

FIB Milling

v2.0

1. Follow procedure in SEM imaging. Standard imaging conditions: 5-20 kV EHT with either 60 or 120 μm aperture in high current mode
 2. Position sample such that when it is tilted to 54 degrees, it will not collide with the pole piece.
 3. Find sample with SEM, adjust focus and stigmation.
 - Set WD to > 10 mm so that there is enough clearance for the **M** adjustment.
 - Turn on the crosshairs
 - >>View >> Crosshairs (Also a button on the Tool Bar).
 4. Set the eucentric point
 - Center a feature in the crosshairs at low magnification.
 - Tilt stage to 5 degrees. Adjust M axis to re-center feature. This is done by pushing the **M** axis arrow button in the direction that the feature moved.
 - Tilt stage to 10 degrees. Adjust M again to re-center feature.
 - Alternate between 5 and 10 degrees, adjusting M so that feature does not change when tilted.
 - Tilt to 54 degrees.
 - **Record the final M axis value. This value will be unique to the selected stage and sample. If same setup used again, you can type in the M value
 - >>SEM Control >> Stage menu.
 5. Turn on the FIB Gun
 - Bring up the >> FIB Control menu.
 - Check Aperture status. If un-initialised, indicator will be red.
 - Click **Initialise**.
 - Check vacuum status.
 - >>SEM Control >> Vacuum
 - Vacuum must be better than 5×10^{-5} mbar for FIB use.
 - To open the Gun Valve and to turn on the FIB:
 - Click **On**
 - The 'on' button sometimes needs to be clicked twice if it does not turn on the first time.
- ** Note that all FIB settings are global. The default FIB beam selected when you open FIB control will be whatever beam the last user selected.
6. Set coincidence point between SEM and FIB beams (focus the two beams on the same point in space).
 - Change to the 30 kV, 50 pA beam.
 - Mill Tab >> 'Imaging' Menu >> 30 kV:50 pA
 - Also change the beam in the 'Milling' Menu
 - The 30 kV:50 pA beam is the reference beam, all other probes are calibrated to this one.
 - Turn on "Track Z" and the crosshairs.
 - Turn on 'Tilt Correction'.

Pull out menu >> Rotate/Tilt menu >> Check 'Tilt Corr.' Set Angle to 54 degrees.

Tilt correction can also be toggled on the Data Zone.

- Start in SEM mode. Focus on the on the surface of the sample.
- In SEM mode, slowly increase WD to 5 mm. Watch the WD on the Data Zone and control rate of increase with magnification.
- Center the crosshairs on a feature that will be visible by both the SEM and FIB. Use the joystick and not beam shift. Zero out any beam shift in the SEM image in SEM Control >> Apertures >> Beam Shift.
- Switch to FIB mode by pressing **F8** or by selecting "FIB Mode FIB" in the drop down menu in the upper right hand corner of the screen.
- In the FIB image, center the same feature in the crosshairs in the 'y axis' of the screen with Z movement, using the joystick.
- Still in the FIB mode: use X movement, with the joystick, to center the feature in the crosshairs on the 'x-axis' of the screen.
- Change back into SEM mode (Select 'FIB Mode SEM', or press **F8**). Use **Beam Shift X** to center the same feature in the 'x axis' of the screen.
- The same feature should now be centered in X and Y in both the FIB and SEM images.

7. Optimization of FIB probes

- Make sure adjust focus and stigmation for FIB beams before milling.
 - Stigmation is most easily adjusted in FIB Control >> Align Tab. Select the beam to optimize in the 'Probe Current' drop down menu.
 - Click the 'Stig' button, carefully adjust sliders on right to tune stigmation.
 - Check quality of beam by drilling a hole.
 - Pullout menu >> Specimen Current Monitor. Check 'Spot' to drill spots.
 - If spot is distorted, adjust stigmation and focus.
- **Note, focus and stig changes are global settings and affect all user accounts.

- 30 kV beams are suitable for most usage, 1 and 5 kV beams are used for polishing.

7.1 Advanced Optimization of FIB probes

- This requires advanced user privileges. If the 'Save' button is shown on the Align tab in FIB control, privileges are enable on your account.
- Load the Faraday cup sample in the 9x9 holder. Set up SEM and FIB.
- All optimization done in the Align tab in FIB control. Start by selecting probe in Probe Current menu.
 - A. Adjust Wobble.
 - In the drop down menu called 'OFF', select 'ON FOCUS'. This will initiate the wobble routine. In the reduced window raster that starts immediately, adjust the aperture in 'Aperture Steps' to remove movement in both the X and Y axis. The image should just come in and out of focus, just as with the SEM wobble.
 - Click the **Y-Up**, **Y-Down**, **X-Right**, and **X-Left** buttons to move the aperture. Choose the step size in the menu to the right from Fine to Course. Fine is appropriate for most cases.
 - When down, select 'OFF' in same menu.
 - B. Focus and Stigmation.
 - Adjust focus and stigmation as done above. Probe spots should be round.
 - C. Condenser.
 - Bring up the 'Specimen Current Monitor' Menu. Check 'SCM On'. Check the 'Spot' and move the spot on the screen to the center of the aperture on the Faraday cup.

-Note, with SCM on, the touch alarm is disabled. Be sure to disable the SCM when you are done.

-The 'Specimen I' will read the probe current. If current value is more than 2% different from the nominal probe current value, adjust the current with the FIB Condenser voltage.

-Click 'Modify Condenser' at top of Align menu. Use slider to adjust the FIB Condenser voltage. Higher voltage → higher probe current.

-When done, click the Save button at the bottom.

D. Beam Shift Correction

-All probes are calibrated to the position of the 50 pA beam.

-With the 1 nA probe, mill a 10 x 10 μm 'Alignment Mark'. This will mill a large 'X' shape.

-Start with the 50 pA probe, center the cross-hairs in the center of the 'X'.

'Beam Shift Correction' will be grayed out.

-Change to the probe you want to adjust. Use 'Beam Shift Correction' to re-center the crosshairs in the center of the 'X'.

E. Saving

-To save the new, optimized FIB probe values, click the **Save** button three times.

(Sometimes it does not register on the first time.)

-If at any point in the process above (particularly with wobble), the probe optimization procedure goes south, you can return to the initial state by choosing a different probe in the FIB Current menu, then returning to the original probe.

-Settings are not saved when probe is changed, unless you click **Save** 3x.

8. SmartSEM for milling:

-Button next to the FIB control box has a drop down menu to select shapes to mill

-Choose either line, box, or trapezoid.

"Fine" shapes are for GIS operations

"Coarse" shapes are for mill jobs

- 'Mill' Tab in FIB control is used to define mill parameters for a given shape

- Red line on shape is where the mill ends

- Select milling current and potential

- Choose 'mill for time' or 'mill for depth'.

- 'Clear list' then 'add' you feature. Click 'mill' to start.

9. Simultaneous FIB and SEM

-Use the 60 or 120 μm SEM aperture in High Current Mode.

- Under FIB control tab, there is an option for 'Mill + SEM'. This will start a SEM scan when a FIB job is started

- Use SESI detector in SEM mode during mill. Make sure to unlock mags before start, so that the SEM mag can be changed during mill. Use SEM X and Y beam shift to find feature. Do not change XY of stage.