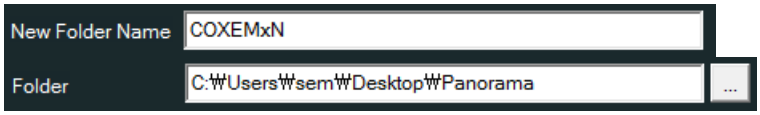
Composition	Details
① New Folder Name	Creates a folder name to be created newly in ② Folder.
② Folder	Sets a folder for saving Panorama shot images.
③ Display Mode	Selects Display Mode. (Photo or Slow)
④ MxN	Start Pos.: Sets the starting coordinate of the Panorama area.
	End Pos.: Sets the ending coordinate of the Panorama area.
	Set: Completes setting. (The number of shots is automatically set in proportion to the area.)
	Start: Starts the Panorama function.
	Stop: Stops the Panorama function.
⑤ Remaining Time	Remaining shooting time (Automatically estimated when the Set button is clicked.)
⑥ HV Off	When checked, it automatically turns off the Beam after shooting is completed.
⑦ Stitch Image	It gathers Panorama images and combines them into one image.

6.9.3 How to Use the Panorama Shot

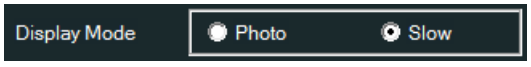
1) Turn on the product.

2) Turn on the electron beam and find the position of the sample to be shot.

3) Designate the location of the folder where Panorama shot images will be saved.



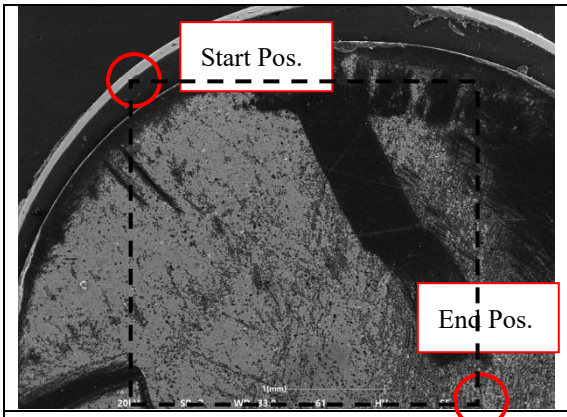
4) Select Display Mode.



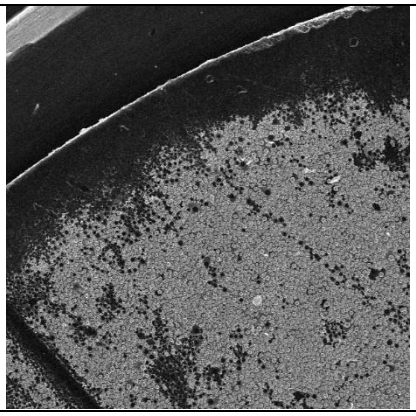
5) Set the coordinate area to be shot with the Panorama function.

Composition	Details
Start Pos.	Selects the starting coordinate.
End Pos.	Selects the ending coordinate.

Ex.) Example of How to set Start Pos. and End Pos. and Panorama image area.



Start Pos. End Pos Setting



Panorama Image

* If Start Pos. and End Pos. are selected, it sets a square area where a Panorama shot will be taken.

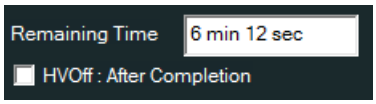
6) Set the Magnification and click the 

button.

- Clicking the Set button automatically sets the number of images to be taken according to the set magnification.

Since the number of images to be taken increases in proportion to the magnification, select an appropriate magnification.

7) Check the Remaining Time.



If the shooting time is too long, you can change the shooting time by changing the settings such as Display Mode, etc.

* If you wish to turn off the Beam automatically after shooting, check the HV Off function.

8) Click the 

button and start taking a Panorama shot.

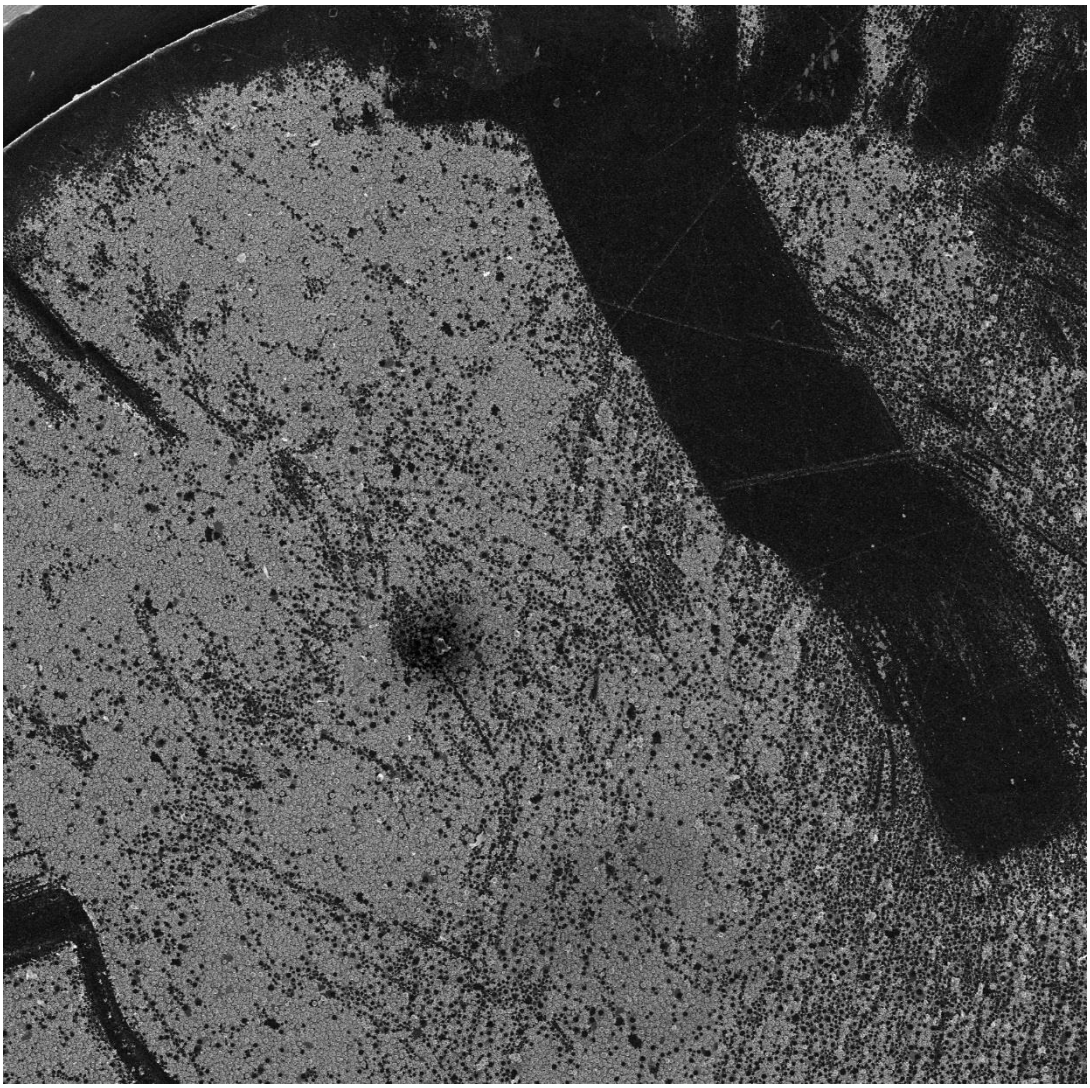
- If you wish to stop shooting, click the 

button.

9) The shooting ends.

10) Click the Stitching button and select the Panorama shot image path.
- It automatically Stitches.

11) Check the image.



* The Stitched image is created as a result file in the save path folder.

12) Turn off the electron beam.

13) Turn off the product.

6.10 STEM- Optional

EM-40 provides the STEM (Optional) function.

Refer to the STEM manual provided separately when you purchased STEM.

7 Aperture Adjustment (Wobble) Work

7.1 Aperture Structure

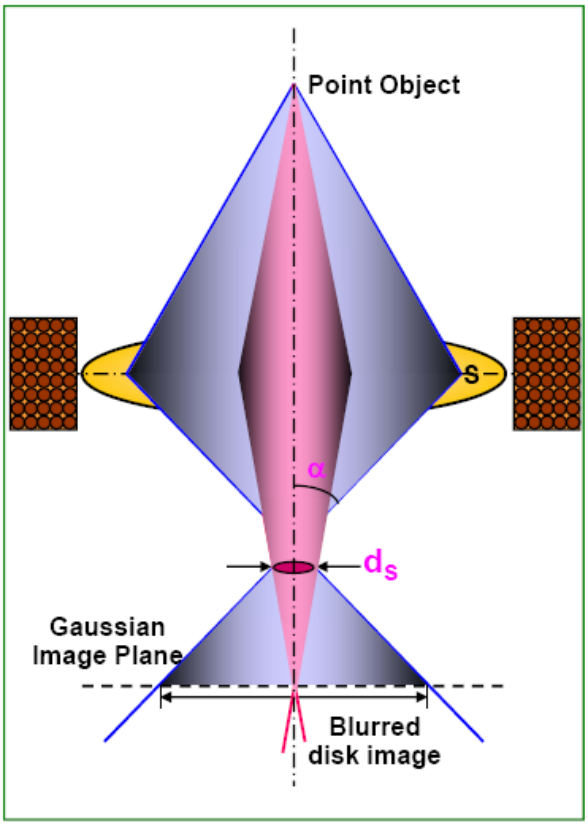
Variable Aperture is built into the EM-40.

Variable Aperture reduces spherical aberration and improves resolution by ensuring that the electron beam passes through the center of the aperture. In addition, Variable Aperture consists of 4 stages; thus allowing you to adjust the current of the electron beam by changing the size of the Aperture.

What is Spherical Aberration?

The farther from the optical axis, the more powerfully the electrons bend due to the magnetic field; thus, focus is made at a shorter distance.

Since spherical aberration cannot be completely removed, it can be minimized by using a lens with good focusing force or reducing the convergent angle of the beam.



In case an electron beam does not pass through the center of the aperture, it is already out of focus or the screen darkens. And if the electron beam faces the aperture, the image is not visible on the screen at all. In this case, Wobble work must be performed.

7.2 Wobble (Aperture Alignment Procedure)

* In case Wobble is necessary
1) In case focus is not accurately made even with adjustment
2) In case the E-Beam size is changed
3) In case ACC voltage is changed
4) In case the filament is replaced
5) In case E-Gun is newly aligned

After selecting Wobble
If the position of the sample does not move up/down/left/right and only the focus changes when changing the focus value, Wobble (Aperture Alignment) is normal.

If the position of the sample changes significantly on the screen, Aperture Alignment is needed.
(Wobble Work 1)

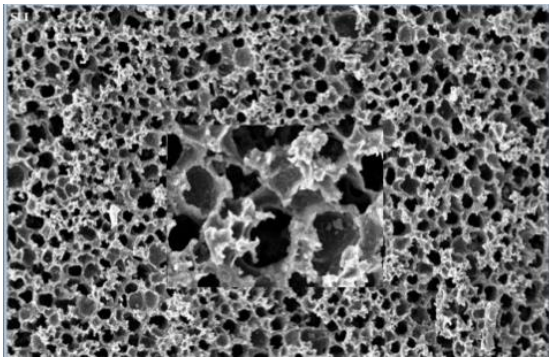
There are times when the screen is not visible at all. In this case, the aperture has completely deviated from the path of the electron beam.
(Wobble Work 2)

7.2.1 Wobble Work 1

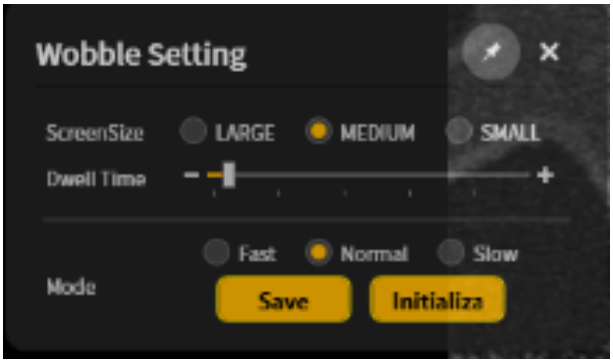
This is a case wherein the aperture deviated slightly from the center of the path of the electron beam, or the image is visible but focus is not properly made even when controlled.

1) Set to low magnification of approximately x500.

2) Click the Wobble button ( ) on top of the screen.

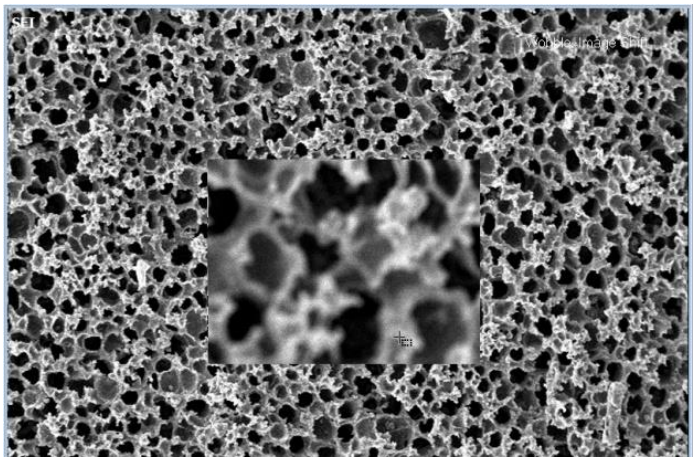


3) Click the Wobble Setting button ( ) to adjust the reduction ratio and dwell time value.



4) Check the direction in which the image shakes on the screen.

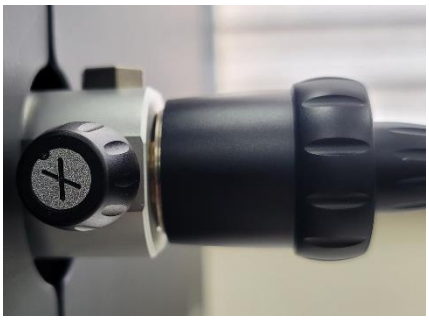
- X-axis: Left-right direction
- Y-axis: Up-down direction



- Turn the X-axis/Y-axis of the aperture adjustment handle on the side of the equipment according to the direction in which the image shakes and adjust so that there is no movement.
- If the movement is not reduced but grows greater instead during calibration while turning the X-axis and Y-axis handle, turn the handle in the opposite direction and adjust so that the movement is reduced.

When performing Wobble work, adjust first the direction of one axis followed by the direction of the other axis.

NOTE

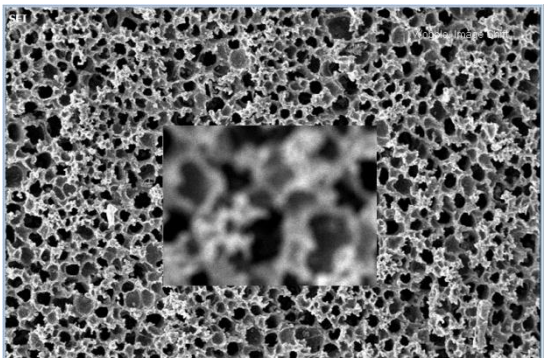


(X-axis adjustment knob)

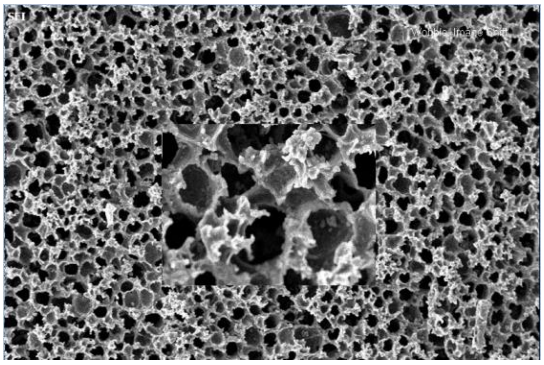
(Y-axis adjustment knob)

---

5) If you adjust the image so that it does not move to the maximum extent, focus is repeatedly made, and then it becomes out of focus in the current position.

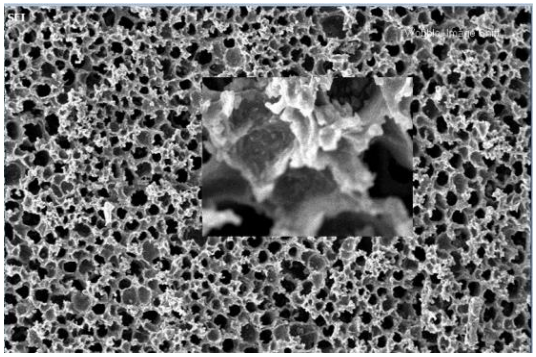


(Out of focus) (Focused)



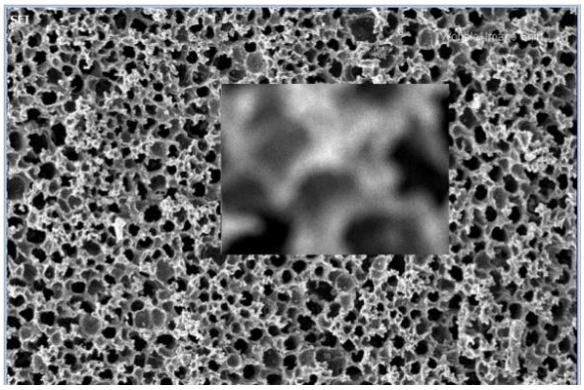
(Out of focus) (Focused)

6) Set magnification to x1000 to check whether it is focused more minutely.

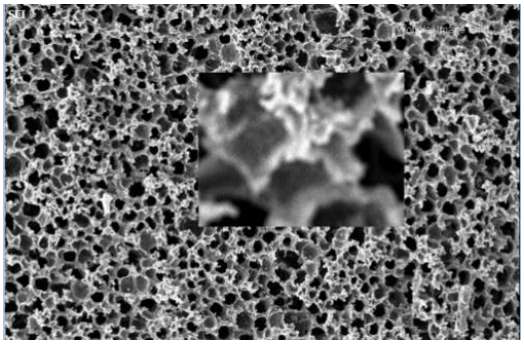


7) If the image shakes in a specific direction, adjust so that it does not move while turning the X-axis/Y-axis handle.

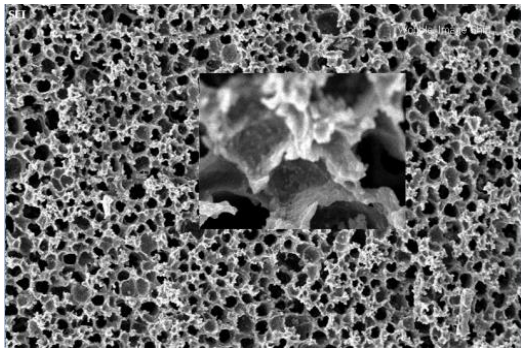
- X-axis: Left-right direction
- Y-axis: Up-down direction



8) If you adjust the image so that it does not move to the maximum extent, focus is repeatedly made, and then it becomes out of focus in the current position.

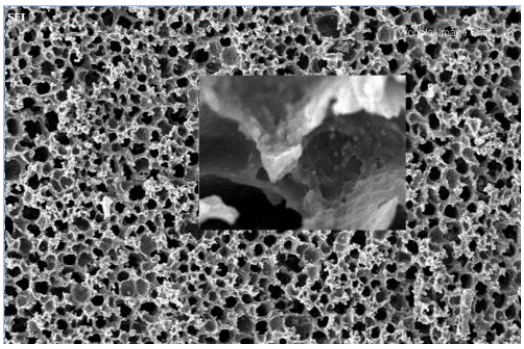


(Out of focus)



(Out of focus)

9) Set magnification to x2000 to check whether it is focused more minutely.



10) If there is movement of the image, adjust so that it does not move while turning the X-axis/Y-axis handle.

11) If Wobble work is completed, press the Wobble ( ) button to finish.

12) Proceed with the observation of the sample.

7.2.2 Wobble Work 2

: In case the image is not visible due to the aperture completely deviating from the path of the electron beam

If the image is not visible at all when observing an image, you must proceed with alignment according to the following procedure:

WARNING	When aligning the filament, it must be done while taking caution to prevent electric shock.

CAUTION	**Proceed with the work below under the premise that the filament is aligned.** If filament alignment is not done properly, the image quality may be degraded or the screen may not be visible. Before proceeding with aperture adjustment, check whether the filament is properly aligned, and then proceed. (For the filament alignment procedure, refer to 3.4.2 Filament Replacement Procedure in the maintenance manual.)

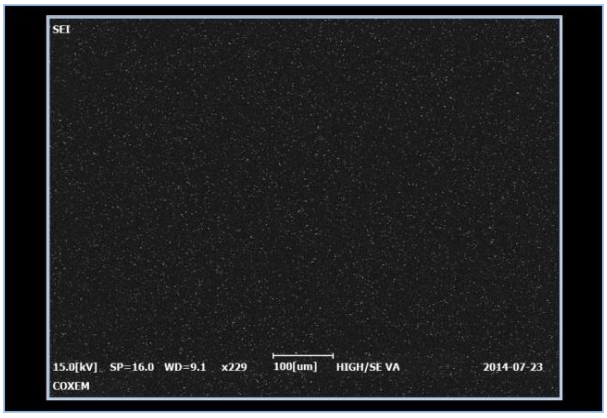
1st work: E-gun alignment

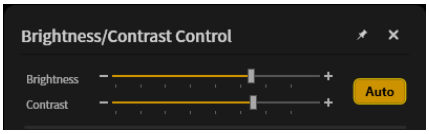
2nd work: Aperture reset

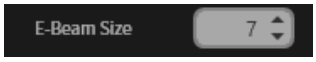
3rd work: Wobble work

1) Check whether the image is not visible on the screen.

- Check while adjusting brightness and contrast.
- Check while adjusting the electron beam size from 1 to 12.

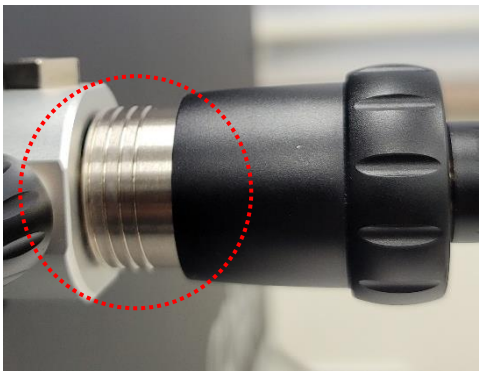






1st work: E-gun alignment

1. Pull the aperture adjustment handle knob all the way and then turn counter-clockwise and fix it.



2. Proceed with electron beam adjustment while the aperture adjustment handle knob is fixed.

NOTE For E-Gun alignment, refer to [9.2 E-Gun Alignment Method].

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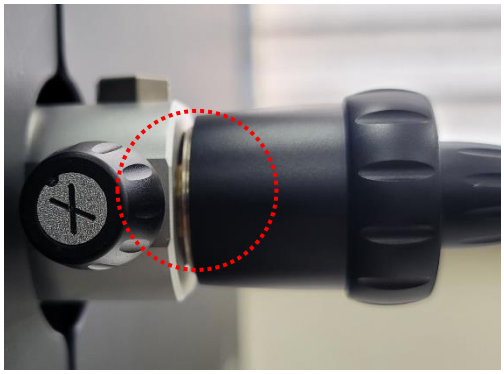
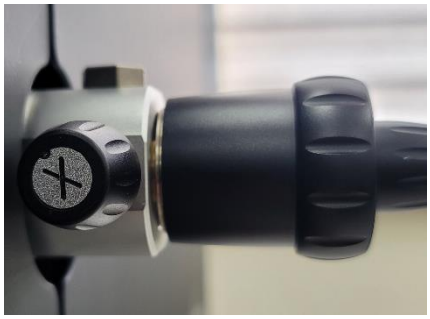
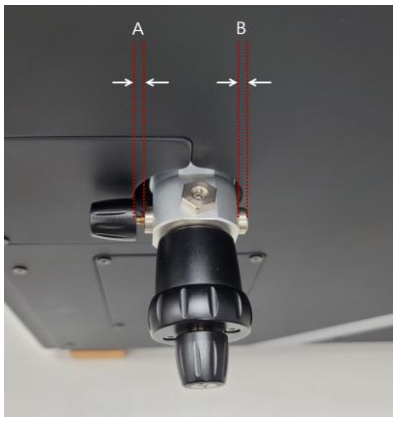
3. Once E-Gun alignment is complete, turn the aperture adjustment handle knob clockwise, and then fix the aperture in its original position.



2nd work: Aperture reset

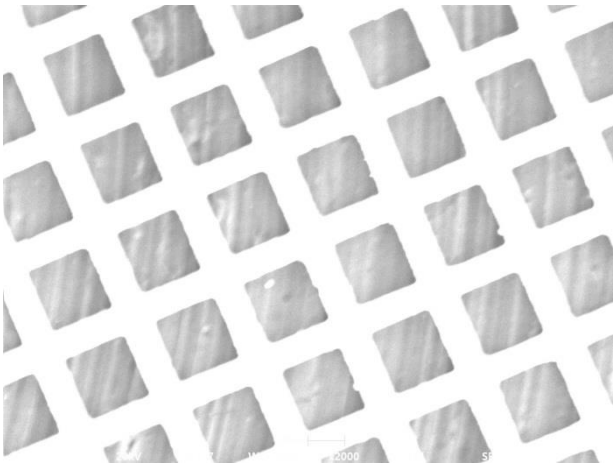
1. Turn the X-axis handle and adjust so that the left side (A) and the right side (B) have identical groove length.



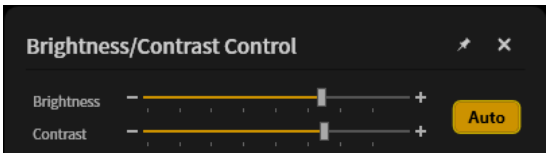


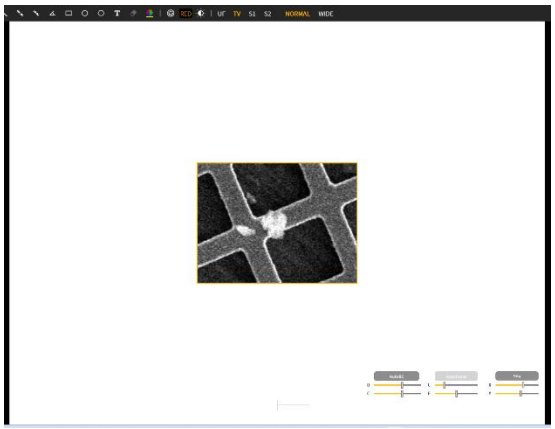
2. Completely turn the Y-axis handle to the direction of 1 (clockwise), and then check whether the image is visible on the screen while turning it in the direction of 2 (counter-clockwise) in 4~6 rounds.

- Current state of the screen



3. Make an image appear by adjusting brightness and contrast while looking at the screen.





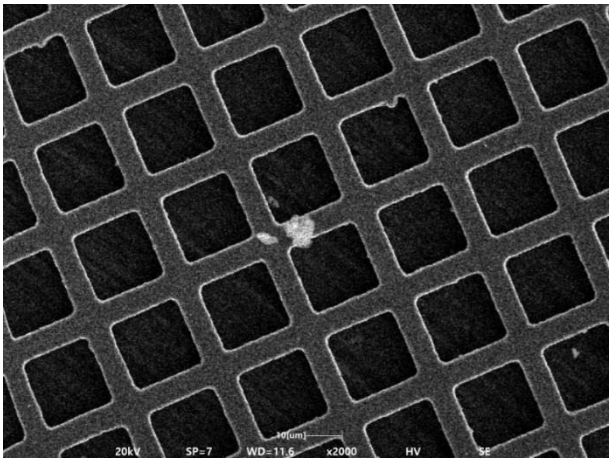
3rd work: Wobble work

1. Press the Wobble button ( ) on top of the screen to start the work.

NOTE For Wobble work, refer to [7.2.1 Wobble Work 1].

2. If Wobble work is complete, press the Wobble button ( ) to finish.

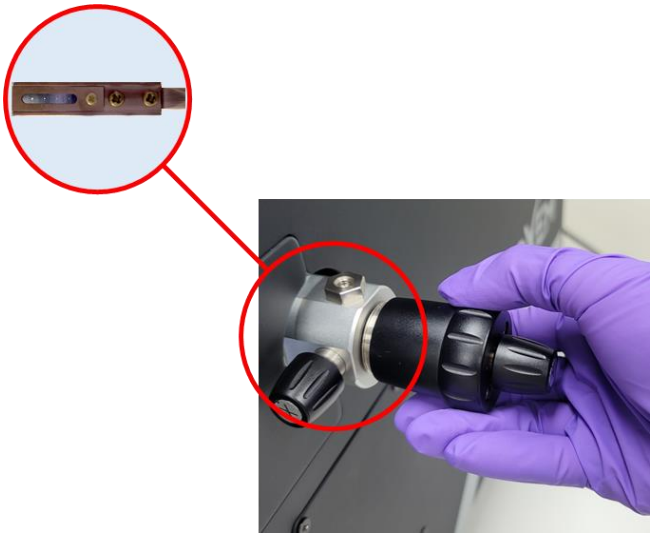
3. Proceed with the observation of the sample once again.



7.2.3 How to Set the Aperture

1. Aperture location check

The aperture is located inside the knob, and there are 4 holes in all. The electron beam passes through this hole.

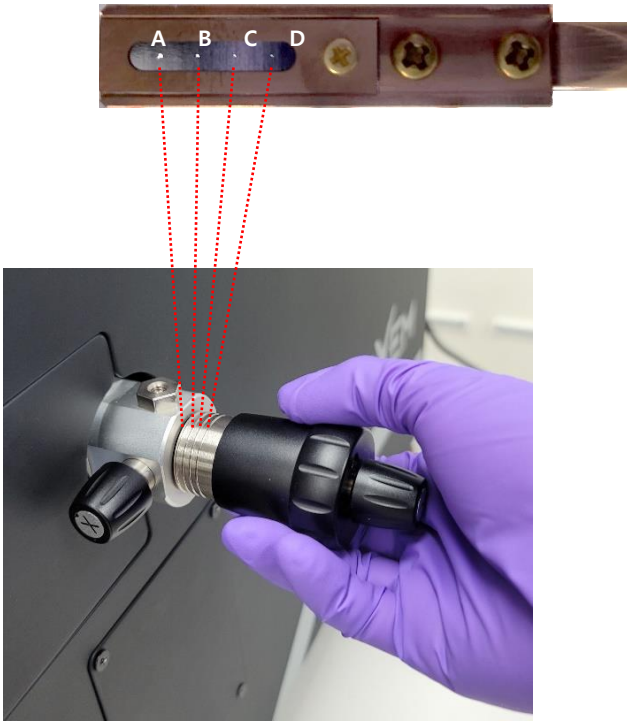


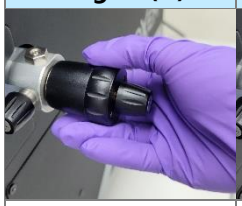
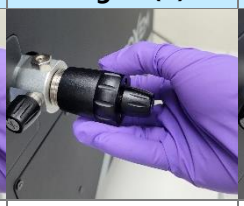
2. How to set the aperture hole

Pull the Knob in the direction of 1 and then turn counter-clockwise as shown in 2 to fix the Knob.

3. Changing the location of the aperture hole

To change the aperture hole, pull the aperture adjustment handle and select the desired aperture hole among the lines marked on the handle.



Stage 1(D)	Stage 2(C)	Stage 3(B)	Stage 4(A)	Stage 5
				
HOLE = 25um	HOLE = 25um	HOLE = 50um	HOLE = 100um	Not Use-Aperture

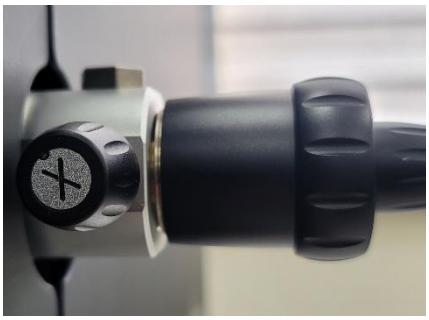
7.2.4 Aperture Alignment (Reset work)

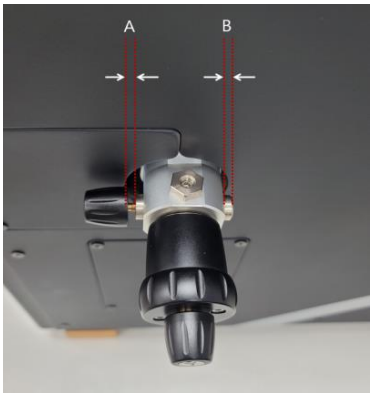
Perform wobble work if an image moves up and down or left and right during coarse focusing and fine focusing. If you move too much to the X-axis or Y-axis during Wobble work, it deviates from the location of the aperture hole.

If you cannot adjust the focus even after gradually turning the aperture knob toward the X-axis or Y-axis, perform aperture alignment.

1. X-axis alignment

Turns the X-axis Knob to adjust so that the left side (A) and the right side (B) have identical groove length.





2. Y-axis alignment

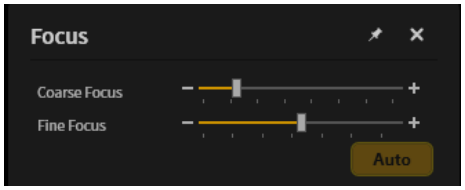
Turn the Y-axis Knob completely clockwise, and then check whether an image is visible on the screen while turning counter-clockwise in 4~6 rounds.

(6 rounds: 30 micro aperture hole location)

※ Since the Y-axis alignment location may vary depending on the product, check while looking at the screen.

3. Focusing

Adjust the focus minutely by adjusting Coarse Focus and Fine Focus.

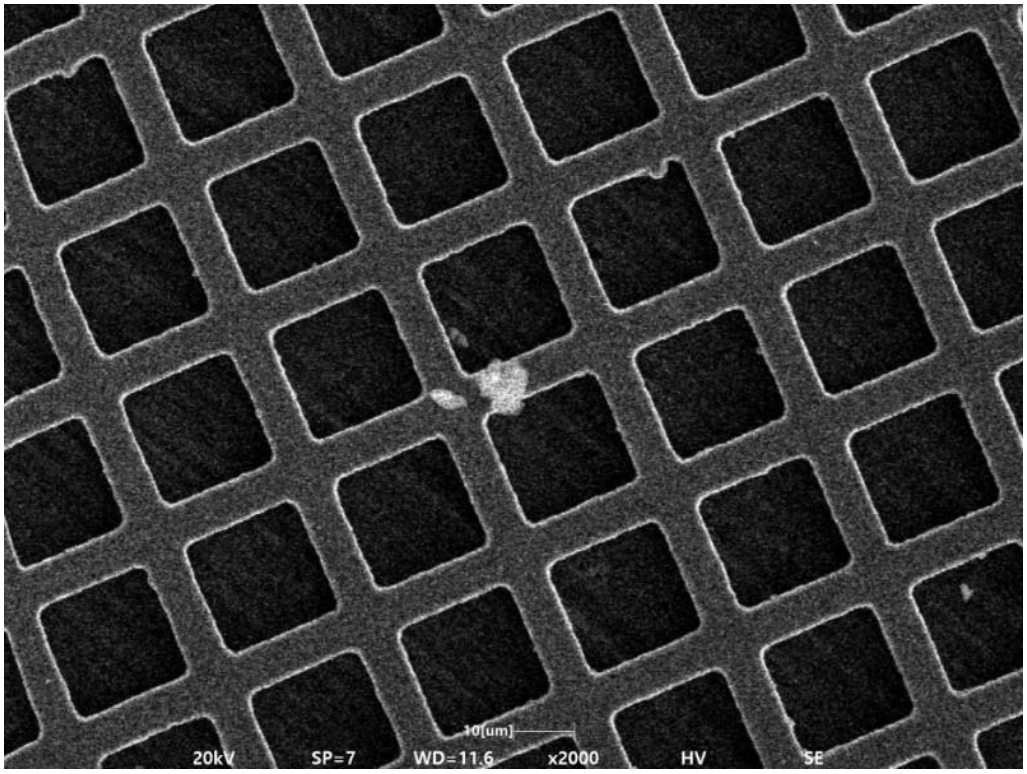


8 Save Image

After observing a sample, you can scan the image and save it as a high-quality image file.

8.1 Image Information Management

Before scanning an image, manage the information displayed in the image below.
If you check or uncheck the checkbox of the desired item in the Menu - Image information at the left side of the screen, you can add or delete the information displayed on the image.



NOTE For details on how to manage image information, refer to [2.4.8 Image information] item.

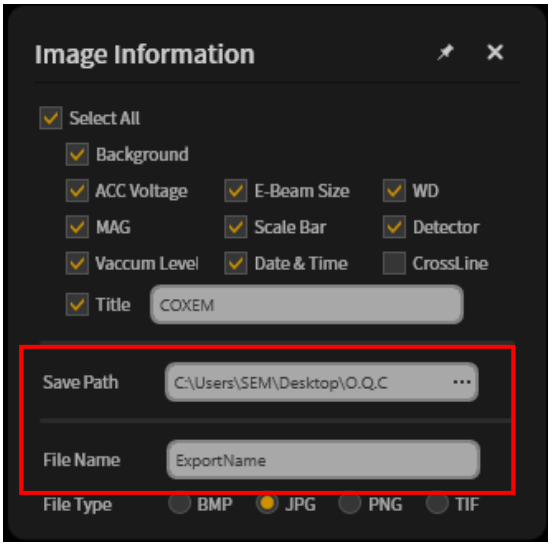
8.2 Save Image Function

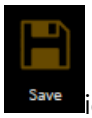
You can save a scanned high-quality image.

8.2.1 Image Save Path Setting

Click the  button on the left side of the screen

to designate the save path, filename, and file format.



- Clicking the 

icon sets the path where the image is automatically saved.

- Save Path: Press the  button and set the Image Save Path.

- Filename: It sets the image filename.

  * The year, month, day, time, minute, and second follow the set name.

    Ex.) COXEM_2023_04_03__15_26_49

- File Type: It sets the format of the image file.

8.2.2 How to Save an Image

Scan a clear image and then press the 

button.

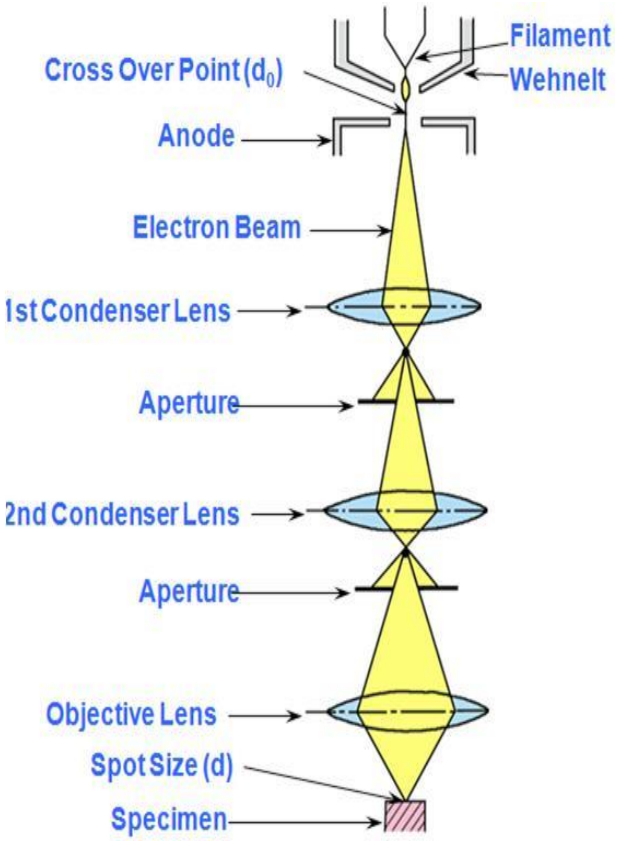
- It saves the image in the set image folder.

9 Alignment Work

9.1 E-Gun Alignment Overview

EM-40 has a built-in E-Gun.
Alignment of E-Gun is needed when replacing the filament or changing the accelerating voltage, or if the size of the electron beam suddenly changes.

In addition, since the path of the electron beam may be altered due to movement or contact of the equipment even if none of the changes above occur, E-Gun alignment is needed.
The structure of E-Gun inside the equipment is as shown in the drawing below.



The alignment of E-Gun is a process of finding the optimum point of the Filament current after aligning the Filament and electron beam in a straight line while the Spot size (d) is opened to the maximum extent. In normal cases, the screen becomes brighter if the electron beam becomes larger, and darker if the beam becomes smaller. If E-Gun alignment is not properly done, however, the changes in screen brightness may differ even if the size of E-Gun changes, and the lifespan of the Filament may be shortened.

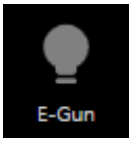
9.2 How to Align E-Gun

E-Gun must be aligned in case the image is not properly visible or after replacing the filament or after changing the accelerating voltage.

The procedure for aligning E-Gun is as follows:

1) Mount the sample in the chamber, and then click the [HV] button to set the vacuum state.

2) If the vacuum level becomes 100%, turn on the [E-Gun] power.



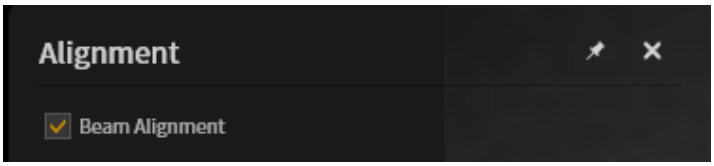
3) Set the filament value in line with an optimum value.

(Refer to [5.2.2 Filament Optimization].)

4) Set the E-Beam size 12.

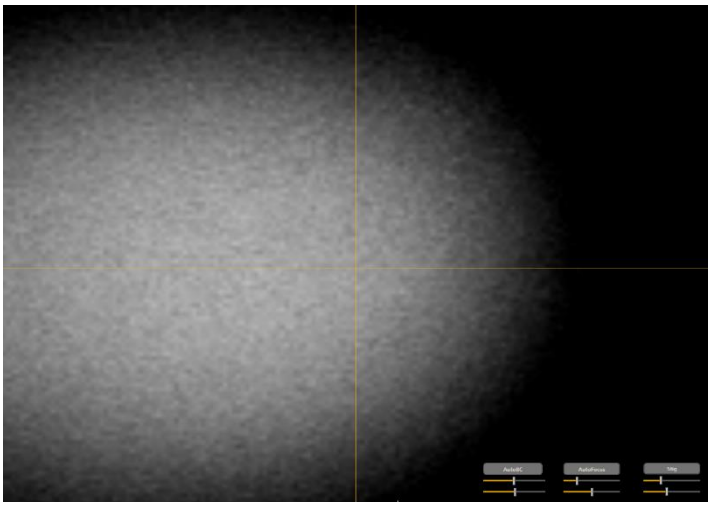
5) Move the X and Y Bar of Tilt in the Alignment control item on the left to the center.

6) Check beam alignment.

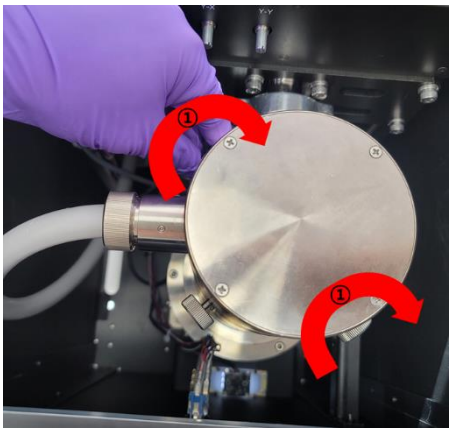


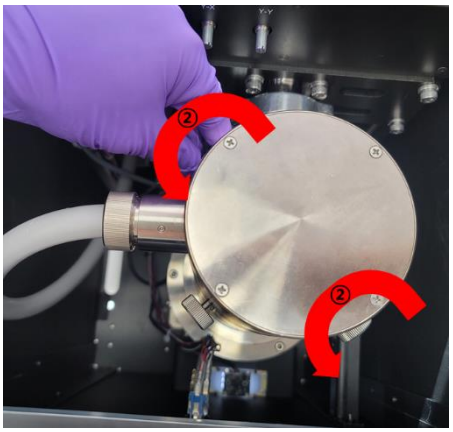
7) Check whether the image is visible in NanoStation.

- If the image is visible, set the contrast to the center so that changes in brightness can be checked.



8) Turn the X-axis bolt in either direction ① or ② so that the beam elliptical center is centered on the screen.

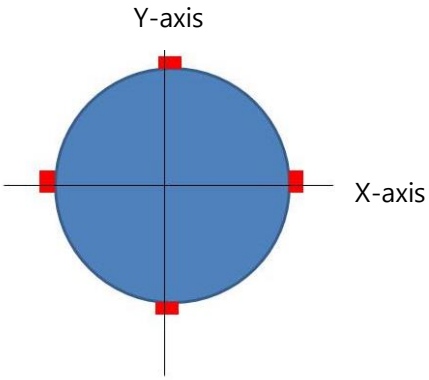




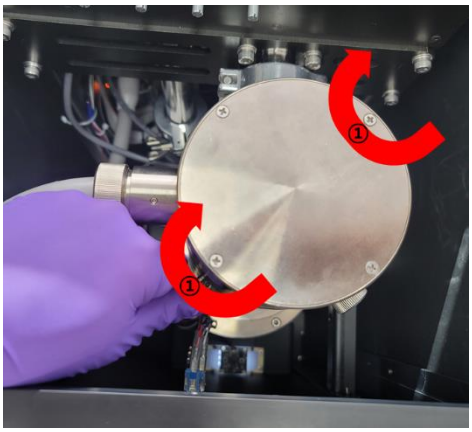
(Rotate the two screws in the same direction (① or ②) and move E-gun to the left or right.)

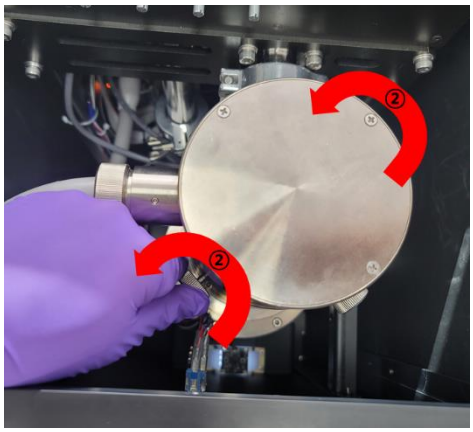
NOTE

4 bolts for Alignment are symmetrical with each other on the side of the top of E-Gun. The bolts facing each other become an axis, and they are adjusted by tightening or loosening the bolts of the axis to be aligned.
(Randomly designate X-axis and Y-axis)



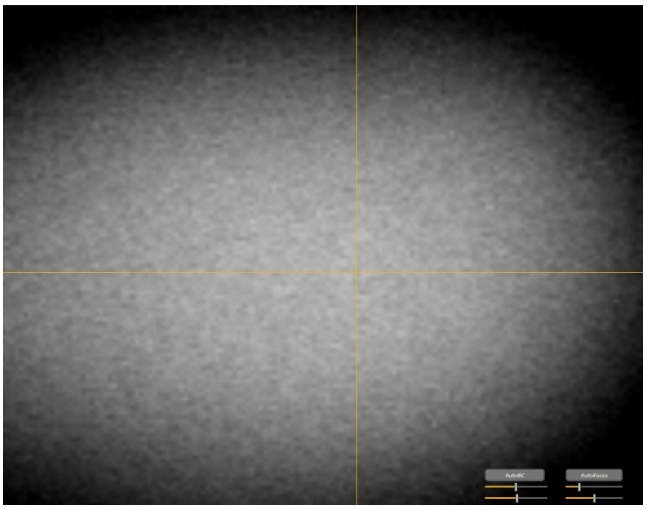
9) Turn the Y-axis bolt in either direction ① or ② so that the beam elliptical center is centered on the screen.





10) Look at the screen and double-check if it's the brightest position.

- If the beam position is out of the center, proceed with steps 8-9 again so that the beam position is in the center.



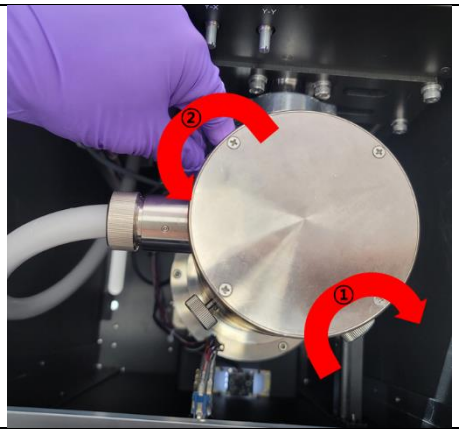
WARNING When aligning E-Gun, it must be done while taking caution to prevent electric shock.

CAUTION If E-Gun is not properly aligned, the image quality may be degraded, or the image cannot be displayed.

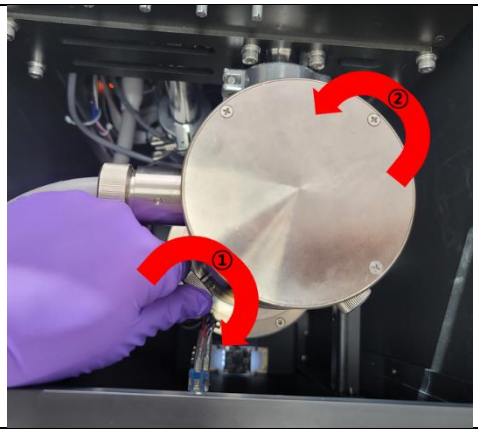
11) If E-Gun alignment is complete,

Rotate the two screws in the X-axis clockwise (tightening direction) to fix them.

Rotate the two screws in the Y-axis clockwise (tightening direction) to fix them.

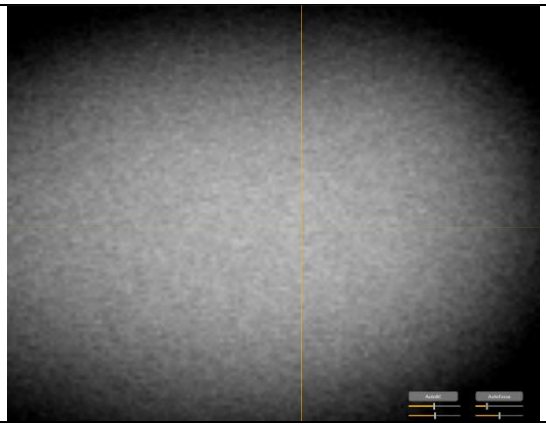
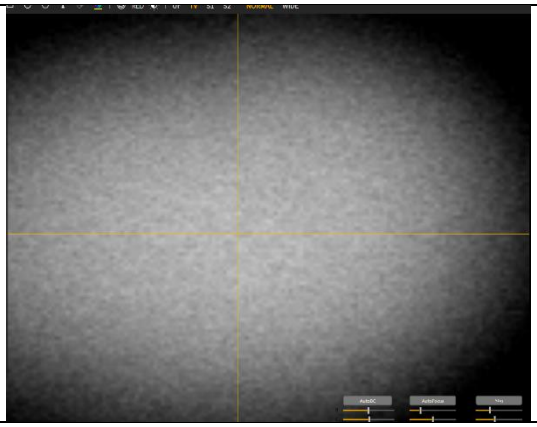


Fixing screws in X-axis

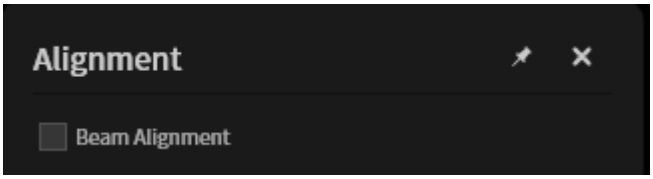


Fixing screws in Y-axis

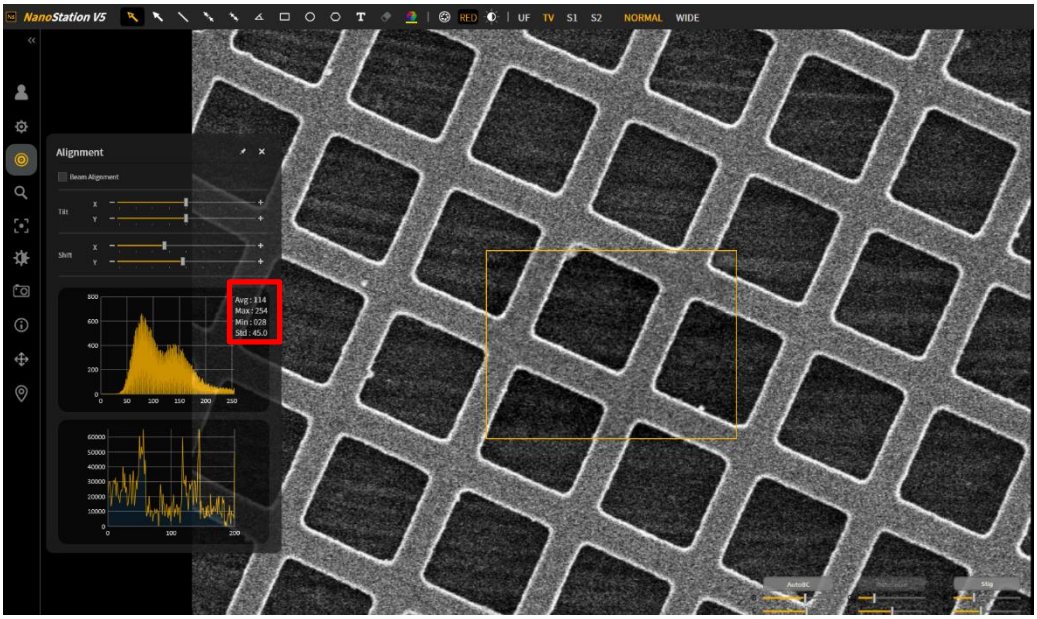
12) Drag the Shift X, Y axes to adjust the brightest point in the beam to the center.

	
Before beam shift adjustment	After beam shift adjustment

13) Uncheck the Beam Alignment window and set it to RED mode.



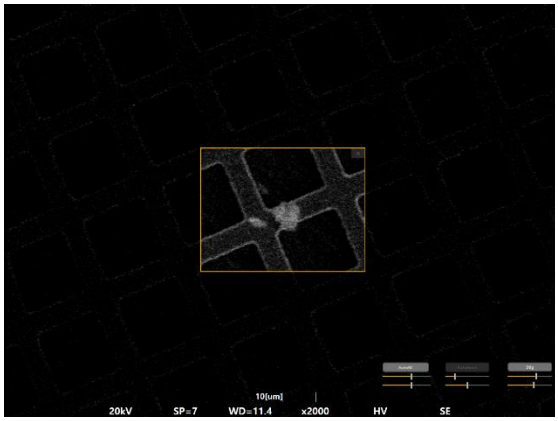
14) Drag X and Y of the beam tilt to change the Avg. value of the Alignment menu to the highest value.



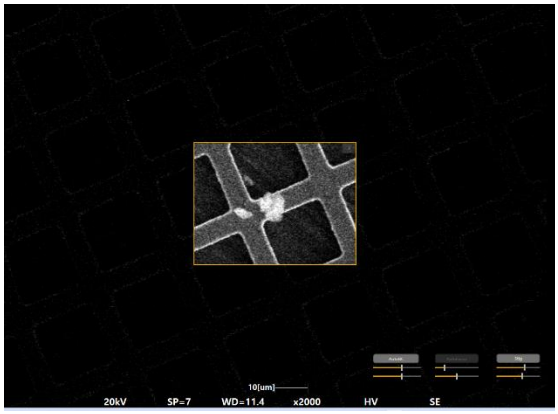
CAUTION

- You must proceed with Gun Alignment in NanoStation after aligning the hardware E-Gun.
- If Gun alignment is used while excessively biased, the equipment can be damaged.)

15) Find the position of E-gun, and then perform Filament optimization.
(Refer to [5.2.2 Filament Optimization].)



(Before Filament optimization)



(After Filament optimization)

16) When the electron gun alignment is completed, change the electron beam size to 1, 4, 7, 10, and 12 and repeat 12 to check whether the screen brightness is bright in proportion to the electron beam size.

NOTE

- The screen becomes brighter if the size of E-beam grows larger and darker if it is small. If the brightness of E-Gun differs depending on the size of the electron beam, E-Gun must be realigned.

Comparison before and after E-Gun Alignment under the same condition

Before E-Gun Alignment	After E-Gun Alignment