

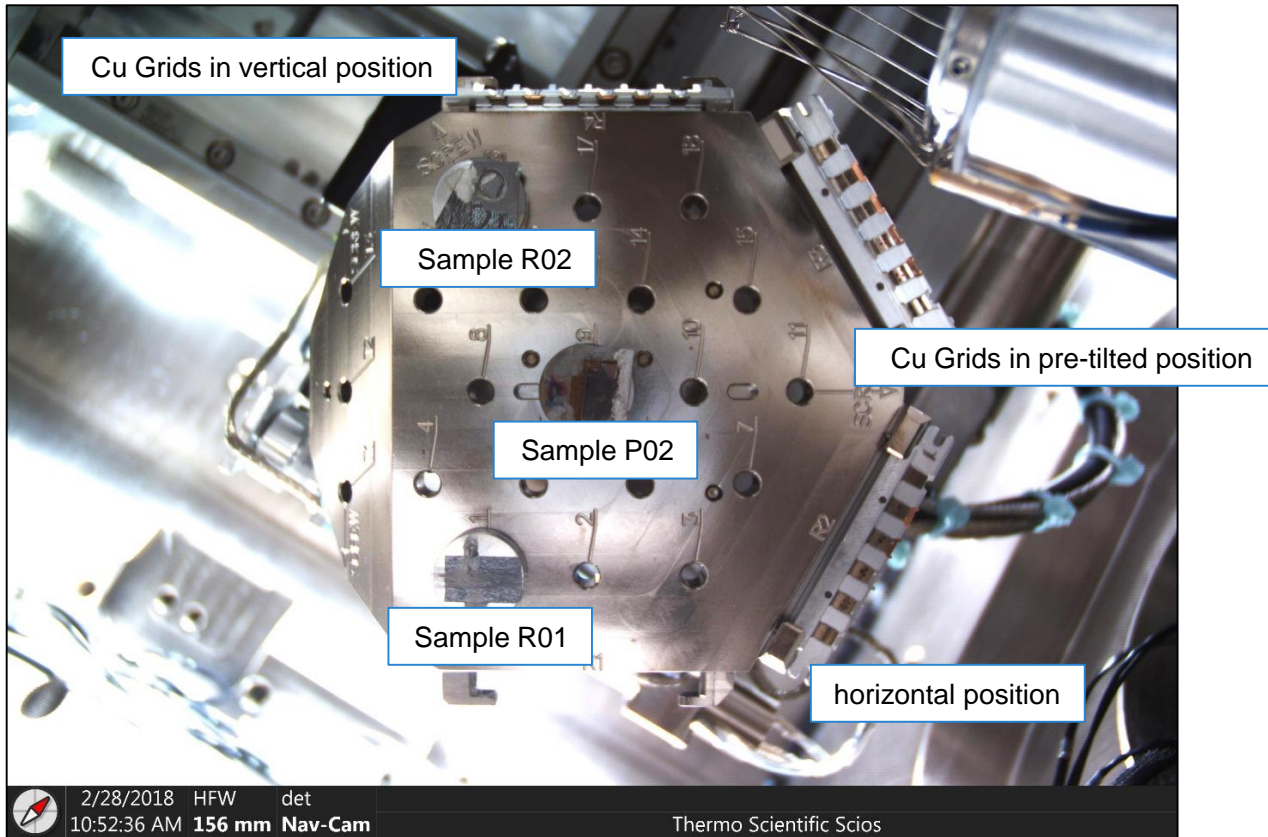


ThermoFisher
S C I E N T I F I C

Scios
AutoTEM4

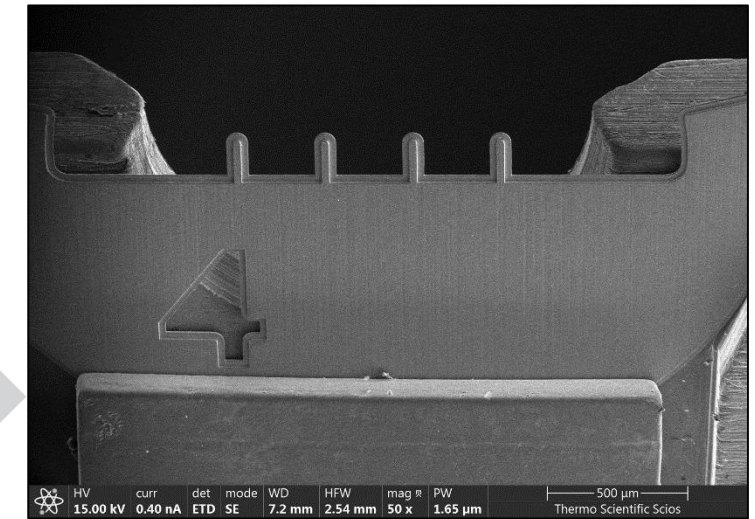
Module 20

Large sample holder; loading samples + TEM grids



- Multiple positions accommodate plenty of samples
- Easy and Fast sample Location/navigation with Nav-Cam
- Bulk samples and TEM grids can be loaded simultaneously (in vertical or pre-tilted position)
- TEM grids in pre-tilted position (R3) allows S(TEM) sample preparation with STEM end pointing and imaging without breaking the vacuum

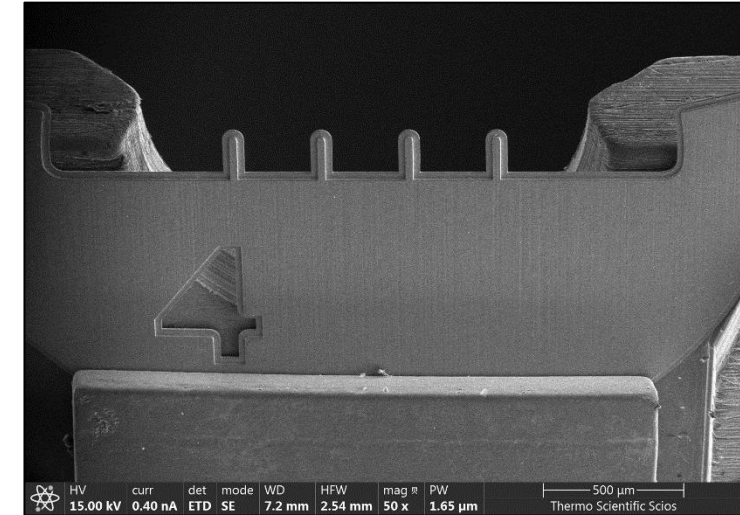
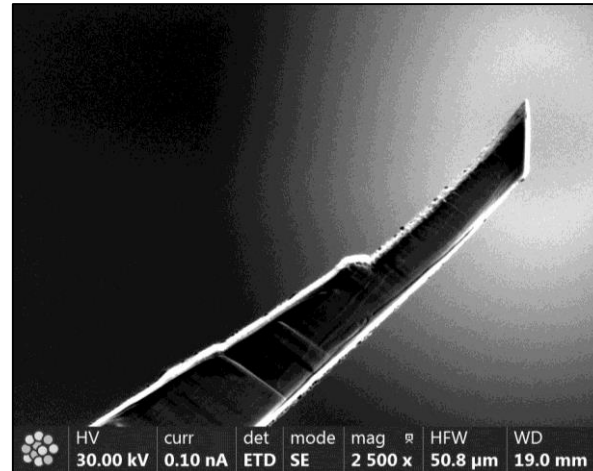
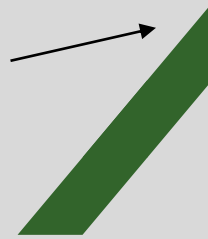
Best way to load the TEM grids in the TEM grid holder



Pre-requirements

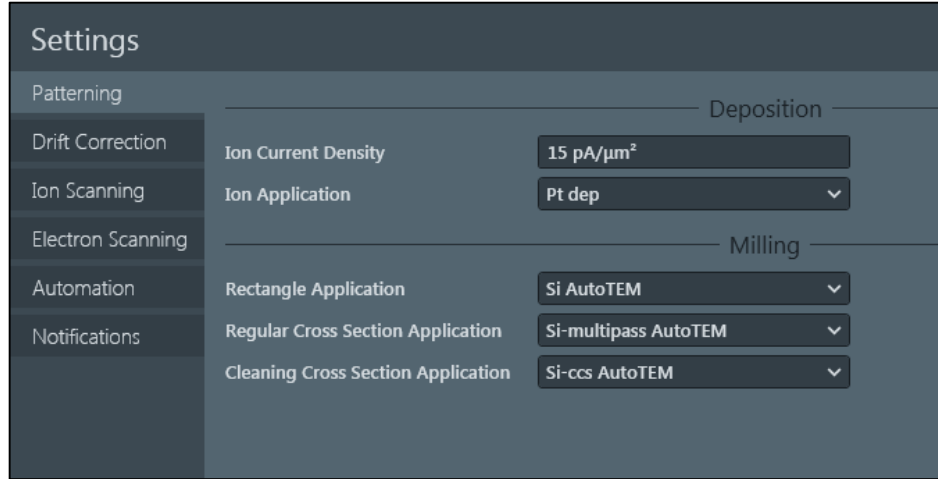
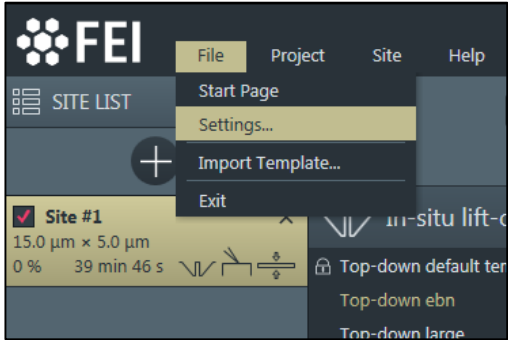
To run a successful AT4 project it is important to:

- Load the Copper grids in the correct position in the TEM grid holder and load the rowbar correctly in large sample holder as well
- Home stage
- Run stage rotation alignment
- Check EasyLift needle; shape needle tip
- Have a good vacuum 10^{-6} mbar
- Check settings AT4

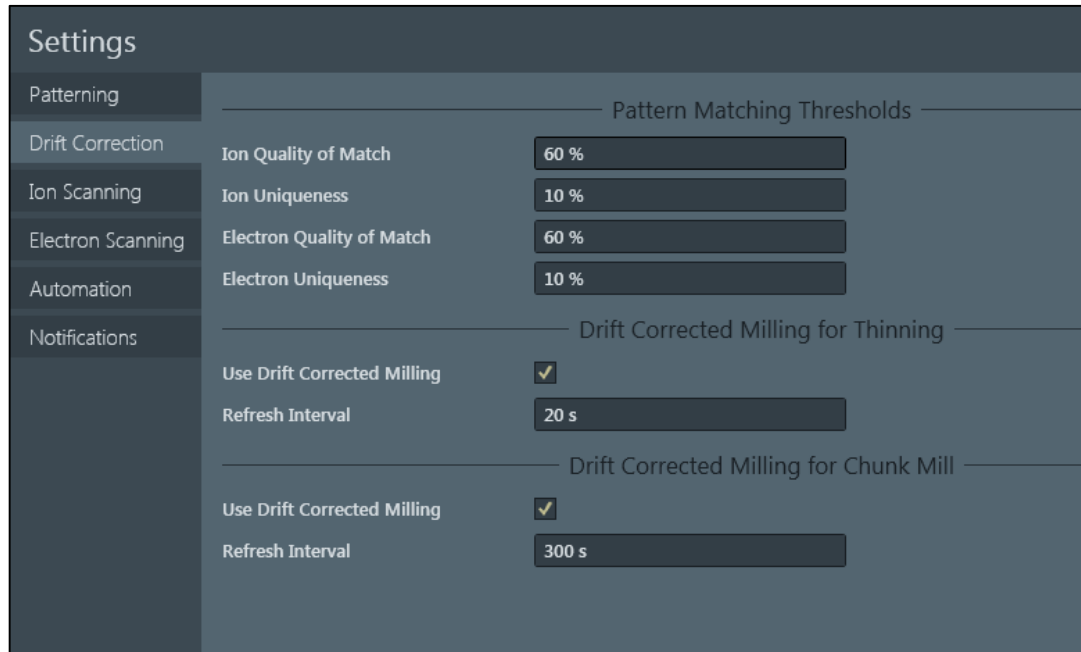


- This is the way to load the TEM grids in the TEM grid holder: flat side to the front
- Mount row bar with clamps towards stage center (as in NavCam image on slide2)
- This is the correct way for both the vertical and pre-tilted position

AutoTEM4; settings-1

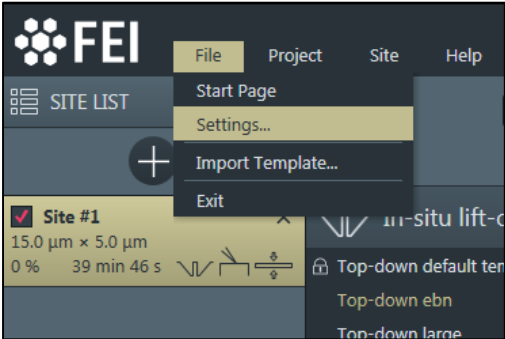


Default application files:
Change Pt dep to Pt dep_high



Thresholds changed to 60% (default 50%)

AutoTEM4; settings-2



Settings

Ion High kV Scanning

	Current	Resolution	Dwell Time	Frame Integration	ACB	Auto Focus
<input type="radio"/>	1.5 pA	1536 x 1024	3 μs	1	<input checked="" type="checkbox"/>	<input type="checkbox"/>
<input type="radio"/>	10 pA	1536 x 1024	3 μs	1	<input checked="" type="checkbox"/>	<input type="checkbox"/>
<input type="radio"/>	30 pA	1536 x 1024	1 μs	1	<input checked="" type="checkbox"/>	<input type="checkbox"/>
<input type="radio"/>	50 pA	1536 x 1024	1 μs	1	<input checked="" type="checkbox"/>	<input type="checkbox"/>
<input checked="" type="radio"/>	0.10 nA	1536 x 1024	1 μs	1	<input checked="" type="checkbox"/>	<input type="checkbox"/>
<input type="radio"/>	0.30 nA	1536 x 1024	500 ns	1	<input checked="" type="checkbox"/>	<input type="checkbox"/>
<input type="radio"/>	0.50 nA	1536 x 1024	500 ns	1	<input checked="" type="checkbox"/>	<input type="checkbox"/>
<input type="radio"/>	1.0 nA	1536 x 1024	100 ns	4	<input checked="" type="checkbox"/>	<input type="checkbox"/>
<input type="radio"/>	3.0 nA	1536 x 1024	100 ns	4	<input checked="" type="checkbox"/>	<input type="checkbox"/>
<input type="radio"/>	5.0 nA	1536 x 1024	100 ns	4	<input checked="" type="checkbox"/>	<input type="checkbox"/>
<input type="radio"/>	7.0 nA	1536 x 1024	100 ns	4	<input checked="" type="checkbox"/>	<input type="checkbox"/>
<input type="radio"/>	15 nA	1536 x 1024	100 ns	4	<input checked="" type="checkbox"/>	<input type="checkbox"/>
<input type="radio"/>	30 nA	768 x 512	100 ns	1	<input checked="" type="checkbox"/>	<input type="checkbox"/>
<input type="radio"/>	50 nA	768 x 512	100 ns	1	<input checked="" type="checkbox"/>	<input type="checkbox"/>
<input type="radio"/>	65 nA	768 x 512	100 ns	1	<input checked="" type="checkbox"/>	<input type="checkbox"/>

Ion Low kV Scanning

Resolution	Dwell Time	Frame Integration	ACB	Auto Focus
1536 x 1024	3 μs	1	<input checked="" type="checkbox"/>	<input type="checkbox"/>

Settings

Electron Scanning

Resolution	1536 x 1024
Dwell Time	300 ns
Frame Integration	1

Settings

Automation Modes

Chunk Mill / Cross Section	Automatic
Lift-Out	Guided
Thinning	Automatic

Automation

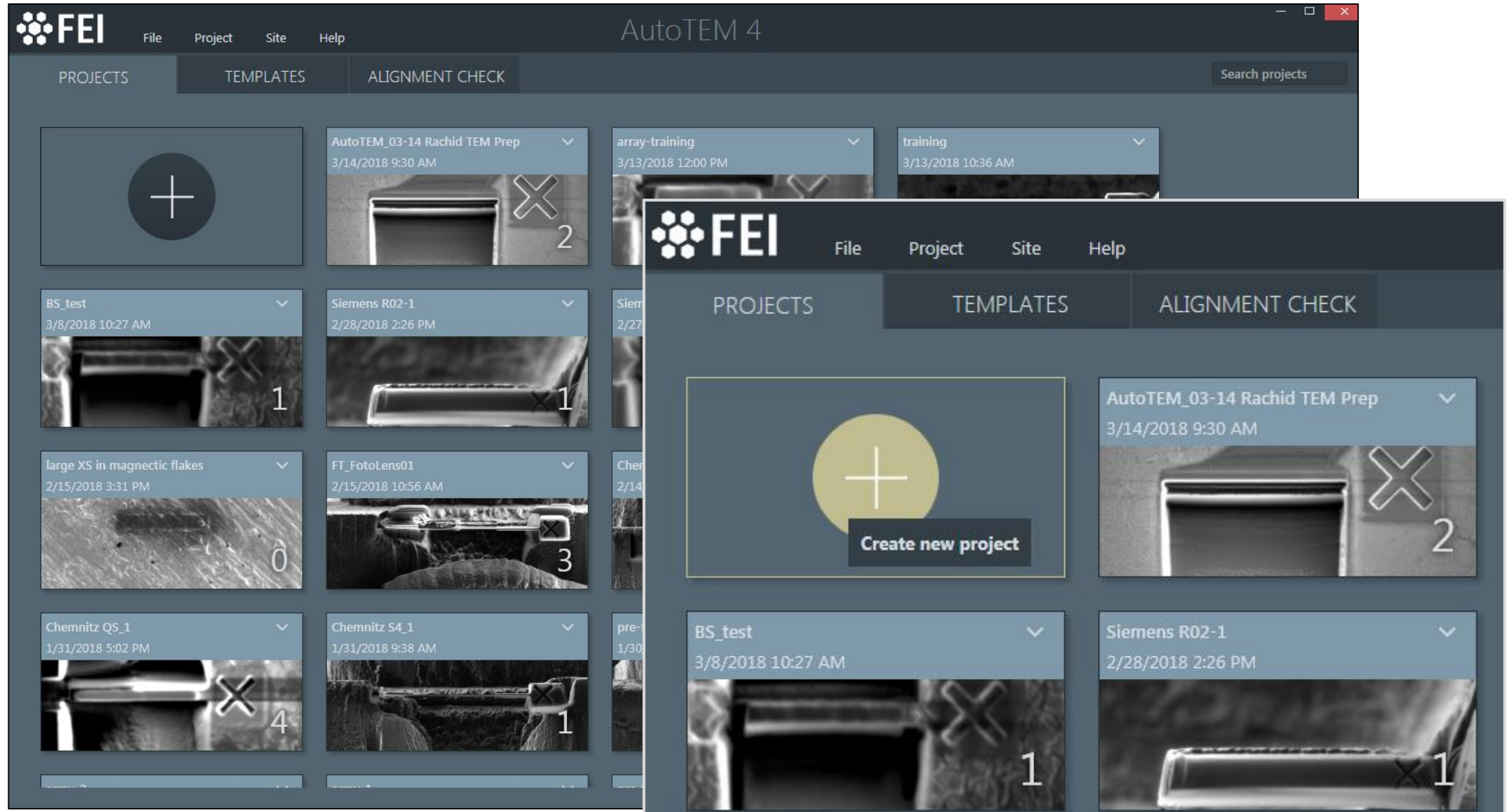
- None
- Sleep
- Beams Off

FIB imaging conditions changed for high BC and default BC is changed

Automation can be set here

NOTE: settings are not linked to a project or template (can be changed by any user)

AutoTEM4; starting by creating (or opening) a project



AutoTEM4; workflow

The screenshot displays the AutoTEM 4 software interface. At the top, the FEI logo and menu items (File, Project, Site, Help) are visible. The main window is titled 'AutoTEM 4' and shows a 'SITE LIST' on the left with 'Site #1' selected. The central area is divided into three columns: 'In-situ lift-out', 'Ex-situ lift-out', and 'Cross section'. Each column has a 'Choose template' button and a list of templates. Below these columns are two large panels: 'Chunk Position' and 'TEM Grid Position', each with a list of preconditions. At the bottom, a progress bar shows the current step: 'Site #1 15.0 μm × 5.0 μm Top-down ebn'. The progress bar includes icons for 'CHUNK MILL Automatic', 'LIFT-OUT Guided', and 'THINNING Automatic'. On the right side of the progress bar, there are fields for 'Site' and 'Project', a 'RUN' button, and a 'STOP' button. The status bar shows 'N/A 0% 39 min 46 s' and 'Guided'.

Choose template

In-situ lift-out

Ex-situ lift-out

Cross section

Chunk Position

Preconditions:

- Stage at eucentric distance and Z linked
- Tilted at 52°
- Ion beam focused

TEM Grid Position

Preconditions:

- Stage at eucentric distance and Z linked
- Tilted at 0° (or proper angle if using a pre-tilted hold)
- Ion beam focused on the grid
- HFW approx. 200 μm

Site #1
15.0 μm × 5.0 μm
Top-down ebn

CHUNK MILL
Automatic

LIFT-OUT
Guided

THINNING
Automatic

Site: _____ N/A
Project: _____ 0% 39 min 46 s

RUN STOP

Guided

Define a site:
stage coordinates

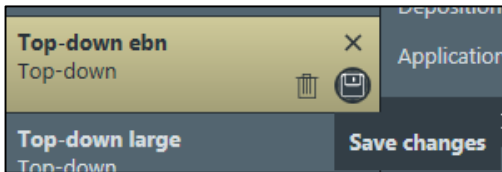
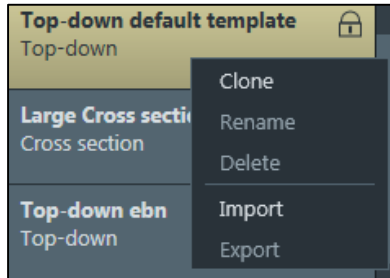
Automatic
Chunk mill

Guided
Lift-out

Automatic
Final thinning

AutoTEM4; templates

- Template can be modified
- Clone (RM) an existing template
- Rename
- Modify and save changes
- Note: in a site template temporary changes can be made



The screenshot shows the AutoTEM4 software interface with the 'TEMPLATES' tab selected. The 'TEMPLATE LIST' on the left shows several templates, with 'Top-down ebn' selected. The main area displays the parameters for the selected template, organized into sections: 'Chunk Mill', 'Lift-Out', 'Thinning', 'ELECTRON BEAM DEPOSITION', 'CREATE FIDUCIAL', 'GROUND', 'ATTACH NEEDLE', 'EXTRACT CHUNK', 'DRIVE TO GRID', 'GRID CLEANING', and 'WELD CHUNK (GIS FREE)'. Each section contains various parameters such as Size, Thickness, Deposition Voltage, and Milling Current, with some having dropdown menus or input fields.

AutoTEM4; creating site – stage position

The screenshot displays the AutoTEM 4 software interface. At the top, the menu bar includes 'File', 'Project', 'Site', and 'Help'. The main window is titled 'AutoTEM 4' and shows a 'SITE LIST' on the left with a '+' icon. The selected site is 'Site #1' with dimensions '15.0 μm × 5.0 μm', '0%' progress, and a time of '39 min 46 s'. The site configuration shows 'Site Name: Site #1' and 'Template: Top-down ebn'. Below this, three process steps are visible: 'In-situ lift-out' (selected), 'Ex-situ lift-out', and 'Cross section'. Each step has a 'default template' dropdown. The 'In-situ lift-out' dropdown is open, showing options: 'Top-down ebn' (checked), 'Top-down large', and 'Top-down MgO'. A green checkmark is next to 'Top-down ebn'. The bottom of the interface features a progress bar with icons for 'CHUNK MILL Automatic', 'LIFT-OUT Guided', and 'THINNING Automatic'. On the right, it shows 'Site Project' progress bars, 'N/A' for the site, '0%' for the project, and '39 min 46 s' for the project. A 'RUN' button and a 'STOP' button are also present.

This inset screenshot shows a context menu for 'Site #1' in the 'SITE LIST'. The menu items are: 'New', 'Clone as Array', 'Clone', 'Save As Template...', 'Update Template', 'Delete', 'Go To Chunk Position', 'Go To TEM Grid Position', 'Delete All', 'Select All', and 'Deselect All'. The 'SITE LIST' on the left shows 'Site #1' with dimensions '15.0 μm × 5.0 μm', '0%' progress, and a time of '39 min 46 s'. The 'In-situ lift-out' template is selected for this site.

AutoTEM4; when bulk sample it too high

The screenshot displays the FEI AutoTEM 4 software interface. The main window shows a top-down view of a sample with a 'Chunk' highlighted. The 'LIFT-OUT' panel on the right lists the following steps:

- DRIVE TO CHUNK (checked)
- ATTACH NEEDLE (checked)
- EXTRACT CHUNK (checked)
- DRIVE TO GRID (highlighted with a red circle)
- GRID CLEANING (unchecked)
- WELD CHUNK (GIS FREE) (58 s, checked)
- WELD CHUNK (48 s, checked)
- CUT OFF (42 s, checked)

A warning message is displayed below the steps: "Please meet all the preconditions, then locate a grid finger in XT UI and update the image. Move graphic to the left edge of the grid finger." Below the message is a small inset image showing a grid finger.

The bottom status bar shows the current step is 'LIFT-OUT Guided' and the system is 'Waiting to continue...'. The 'CONTINUE' button is highlighted.

When a sample is too high, Run entire process without updating TEM position at the start.

Arriving at this point of the process a TEM grid position needs to be defined. This can be done after venting and taking out the sample. When vacuum is ok again, move to the TEM position, set height and tilt if needed. Update image and continue process from here.

AutoTEM4; building an array followed by lift-out and thinning

FEI AutoTEM 4

SITE LIST

- Array [1, 1] 12.0 μm \times 5.0 μm 46% 14 min 19 s
- Array [1, 2] 12.0 μm \times 5.0 μm 46% 14 min 19 s
- Array [2, 1] 12.0 μm \times 5.0 μm 0% 26 min 35 s
- Array [2, 2] 12.0 μm \times 5.0 μm 0% 26 min 35 s
- Array [3, 1] 12.0 μm \times 5.0 μm 0% 26 min 35 s
- Array [3, 2] 12.0 μm \times 5.0 μm 0% 26 min 35 s

Position

distance and Z linked
per angle if using a pre-tilted holder
on the grid

LIFT-OUT

Welding Position: Left
Attachment Offset: 100 nm

- DRIVE TO CHUNK 1 min 40 s
- ATTACH NEEDLE 1 min 44 s
- EXTRACT CHUNK 1 min 17 s
- DRIVE TO GRID 1 min 8 s
- GRID CLEANING
- WELD CHUNK (GIS FREE) 32 s
- WELD CHUNK 1 min 6 s
- CUT OFF 42 s

Please meet all the preconditions, then locate a grid finger in XT UI and update the image. Move graphic to the left edge of the grid finger.

Array [1, 1] 12.0 μm \times 5.0 μm Top-down default template

CHUNK MILL Automatic

LIFT-OUT Guided

THINNING Automatic

Stopped Site: N/A Project: 46% 28 min 38 s

When building an array: choose a template with all 3 steps (chunk mill, lift-out and thinning)

Run drop down: **“Run chunk mill only”**.

When finished, the chunks can be revisited and decided to lift out one (or more) of them.

Revisit chunk position (RM on array site **go to chunk position**) and press run.

Guided lift out until **“drive to grid”**
Define a TEM grid position: move to the TEM position, set height, tilt if needed and update image.....
and continue process from here.

RUN STOP

- RUN ELECTRON BEAM DEPOSITION ONLY Guided
- RUN CHUNK MILL ONLY Automatic
- RUN LIFT-OUT ONLY Guided