# Instructions


  - Nova users' instructions:
  - Sample size: Wafers up to 2"
- Basic operations:
- Mounting sample:
- Loading sample:
- SEM imaging and establishing eucentric height
- Milling and patterning sample:
- Milling and viewing a cross section:
- Saving an image:
- Platinum deposition:
- Ending Session:
- Useful software options: Auto Slice and View
- Problems:
- Following actions will be punished with revoking your access to both FIB systems:


## Nova users' instructions:

Described below are basic operation steps for using the Nova system, however, it is absolutely necessary that you make notes during the training session to capture the full capability of the system!

## Sample size: Wafers up to 2"

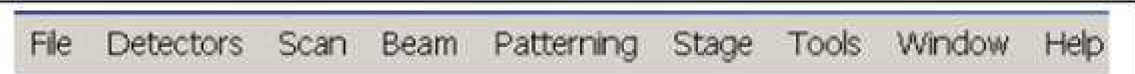
# Basic operations:

When opening the software it displays 4 image windows: e-beam image (top left), ion-beam image (top right), applications status and CCD camera image (bottom right). The 4th window is optional.

The windows are presented by following icons:

Left: e-beam, middle: ion-beam, right: optical image (CCD camera)

On top of the screen is the *Menu bar:*

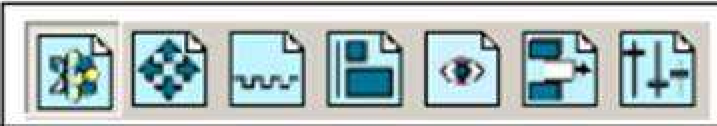



File: administrative functions; Edit: edit patterns; Detector: list of detectors; Scan: scan conditions for e-beam and ion-beam; Beam: choice of beam conditions; Patterning: patterning and deposition

conditions; Stage: stage navigation and corrective functions; Tools: image auto functions; Window: image display functions; Help: on-line help.

Most of the functions of the pull down menus can be operated with keyboard functions, mouse functions or toolbar icons.

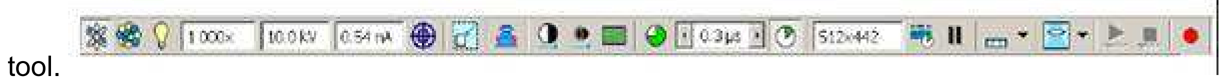
On the right side of the screen are 7 icons for *Pages and Modules* :



(From left-to-right) Beam control, Navigation, Patterning, Processing, Detector, Sample Prep, Alignment

These are the main pages for operating the system.

The *Toolbar* allows system functions by using their icons. Resting the cursor on the icon for 2 seconds displays the use of the




tool.

The toolbar contains icons (from left-to-right) for beams, column settings, lens alignment, scan functions (videoscope, reduced area), link z to FWD, lens and scan functions, auto functions, scan speeds, pixel resolution, image caption, pause, filtering, e-beam modes, patterning and movie recording.

In general there are multiple ways operating the systems: MUI, keyboard and mouse or pull-down menus. Please familiarize yourself with the options during attending the training sessions (and using the FEI xT Nova Nanolab complete user's manual).

# Mounting sample:

- Mount your sample on a specimen stub using carbon tape; wearing gloves is MANDATORY for preparing the sample! Non-conductive samples may be coated with a gold layer to avoid charging. (Any questions about sample prep, please ask staff BEFORE loading sample into the machine.  Powders require special handling procedures and are allowed on a case by case basis and MUST BE APPROVED BY STAFF BVEFORE PUTTING INTO THE SYSTEM)

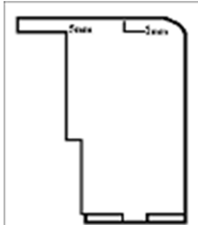
# Loading sample:

1. Log on to xT server software (using "log on" box on screen with your user name and password)

2. Go to beam control page and click Vent, resulting a window pops up prompting you "venting are you sure?"-click "ok". Venting takes about five minutes minutes-the vacuum status sign switches from:

to when the system is vented. Note that there is not a Wide-Range Pressure Gauge on the system so you will not know when it is fully vented – you will just have to try to open the chamber. If gently pulling on the door does not open it, you need to keep waiting for it be vented.

- Open chamber and fix the specimen stub to the holder and tighten the grub screw (only finger tight!) using an Allen key.
- Use the measuring tool (elephant nose) to ensure that the highest point of your sample is below 5 mm!!!Make sure that you place the elephant nose on the sample stage (lower stage) and not on the micromanipulator stage!



NEVER close the chamber door without checking the height of your sample!!! Violation will result in losing your access to the system! NEVER leave the measuring tool inside the chamber!!!

- In case you have to lower the stage use the manual z-knob. Please make sure that the chamber is exposed to ambient atmosphere as short as possible. NEVER lean on the chamber door!!!!!
- Close the chamber door (gently); watch the process on quad 3 and press pump on beam page. Pump down time will be about 5 minutes-vacuum icon turns green when the chamber is pumped down- if it is longer than 7 minutes please stop and find staff.
- Click wake-up button in case system was in sleep mode; this will turn on the e-beam and ion beam source (FEG source is always on, as indicated by the green source sign). If the system was in use before and the ion source is already turned on (you can check that by clicking on quad 2 and checking the source bar on the beam control page), activate quad 1 through clicking on beam on on the beam control page. Yellow highlighting always indicates activated.

# SEM imaging and establishing eucentric height

- Verify that quad 1 (e-beam) is activated (click in quad 1, status bar at the bottom of the window is blue, when activated), and un-pause the beam in tool bar using:

- Image the sample and focus on a distinct feature (highest point of your sample) with a magnification around 2000-5000x (mode I, SE, Detector page). Correct for astigmatism, adjust contrast and brightness (can be achieved manually, or automatically by clicking on icon in toolbar or pressing F9).
- VERY IMPORTANT: Make sure you have a well-focused image with a magnification of 2000 - 5000x. Link now the z to free working distance by clicking on the Z-FWD icon:

Will turn to

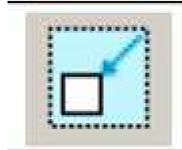
If icon changes to at any point in time while using the instrument, you need to re-link the z to free working distance by clicking that icon again.

This step is very important, linking the focal distance to the free working distance activates the touch alarm sensor; if your sample is moving to close to the column a touch alarm is triggered and you have to home the stage.

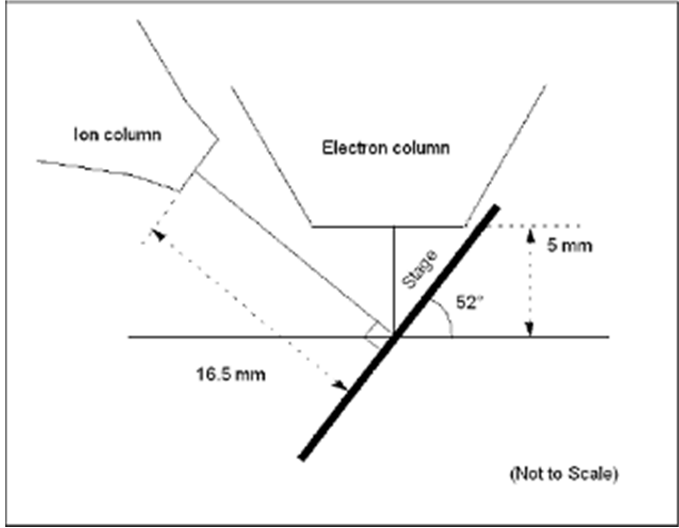
- Go to navigation page (coordinates) and bring your sample in small increments to » 4.8mm, which is close to eucentric height (move to e.g. 8 mm, 6mm and finally 4.8mm -you can move the stage in "z" by clicking enter or go to).
- Display the small yellow cross in the center of the screen (pull down menu bar "windows" and click on center cross or press Shift+F5).
- Make sure you have a recognizable feature located at the center cross and your magnification is 1500 - 5000x. You can use the reduced scan area button:

Reduced area can be used as an aid to focus as the scan speed is faster and the scanned area is smaller.

- In order to establish eucentric height-after moving sample to 4.8mm and finding a feature to zoom in / align on at 2500X , tilt the stage in small increments as follows - 2°, 5°, 10°, 20°, 40°, and finally 52° (enter tilt angle in the "T" box of the navigation page). If feature moves, bring your feature back under the center cross by manually changing the height with the z-knob on the chamber door (careful!). Tilt back to 0 ° and refocus then tilt to 5-10 ° and repeat procedure. The feature has to stay in the center, continue this procedure (tilting sample above tilt values until you can tilt the stage to 52º without the feature moving out of the center. Eucentric height should be around 4.8 mm (4.8 - 5.1 mm). After tilting the stage to 52°, the sample is perpendicular to the ion-beam.



- Switch to ion beam (quad 2) and check on beam control page that beam on is activated (yellow). Set the aperture to 10pA - 50pA for adjusting your ion beam image - do not un-pause your beam - imaging with the ion beam is sputtering your sample! Take a snapshot (single scan, "life" no averaging):



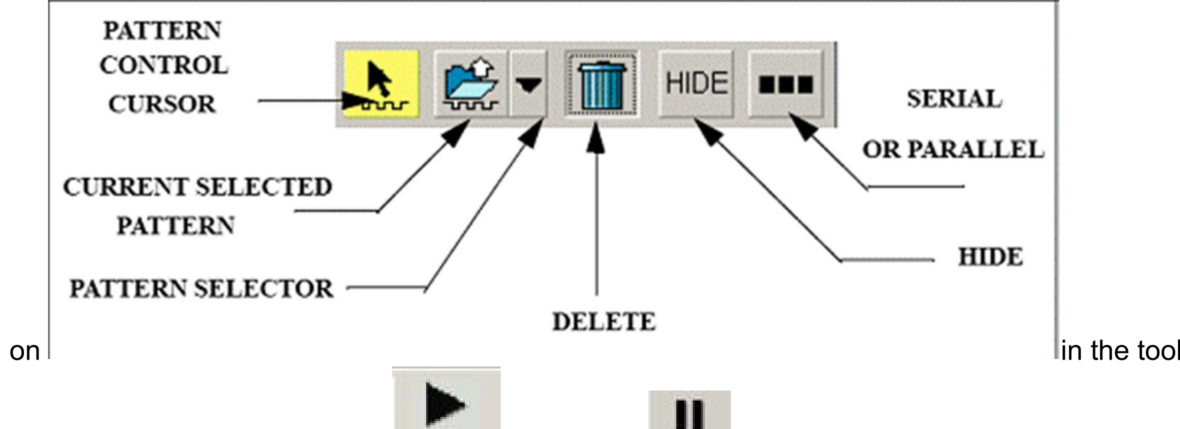

- Adjust focus, astigmatism, contrast and brightness of your ion beam image by either reducing scan area (move it to an area of your sample that is not precious to you and adjust during life imaging) or correct by adjusting and taking snapshots.
- Now adjust e-beam and ion-beam to be coincident by bringing the sample spot of interest into the center using beam shift (beam control window or MUI). Magnification of e-beam and ion-beam can be coupled by activating couple magnification on beam control page.

# Milling and patterning sample:

- Make sure the beams are coincident and both e-beam and ion-beam image are in good focus. Switch back to e-beam quad and locate the area for milling.
- Switch to ion-beam and take a snapshot, then switch to patterning page and select the desired pattern (e.g. regular cross section) from patterning selector. Drag out box of dimensions for patterning with the mouse (size of pattern can be altered by changing x & y values in the patterning box or with mouse). Bitmap files can be uploaded-files have to be stored on the microscope computer (not support!) in the "userfiles" folder. Bitmap

files are the ONLY files you are allowed to store on the microscope computer! FEI provides pre-defined application files in the patterning box. Milling time is determined by volume per dose parameter and beam current.

- Milling is performed at 30 kV; choose a beam current so your milling time is in a reasonable time frame. Cross sectioning requires usually a larger aperture setting (beam current > 1nA). Take a snapshot and make sure image is in good focus. At higher beam currents, do NOT un-pause the beam - scanning will damage your sample!
- Start the milling process by clicking on




in the tool bar. Patterning can be paused or stopped. It is recommended to take periodical snapshots during milling to ensure that there is no drift. If you restart patterning after pausing it will resume.

- The end point monitor shows the specimen current and provides information on the progress of the milling process.

# Milling and viewing a cross section:

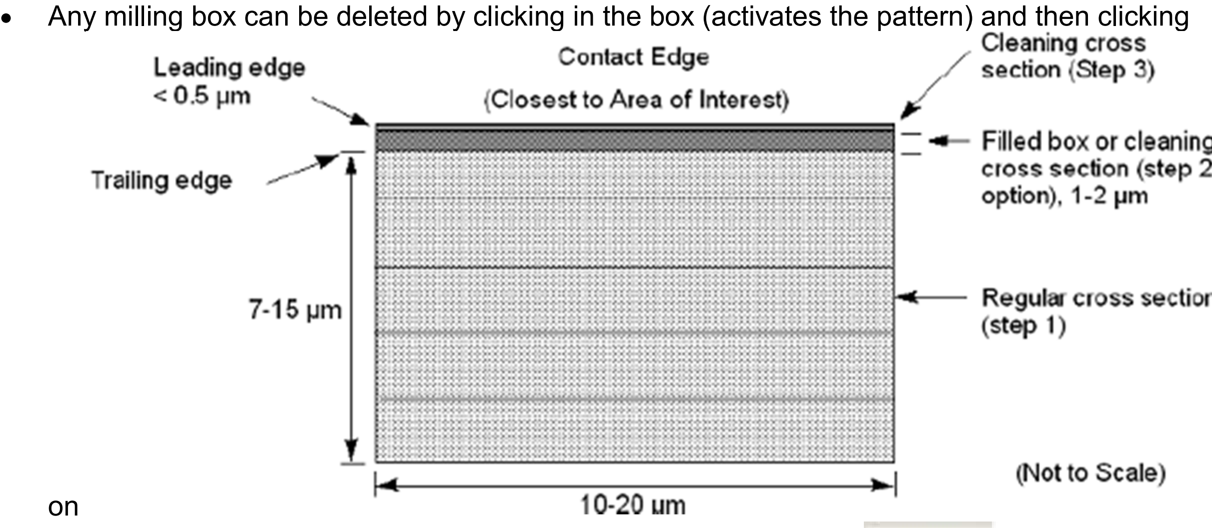
- Make sure the beams are coincident and both e-beam and ion-beam image are in good focus. Switch back to e-beam quad and locate the area for milling.
- Switch to ion-beam and take a snapshot, then switch to patterning page and choose regular cross section. Draw the box with the mouse. Cross sections are milled in stair step pattern, which allows viewing the exposed layers at a stage tilt of 52°.

If you have a very specific area you want to cross-section, be aware of offsets for large beam currents (position the box approx. 2 µm away from the point of interest). Define the outline of the box relative to the depth you wish to mill (y dimension should be 1-2x z-dimension). Use a second milling step as indicated in the figure if you are milling a large area.

- In order to remove re-deposited material and damaged edges perform a cleaning cross section (step 3 in figure). Choose "cleaning cross section", draw box, adjust the box that its leading face

crosses the target area and the trailing edge extends just beyond the rough cut, and reduce milling depth. Reduce the beam current for the cleaning step (100pA - 1000pA).

- Viewing the cross section: The cross section can be viewed with the e-beam without moving the stage or with the ion-beam by tilting back to 0 ° and rotating by 180 ° (scan rotation). Keep in mind that viewing with e-beam causes much less damage than imaging with ion-beam.
- Any milling box can be deleted by clicking in the box (activates the pattern) and then clicking




on

- For high resolution SEM imaging, switch to Mode II by clicking on in the tool bar. Mode II can only be used at magnifications > 1000x and kV settings lower than 18 kV. Mode II is STRICTLY forbidden for magnetic samples!!!

# Saving an image:

- Achieve a desired image, focus, correct for contrast and brightness, go to Scan in menu bar, select photo (or press F2), and save photo on support computer in "userfiles" in your folder. Settings for "photo" or "snapshots" can be changed in "preferences"-"scanning". Please choose one of the preset settings, DO NOT modify settings.
- Switch to Measurement/Annotation page. Measurement functions on this page allow you to measure distances, angles, diameter, etc., and label them. Click on appropriate symbol button this opens property list (click in there to change color, font etc.)
- The saved images include a scale bar and time stamp. Toolbar settings can be also changed in preferences.
- It is NOT allowed to store images on the microscope computer!

# Platinum deposition:

Follow step 1 - 14 (loading sample and setting eucentric height). It is VERY important to bring the sample to eucentric height, Make sure that you set eucentric at the highest point of your sample, if

your sample is not flat contact staff. Failure to set eucentric height may result in damage of the Pt deposition needle and users will not only be liable for any damage, but misuse will also lead to loosing access to the FIB systems.

- After bringing the sample to eucentric height and tilting to 52 °, go to "patterning" page. Click on Gas injection box on patterning page.

Double click on cold next to Pt dep. This will heat the gas injection source (GIS) source to 44 °C. When it is fully heated cold is replace with warm.

- Select a pattern from the pattern module and drag out the pattern.
- Select Pt dep in the application file menu - milling box is green when Pt dep application is selected.
- Estimate the beam current depending on the size of your pattern and following the relation: **2-6pA/um^2.**
- Inject the GIS needle by clicking in left to Pt dep. in the GIS injection box. The computer will prompt you: "Is it safe to bring the needle in?" (If you are not sure that the sample is correctly set to or (below) eucentric height DO NOT insert the needle). The inserted needle is only 100 - 200 µm away from eucentric height and is inserted at a high speed! Again your sample is at eucentric height when a recognizable feature set to the middle of the window (overlapping the center cross) does not move out from the center when tilting the sample (make sure that you are working at an appropriate magnification of 2000 - 5000x).
- After you insert the needle, take another snapshot (images might move due to insertion of the needle).
- Start the deposition by clicking on

in the tool bar. The GIS opens automatically when patterning is started. Progress of the deposition can be simultaneously monitored with e-beam or periodically monitored by taking snapshots with ion-beam.
- When deposition is finished FIRST retract needle by ticking off the in box in the GIS injection box.
- Double click on warm next to Pt dep to cool down the GIS. Remove your pattern by activating the box and then clicking on trash

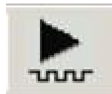
# Ending Session:

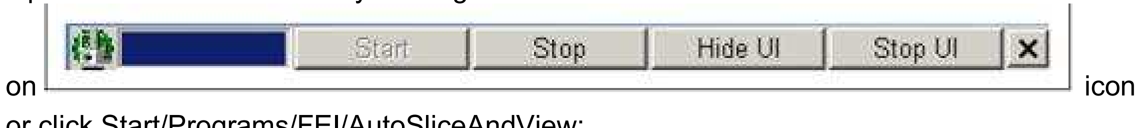
- Tilt stage back to 0 °. Pause beams, go to beam page and click beam on (when the color of the button turns from yellow to grey the beam is turned off) then click vent. The computer will prompt you "Venting, do you want to vent the chamber?"-click "ok". Venting takes approx. 3-5 minutes.
- Make SURE you are wearing gloves before you open the chamber. Loosen the grub screw with the Allen key and take your stub with sample out. Never try to just remove your sample from the holder!!!
- Take out your stub/sample. If you load another sample, make sure to check the height of your new sample again before closing the chamber door.
- If you finish your session - take out the sample, gently close the chamber door and pump down. Log off from the software interface.
- Clean up.

# Useful software options: Auto Slice and View

Auto Slice & View (Auto S&V) automatically mills consecutive slices through a three-dimensional feature, collecting images of the slices. When the operation is complete, you can review the images individually or in an animated sequence called a "movie". You can also review images offline, using any bitmap editor. An Auto Slice & View operation consists of up to three process steps: protective coating, rough cut, and slice.

  - Perform a cross-section cut (rough) and cleaning step following the procedure above (at established eucentric height and a tilt angle of 52°).
  - Hide interface on **Server Dialog bar**



  - Open Auto Slice and View by clicking on 

icon or click Start/Programs/FEI/AutoSliceAndView;

Program contains 5 pulldown menus: *File, Setup, Utilities, View* and *Help*

- Select Setup>e-beam scan parameters to set e-beam resolution and scan time.
- Click Show UI on Server Dialog Bar
- Set parameter for slicing (if a rough cut is done, no settings for projective layer and rough cut are needed)
- Click show/refresh to update/check setup
- Optimize e-beam image
- Click run
- For viewing slices: select view "animate"

# Problems:

- *Stage freezes:* In case the stage freezes or one of the axes is grayed-out, perform "home stage" (stage pull down menu).
- *Software freezes*: Close program and then restart the computer (log on to windows using your xT server user ID and password). If you are not sure, please contact Eric immediately! Please email Eric if you restart the microscope PC.
- *Touch alarm triggered:* This will freeze the stage and you have to perform a home stage. Notify staff immediately.
- *Chamber is not pumping down: Call Eric*.
- *Emission current (ion beam) cannot be maintained:* Call Eric

# If you do any of the following, your access to the system may be removed:

- Handling samples and loading samples without gloves.
- Operation of the system without linking z to FWD.
- Not establishing eucentric height for Pt deposition and milling.
- Deactivating touch alarm sensor.
- Unlinking Z to FWD.
- Attempting to install software on support or microscope computer.
- Any attempt to do mechanical or software alignment.
- Any careless handling of the FIB systems.