

FEI Helios NanoLab 460F1
FIB operational guide
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- Finishing the secession

☐ SCOPE

- The purpose of this document is to describe requirements and basic operating instructions for the FEI Helios SEM/FIB System. The use of this tool is limited to approved processes only.

☐ SAFETY

- Be sure that you are trained and signed off to use this equipment.
- Be sure to keep all doors and protective shields in place before operating this equipment.
- Use care when operating around high voltage or high current.
- If you are unsure about any procedure or indication while operating this equipment be sure to contact a staff member or trainer for assistance.

Beginning your session

Note:

- Always check the stage in quad 4 on the screen when loading/unloading your samples.
- Please contact staff for ferromagnetic powers/particles or small samples.
- For ferromagnetic samples, place your sample securely on the stub so that samples will not hit the objective lens.

Starting your session

1. Start iLab.
2. Log in to the user software
3. Load your sample
 1. Check the height of your sample (pictures on next slide)
 2. Load samples (next slide)
 3. Wait until the stage transfers to the loading/unloading chamber
 4. Release the stage: 'Release' button
 5. Pick up the stage, load your sample, and place the stage back on the stage holder
 6. Click 'Load' button
 7. Wait until the stage transfer is completed
4. Take a Navigation picture
 1. In the menu, 'stage' – **'take nav-Cam Photo'**
 2. Explore the sample locations by clicking the specific locations in the picture at 3rd quad

Sample mount and loading/unloading

Sample stage: five slots



Max sample height

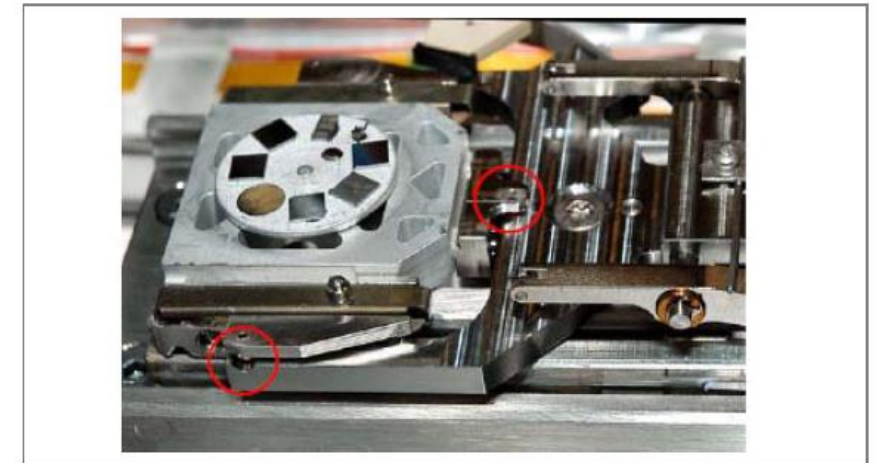
Unloading Sequence

1. Push the **Unload / Release** button to start the unloading sequence (lit is blinking). After finishing, the Loadlock is vented and the lid can be opened. Both buttons are enabled.
2. Open the lid, the **Clamp / Load** button becomes disabled. Push the **Unload / Release** button to release the carrier from the Loadlock arm.
3. Take the carrier out from the Loadlock arm.

Loading Sequence

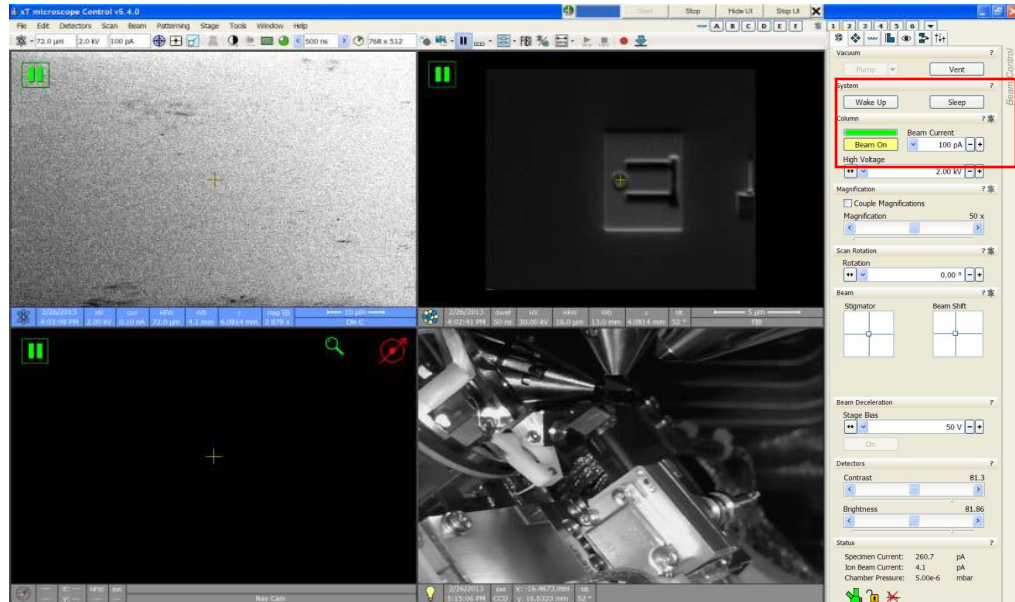
1. Place the carrier on the Loadlock arm, making sure that all three alignment rubies are positioned properly. The **Clamp / Load** button becomes enabled (lit is on).

Figure 5-7 Alignment Rubies with Only Two Shown

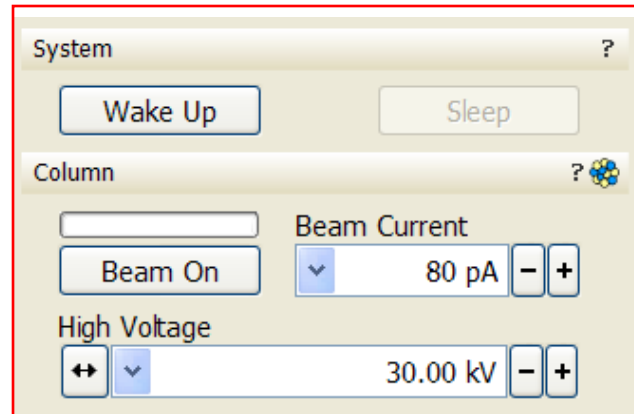


2. Close the lid and push the **Clamp / Load** button. The loading sequence starts (lit is blinking).

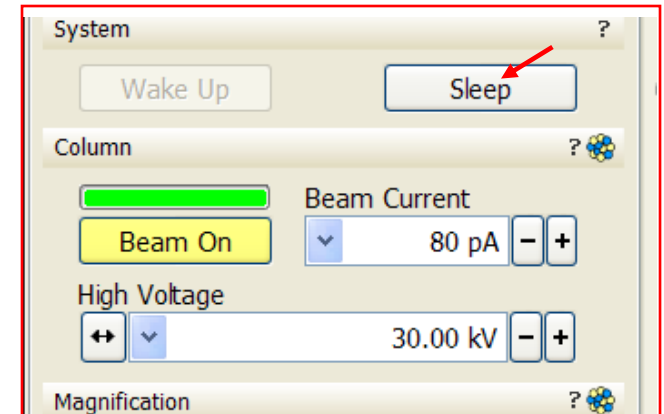
SEM USERS



Ion beam heater **OFF** state
Never click the **Wake Up** button
Sleep button should be grayed out.

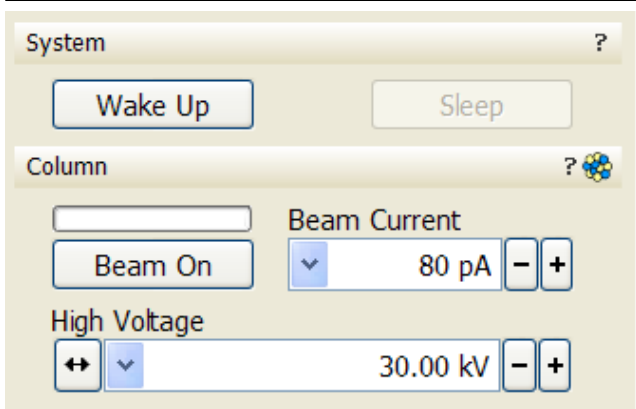


Ion beam **ON** state
If you see the **Sleep** button is activated,
please click it to deactivate it

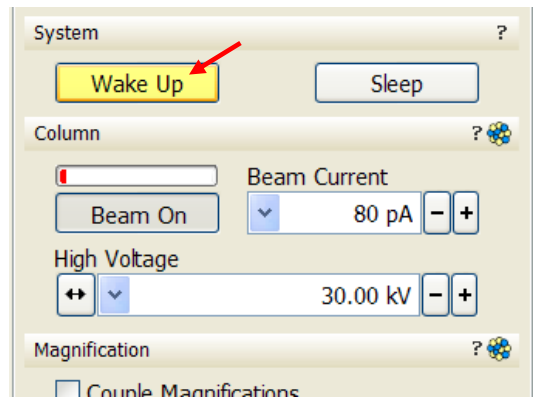


FIB USERS

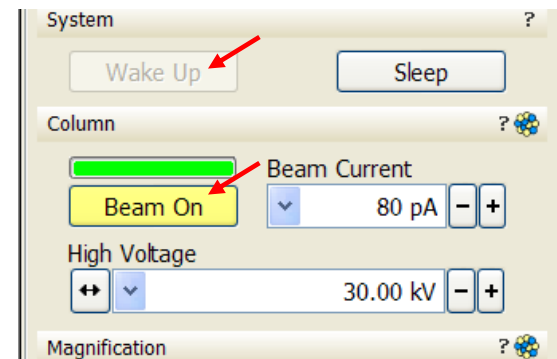
Not operating state: FIB not using
→ Ga ion source heater off
→ Ga ion beam not scanning



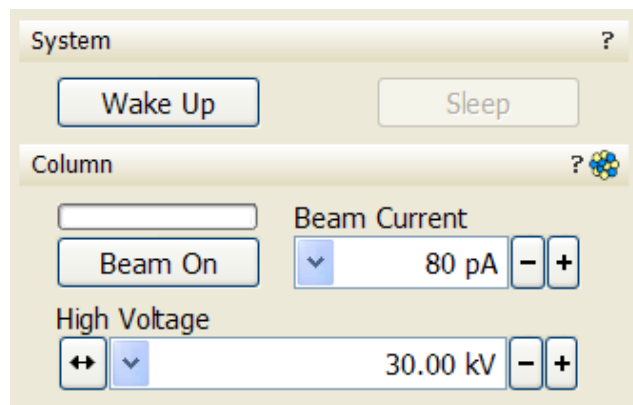
Heater on by click **Wake Up**
→ start to consume ion source
→ Ion beam yet to start to scan



Ga+ source completely heated up - operational
Ion beam scan by click **Beam On**
Good to go for FIB



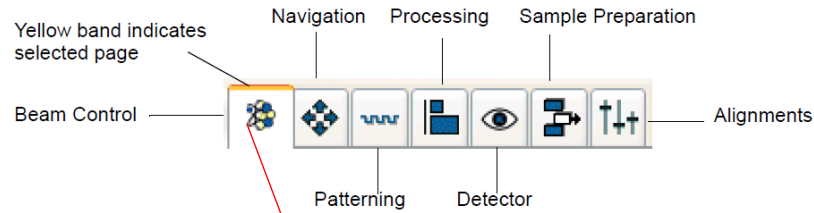
When FIB is finished,
1) Click 'Sleep'
2) Click 'Beam On'



Sleep button deactivated

Start Electron beam

Pages Toolbar



'Reduced Area' icon

'Pause' icon

Beam control page

AT microscope Control v5.4.0

File Edit Detectors Scan Beam Patterning Page Tools Window Help

72.0 μ m 2.0 kV 100 pA 500 ns 768 x 512

Beam Control

Vacuum: Pump Vent

System: Wake Up Sleep

Column: Beam On Beam Current: 100 pA High Voltage: 2.00 kV

Magnification: 50 x

Scan Rotation: 0.00°

Beam: Stigmator Beam Shift

Beam Deceleration: Stage Bias: 50 V

Detectors: Contrast: 81.3 Brightness: 81.86

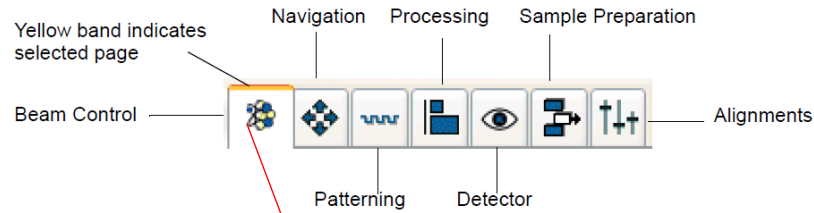
Status: Specimen Current: 260.7 pA Ion Beam Current: 4.1 pA Chamber Pressure: 5.00E-6 mbar

Turning e-beam

1. Click 'Beam control' in the **Pages Toolbar**
2. Click 1st quad on the monitor screen
3. Select the voltage and current
 - Menu bar or
 - **'Beam Control page'**
4. Click the **Beam on** button under the **'Beam Control page'** tab
5. Unpause the screen using the **'Pause'** icon

Start Ion beam (FIB users)

Pages Toolbar



'Reduced Area' icon

'Pause' icon

Beam control page

AT microscope Control v5.4.0

File Edit Detectors Scan Beam Patterning Page Tools Window Help

72.0 µm 2.0 kV 100 pA 500 ns 768 x 512

Navigation

Relative Flip | Tilt Correction EasyUI

Go To

ΔX 0.1000 mm

ΔY 0.0000 mm

ΔZ 0.0000 mm

ΔT 0.0 °

ΔR 0.0 °

Compucentric: Rotation Tilt

Last Position

Chunk Add

Position 1

Position 2

Position 3

Reference Mark Remove All

Stage Z

Down Up

Load Lock

State: Indeterminate

Show Recovery Dialog...

Detectors

Contrast 63.6

Brightness 31.7

Status

Beam Control

Vacuum

Pump Vent

System

Wake Up Sleep

Column

Beam Current

Beam On 100 pA

High Voltage 2.00 kV

Magnification

Couple Magnifications

Magnification 50 x

Scan Rotation

Rotation 0.00 °

Beam

Stigmator Beam Shift

Beam Deceleration

Stage Bias 50 V

On

Detectors

Contrast 81.3

Brightness 81.86

Status

Specimen Current: 260.7 pA

Ion Beam Current: 4.1 pA

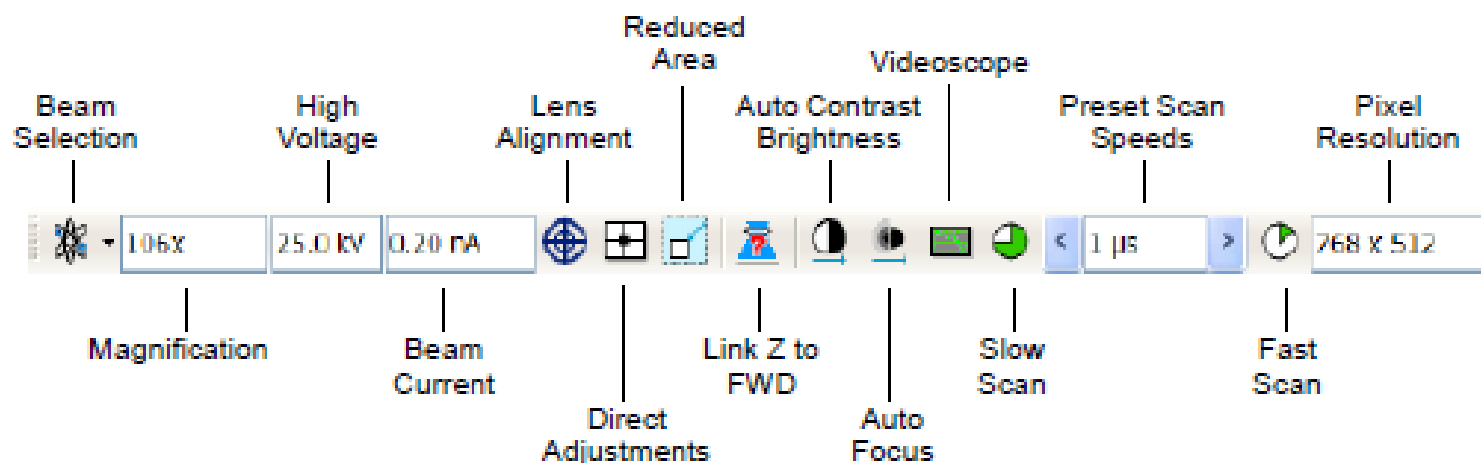
Chamber Pressure: 5.00E-6 mbar

Turning Ion-beam

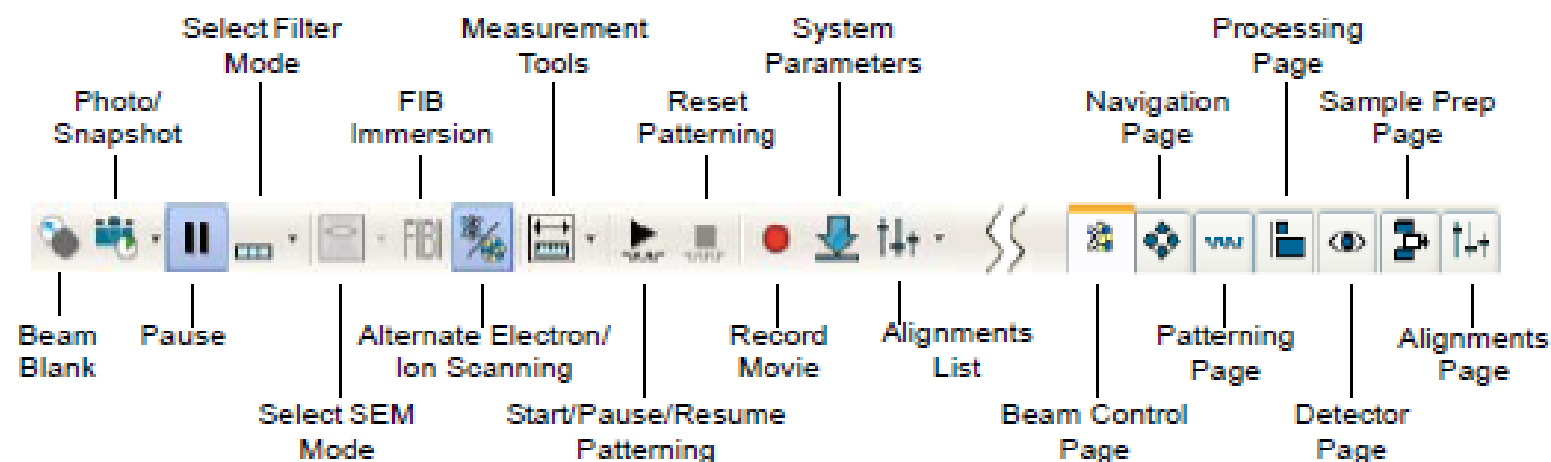
1. Click the 2nd quad on the screen
2. Click the 'Wake Up' button (arrow)
3. Click the 'Beam On' button (arrow)
4. Leave the ion-beam as paused
 - The green pause symbol is shown left top screen

Toolbar icons/menus

Toolbar Left Half



Toolbar Right Half



Eucentric height for FIB users

1. Link Z to working distance

- Focus on the sample surface with SEM
- Click 'Z to WD' icon: the icon changes its shape with green arrow.

2. Set the working distance to 4 mm.

- Input 4 in the Z (Navigate page)
- Click 'go to' button

3. Find Eucentric height/point: the height of the stage where the specific point remains the same at tilt = 0 and 52

- Set magnification X1000
- Find a recognizable feature, and center it under the yellow cross by moving the stage
- Watching the feature, change the stage tilt to 10°. Using the Z control, bring the feature back under the cross
- Repeat the previous step at 20° or 30°
- Repeat at tilt = 52°

'Z to WD icon'



• **Red question mark:** The function is enabled and the link between Z and FWD is unknown. Use the function as soon as possible, after properly focusing the image.

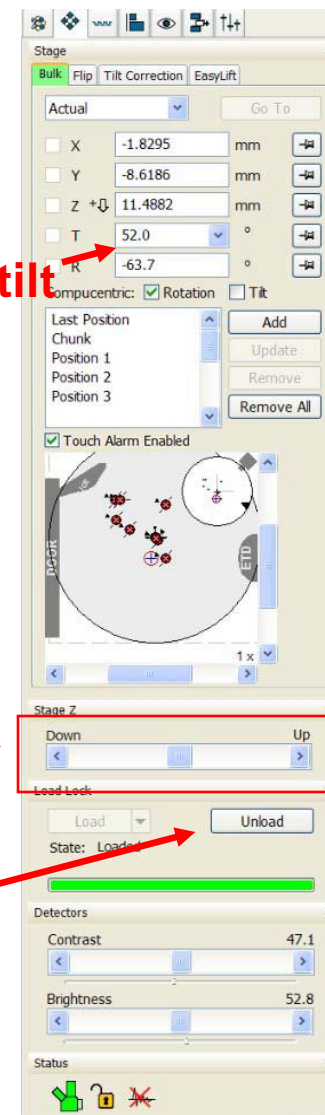


• **Red circle:** The function is enabled. Z is roughly linked to FWD, but it needs correction. This could happen after changing the sample, focusing and linking Z to FWD at a long working distance (WD), and then moving the stage to a short WD. Focus the image carefully at a WD around 4 mm and use this function again.



• **Green double-ended arrow:** The function is still enabled and Z is properly linked to FWD. It is now safe to change the WD by setting a Z coordinate on the Stage page.

'Navigate'



tilt

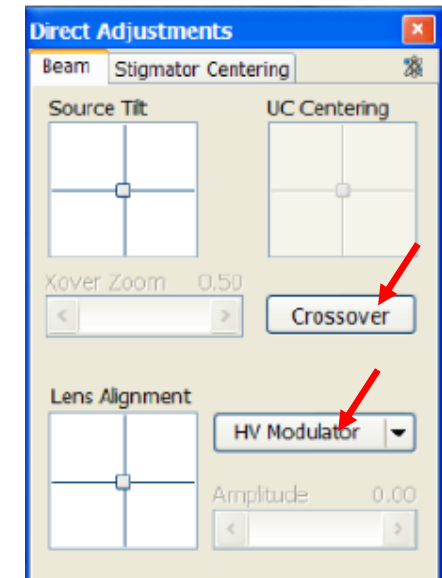
Stage move up/down

Load/Unload button

E-beam alignment

1. Focus on the surface with the magnification you will be doing operation.
2. Adjust stigma
3. Do the lens modulation
 1. Click 'Direct Adjustments' icon
 2. Click 'Crossover' button and center the beam
 3. Click 'HV Modulator' and make the image static by adjusting the horizontal and vertical lines. Click and drag the lines one by one.
4. Adjust focus and stigma again.

'Direct Adjustments'



For SEM USERS

do your job and move to the last slide to shutdown the system

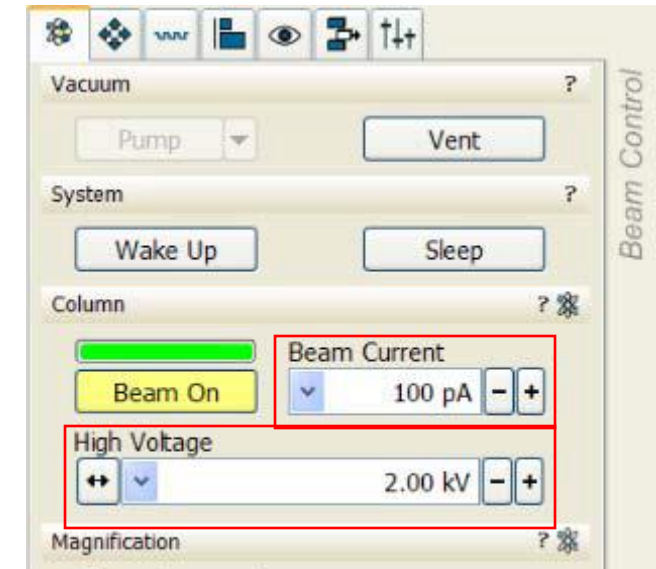
For FIB USERS

Go to next slide

FIB operation

Starting Ion-beam, tilt = 52°

1. Click 2nd quad on the screen
2. The Ga ion source was activated previously by clicking the 'Wake Up' button.
3. Select the 'Beam Current' and 'High Voltage': those can be selected in the 'Beam control page' or in the menu bar.
4. Before scanning I-beam, adjust the magnification.
5. Once the 2nd quad is unpaused, the ion beam scans the sample area.
6. 'Shift' key + 'mouse left drag' is used to shift the I-beam image to align it with the SEM image.
7. Adjust focus and stigma



Aperture		use
1.1	pA	High resolution imaging
7.7	pA	High resolution imaging
24	pA	High resolution imaging, small cross section cleaning
40	pA	General resolution imaging, cross section cleaning
80	pA	General resolution imaging, cross section cleaning
230	pA	Imaging, cross-section cleaning
430	pA	Cross-section cleaning
790	pA	Medium bulk milling or large cross-section cleaning
2.5	nA	Large cross-section cleaning
9.3	nA	Rough bulk milling for large cross-sections
21	nA	Extremely rough bulk milling for large cross-sections
47	nA	Extremely rough bulk milling for large cross-sections
65	nA	Extremely rough bulk milling for large cross-sections

Patterning tap (1/2)

1. Select a pattern from the Pattern Selector and draw a pattern in the active quad (1st quad: electrons, 2nd quad: ions).



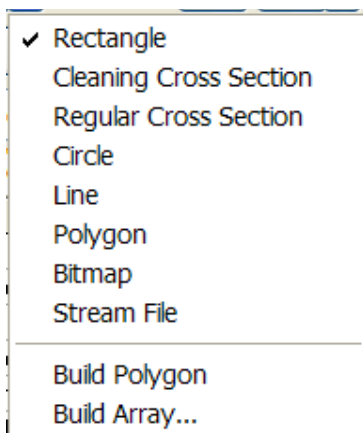
2. Select a beam for patterning from the toolbar.
3. Enter a value in μm as the depth in the Property Editor.
4. Select the milling aperture.
5. Focus and stigmatize the beam on the area adjacent to the pattern.
6. Snapshot a single frame to confirm the pattern position.
8. Select **Patterning > Start Patterning** or click **Start Patterning** on the toolbar to begin milling.
9. **Pause**, **resume**, and **stop** patterning by clicking the corresponding buttons in the menu bar

Patterning tap (2/2)

Pages Toolbar



Click drop down menu



Patterning Properties

Basic		Advanced	Progress	S. Mill
Name	Value			
Application				
X size	0 μm			
Y size	0 μm			
Z size	0 μm			
ScanDirection	Bottom To Top			
DwellTime	0 s			
Beam	Electron			
Time	0 s			
Beam Current	0 pA			

Application: Name of the application. Clicking the value field produces a dropdown arrow and list of applications. The parameters for the selected application are automatically set for the subsequent properties.

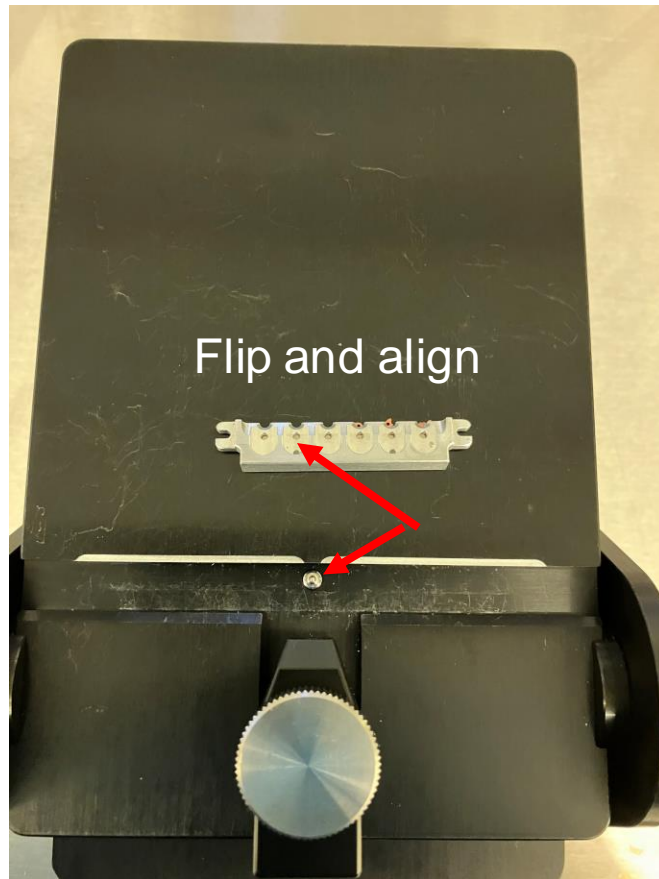
Scan Direction: Bottom to Top or Top to Bottom, etc.

Beam: The beam used for patterning

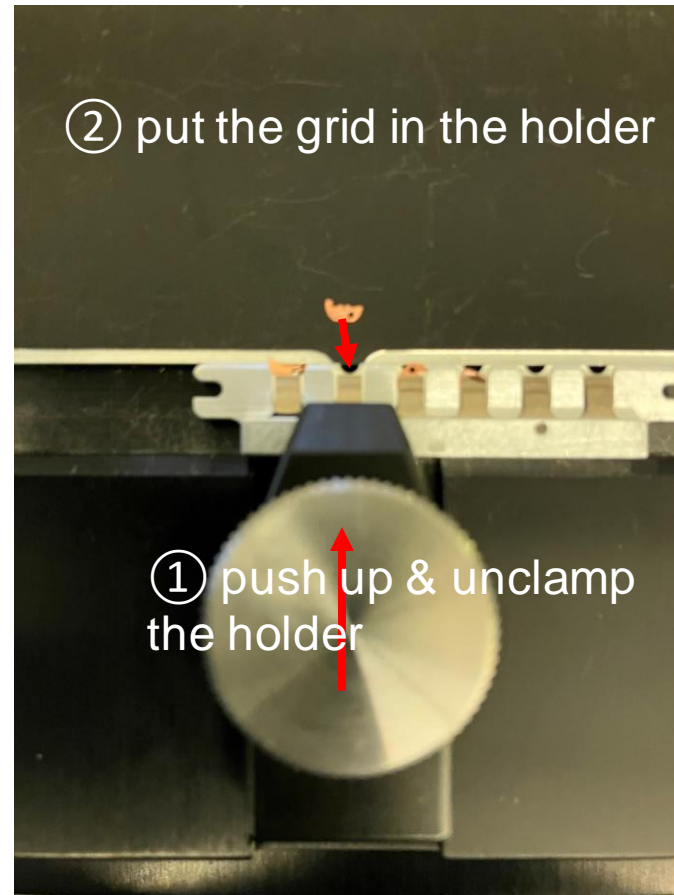
Beam Current: The amount of current striking the sample.

TEM lift out grid

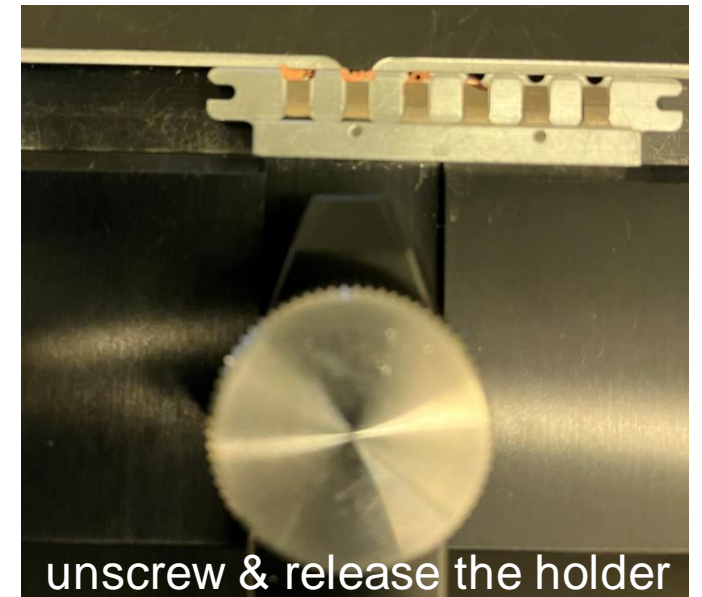
Placing TEM grid holder on the base



Clamping the grid

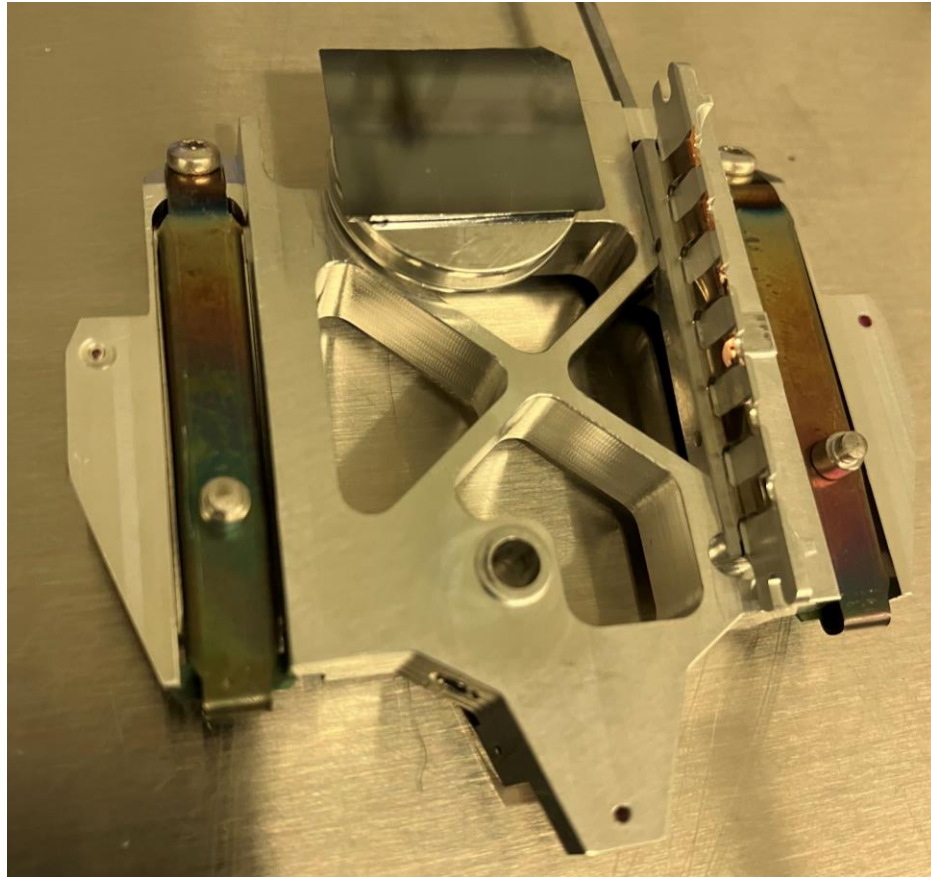


Releasing the holder

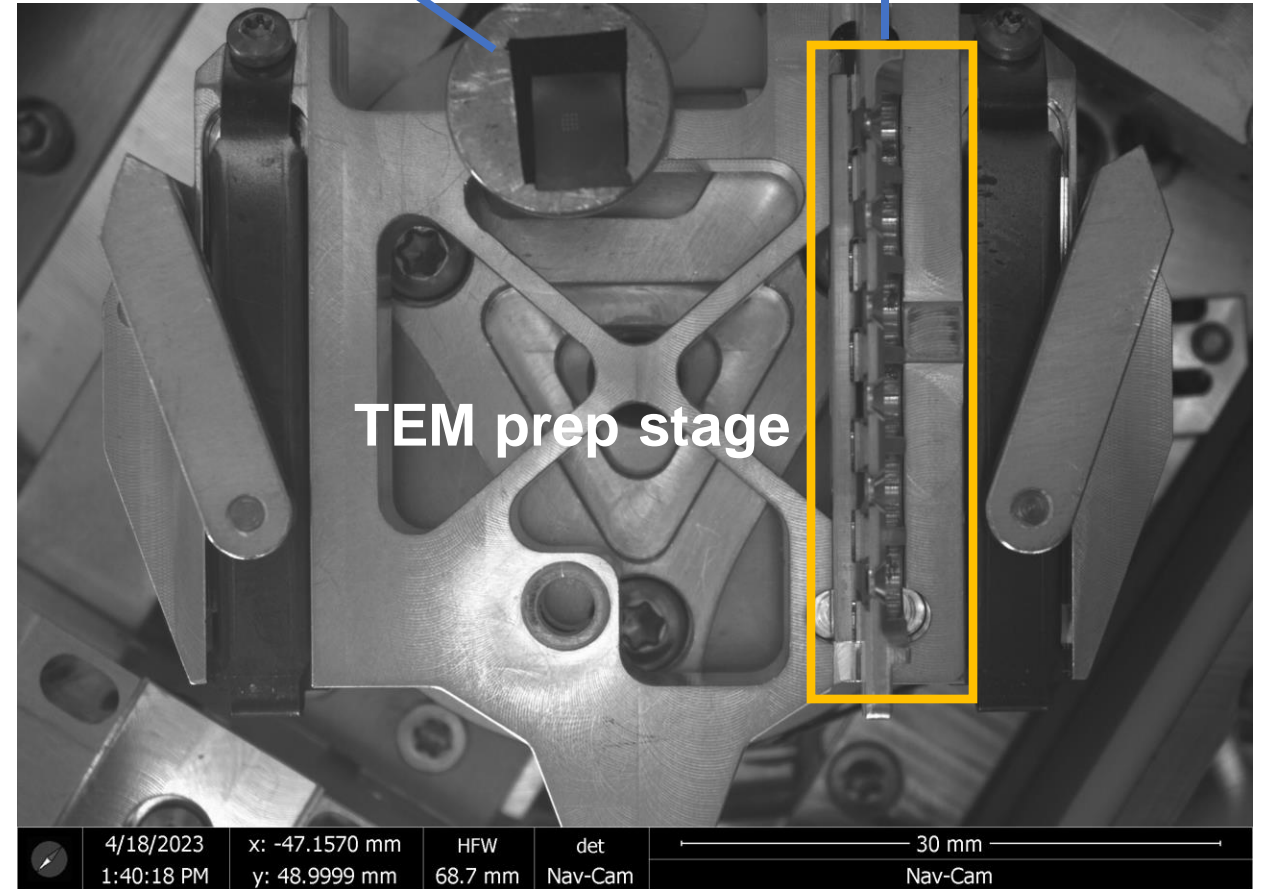


TEM sample holder

Dedicated stage for the TEM grid holder

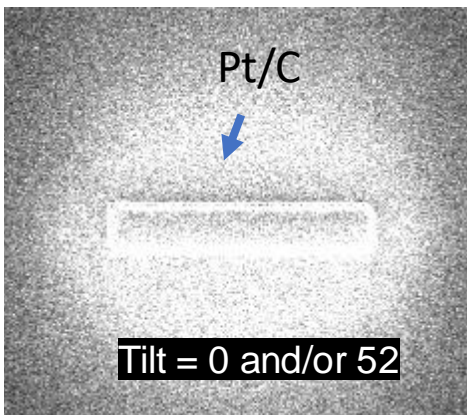


Sample TEM grid holder

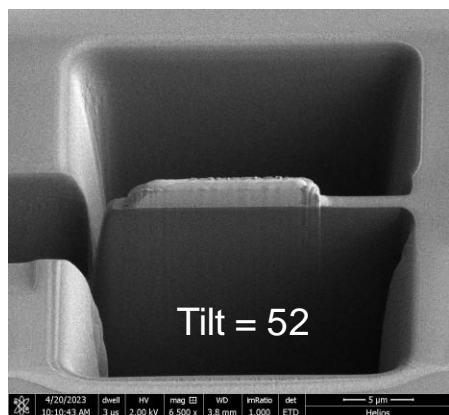


TEM sample lift out flow

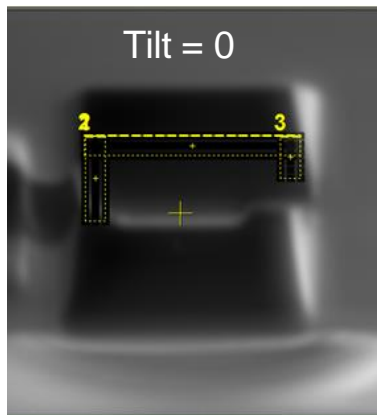
1. Cap deposition



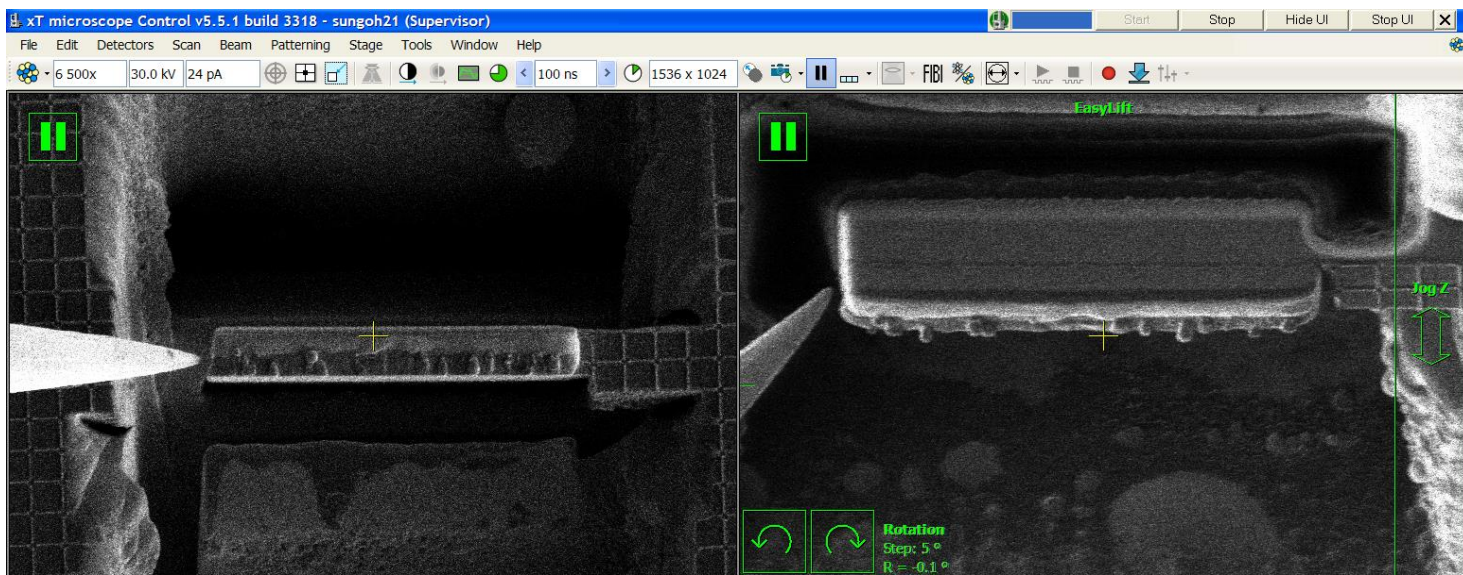
2. trenches



3. J cut



4. EasyLift: micromanipulator for sample handling



①

②

③

④ Click 'Insert' or 'Retract' to insert and retract the tip.

⑤ manipulate the tip with the Jog

Cap deposition

The screenshot displays the xT microscope Control v5.5.1 build 3318 - sungoh21 (Supervisor) interface. The main window is divided into several panels:

- Top Left:** A grayscale image of the sample surface with a green crosshair. A green square icon in the top left corner is labeled ② draw pattern.
- Top Right:** A 3D model of the sample with a green rectangular pattern drawn on its surface. A green square icon in the top left corner is labeled ② draw pattern.
- Bottom Left:** A close-up image of the sample stage with a green crosshair. A green square icon in the top left corner is labeled ② draw pattern.
- Bottom Right:** A close-up image of the sample stage with a green crosshair. A green square icon in the top left corner is labeled ② draw pattern.

The right-hand side of the interface features a 'Patterning' panel with the following sections:

- Pattern:** A dropdown menu showing '1-Rectangle 1'. A green square icon in the top left corner is labeled ①.
- Basic:** A table of parameters for the pattern.
- Progress:** A section showing 'Total Time: 0:01:31' and progress bars.
- MultiChem:** A table of gas types and their flow rates.
- End Point Monitor:** A section with checkboxes for 'On', 'Pause', and 'Save', and a 'Time Interval' of 1.00 s.
- Status:** A section showing 'Specimen Current: 1.8 pA' and 'Ion Beam Current: 392.3 pA'.

Red arrows point from the numbered callouts to the corresponding elements in the software interface.

⑤ Click 'start' - triangle

③ Application: Pt_M

④ Insert the nozzle by click the green square for Pt

Cap deposition

1. Deposition for protecting the sample. Example: carbon and Pt deposition
 1. E-beam induced deposition, stage tilt = 0°
 1. In the 'Pattern' tab, draw a rectangle pattern in the 1st squad (SEM)
 2. In the 'Application', select 'C e-dep surface'
 3. Insert gas injector needle: click the square for the gas you want to use
 4. Hit the start icon, triangle in the menu
 5. Low HV (<5kV) and high current (~26nA)
 6. Retract the gas nozzle
 2. I-beam induced deposition, stage tilt = 52°
 1. Align the SEM and the FIB images using '*beam shift*'
 2. Click the 2nd squad, and draw the pattern on the pattern
 3. Ex) carbon & Pt deposition, carbon deposition '*C_M*' and followed by Pt, '*Pt_dep*'
 1. Ion beam current depends on the size of patterns.
 2. Check focus, stigma, and shift when the beam current changes

Trenches

④ Click 'start' - triangle

② draw pattern

③ Application: Si or other materials

Basic	Advanced	Progress	Set Mill	EasyLift
Name		Value		
Application		none		
X size		0 μm		
Y size		0 μm		
Z size		0 μm		
ScanDirection		Bottom To Top		
DwellTime		0 ps		
Beam		lon		
Time		0 ps		
Beam Current		0 pA		

In	Gas Type	Status	Flow
Pt		Ready	80.00%
C		Ready	80.00%
H2O		Ready	1.00%
XeF2		Off	1.00%
TEOS		Ready	10.00%

ISPI	Monitor	Settings
<input type="checkbox"/> On	<input type="checkbox"/> Pause	<input type="checkbox"/> Save
Time Interval: 1.00 s		
CCS Line Interval: 1.0		

Status		
Specimen Current:	106.10	nA
Ion Beam Current:	390.9	pA

1. Cross-section cuts – ‘Regular Cross Section 1’ top and bottom of the protection pattern
 1. Draw the cut patterns that are a couple microns wider than the protection pattern
 2. For bulk cuts, high current might be chosen. Adjust focus and stigma.
 1. Turn off the beam blaker, full screen, and then check the beam using the snapshot
 1. ‘Scan’ – ‘Spot’ mode. Select the point where the beam is pointing at.
 2. ‘Scan’ – ‘Beam Blank’. I-beam exposure immediately.
 3. ‘Scan’ – ‘Full Frame’.
 2. Put the gaps between the cut and the protection pattern according to the beam size
2. Cleaning cross section cut with two or three lower aperture (~20nA or less if needed)
 1. Application - ‘Si New’

Easy-Lift: micromanipulator

The screenshot displays the 'xT microscope Control v5.5.1 build 3318 - sungoh21 (Supervisor)' software interface. The main window is divided into several sections:

- Top Panel:** Contains menu options (File, Edit, Detectors, Scan, Beam, Patterning, Stage, Tools, Window, Help) and a toolbar with icons for various functions.
- Left Panel:** Shows a large grayscale image of a sample with a central feature.
- Right Panel:** The 'EasyLift' control panel, which includes:
 - Buttons for 'Bulk', 'Flip', 'Tilt Correction', and 'EasyLift'.
 - An 'Initialize' button and an 'Insert To' button.
 - Controls for 'Jog' (selected) and 'Step' modes, with a speed of 10 $\mu\text{m/s}$.
 - Directional movement buttons for X, Y, Z, and rotation.
 - A 'Rotation Step' set to 5° and a rotation rate of R = -0.1°.
 - A 'Status: Retracted' indicator.
 - A 'Park position' list with a 'Go to' button.
 - Buttons for 'Add', 'Update', 'Remove', and 'Remove all'.
- Bottom Left Panel:** A detailed view of the micromanipulator's mechanical structure, with labels for 'Sample stage' and 'TEM grid'.
- Bottom Right Panel:** A view of the microscope's internal components, with a 4 mm scale bar.

A dialog box titled 'EasyLift insert needle' is overlaid in the center, asking 'Do you want to insert the EasyLift needle to the position?' with 'Park position' and 'Cancel' buttons. A red arrow points from the 'Park position' button in the dialog to the 'Park position' entry in the EasyLift control panel.

Four numbered callouts (1, 2, 3, 4) with red arrows point to specific UI elements:

- ① Points to the 'EasyLift' tab in the top toolbar.
- ② Points to the 'Insert To' button in the EasyLift control panel.
- ③ Points to the 'Park position' entry in the 'Park position' list.
- ④ Points to the 'Insert To' button in the EasyLift control panel.

Callout 5 points to the 'Park position' button in the dialog box.

TEM sample lift out

5. Lift out the sample

Tip-sample welding (Pt deposition)

cut

Jog Z

Rotation
Step: 5°
R = -0.1°

4 mm

Pattern

Name	Value
Application	Si
X size	913.14 nm
Y size	4.07 μm
Z size	10.00 μm
Scan Direction	Bottom To Top
Dwell Time	1.000 μs
Beam	Ion
Time	0.0139
Beam Current	2.63 nA

MultiChem

In	Gas Type	Status	Flow
Pt	Pt	Ready	80.00%
C	C	Ready	80.00%
H2O	H2O	Ready	1.00%
XeF2	XeF2	Off	1.00%
TEOS	TEOS	Ready	10.00%

End Point Monitor

ISPI Monitor Settings

On Pause Save

Time Interval: 1.00 s

CCS Line Interval: 1.0

Status

Specimen Current: -34.3 pA
Ion Beam Current: 2.62 nA

TEM sample lift out - continued

xT microscope Control v5.5.1 build 3318 - sungoh21 (Supervisor)

File Edit Detectors Scan Beam Patterning Stage Tools Window Help

3 500x 2.0 kV 100 pA 300 ns 1536 x 1024 FIBI

Stage: Bulk | Flip | Tilt Correction | EasyLift

Initialize Retract

Jog Step Rotation Step

1 $\mu\text{m/s}$ 5 $^\circ$

X, Y Z R = -0.1 $^\circ$

Status: Ready

Park position

Stop Go to Add Update Remove Remove all

Stage Z: Down Up

Load Lock: Load Unload State: Loaded

Detectors: Contrast 58.4 Brightness 41.4

Status: [Icons]

7/13/2023 2:46:09 PM	dwell 300 ns	HV 2.00 kV	mag 3 500 x	WD 3.8 mm	mRatio 1.000	det ETD	curr 0.10 nA	10 μm	Helios
7/13/2023 2:45:58 PM	dwell 100 ns	HV 30.00 kV	HRW 82.9 μm	WD 13.1 mm	mag 2 500 x	curr 80 pA	20 μm	Helios	
7/13/2023 9:29:25 AM	x: -47.1570 mm y: 49.0001 mm	HRW 80.2 mm	det Nav-Cam	30 mm	Nav-Cam				
7/13/2023 2:46:13 PM	det CCD	x: -5.5900 mm y: 13.5107 mm	tit 0 $^\circ$						

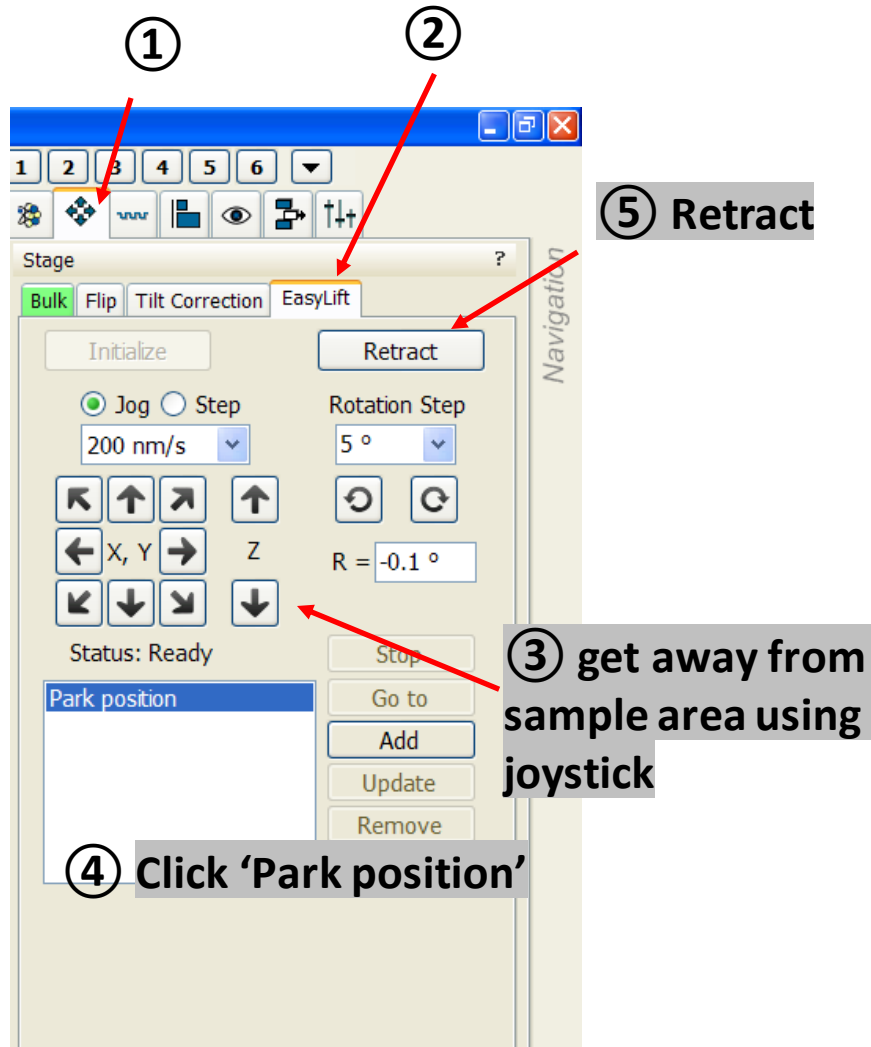
Place the sample on the grid

The screenshot displays the xT microscope control software interface. The main view is divided into four quadrants. The top-left quadrant shows a low-magnification SEM image of a sample. The top-right quadrant shows a high-magnification SEM image of a sample being cut (labeled '2 cut') and welded (labeled '1 welding') on a grid. The bottom-left quadrant shows a close-up of the sample bulkout on the grid. The bottom-right quadrant shows the internal structure of the microscope. The software interface includes a menu bar, a toolbar, and several panels on the right side, including 'Pattern', 'Progress', 'MultiChem', and 'End Point Monitor'.

TEM grid:
The lamella can be oriented by rotating the stage or the micro-manipulator

Shutdown the system: FIB session

If you used the micromanipulator,
Retract the micromanipulator



Finish the secession

1. Click the 'Pause' button to stop beams
2. Turn off the Ion-beam:
 - Click 2nd quad
 - Click '**Beam On**' AND '**Sleep**' button
3. Turn off the Electron-beam:
 - Click 1st quad
 - Click '**Beam On**'
4. Set tilt = 0
5. Unload your samples
6. Transfer the stage back to the main chamber:
 - wait until the stage comes back to the main chamber
 - Check visually through the CCD CAM at quad 4.
7. Log off the SEM/FIB software
 - File – log off
8. Log off iLab

1. Click the 'Pause' button to stop beams
2. Tun off the Electron-beam:
 - Click 1st quad
 - Click '**Beam On**'
3. Set tilt = 0
4. Unload your samples
5. Transfer the stage back to the main chamber:
 - wait until the stage comes back to the main chamber
 - Check visually through the CCD CAM at quad 4.
6. Log off the SEM/FIB software
 - File – log off
7. Log off iLab

Revision history

SIGNATURES AND REVISION HISTORY

1. Original author of this document: Dr. Sung Oh Woo
2. Original author Title or Role: Research Engineer
3. Date of original: 9/1/2022
4. Revision B notes: description of the LMIS handling is added

Approvals:

Technical Manager Signature:___*Sandra G Malhotra*

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