Basic Operating Instructions for Strata Dual Beam 235 FIB/SEM

Warning

Always adjust your specimen height before closing the chamber door to make sure your specimen will not hit the bottom of the lens; see instructions for details.

If your samples are not flat, discuss with a Lab Manager before using the FIB.

Do not put magnetic samples in the FIB without prior discussion with a Lab Manager.

Note

New users should familiarize themselves with the icons and menus, and the windows on the right-hand side of the screen.

Start-up

1. Log into Badger with your Badger id and password. Enable the FIB.

2. Log in to the FIB computer with your user id and password.

3. Check that the Vacuum and High Tension (HT) hardware buttons are lit.

4. Check that the ion source is on (yellow). If not, turn on the ion source to warm up. Emission will fluctuate for a few minutes, but should stabilize at 2.1 – 2.3 μamps. The extractor is set at 12.00 kV; suppressor varies.

   For more info and instructions on what to do if you think the source is not behaving properly, see the last page of instructions.

5. **Load sample:**
   Choose OM in "detectors" menu. In RH start up window, choose "Vent", then "OK". Venting takes 3 – 5 minutes until the front door of the microscope can be opened.

   When inserting your sample:
   - **a) wear gloves**
   - **b) make sure set screw is not engaged when you place your sample in the mount. Tighten the set screw gently** (barely finger-tight, **DO NOT OVERTIGHTEN**)
   - **c) adjust the top of the sample to 5 mm from the lens** (use eucentric height adjuster, aka. "elephant ear")
   - **d) watch OM image while closing the chamber door to make sure the sample does not touch the lens**

   While holding the door firmly closed via the push bar, click on "pump" command. Keep pressure on the door for a few seconds; tug to check the seal. Click "cancel" on the "Confirm holder settings" dialog box. Wait until "Vac OK" message appears at the bottom of the startup page, about 3 – 5 mins. Chamber vacuum must also be below 1.2 x 10^{-4} mbar.

6. **Bring up electron and ion HV:**
   Turn on HV for electron and ion beams (independently), which are usually at 5 kV and 30 kV, respectively. Electron spot size is normally set at 3.

   IMPORTANT: When the electron column HV is turned on and the detector unfrozen, the "e-beam confirm focus" window pops up. DO NOT CLICK "OK" ON THIS WINDOW UNTIL YOU OBTAIN A SEM IMAGE AND FOCUS AS INSTRUCTED (see following). This tells the computer how far your sample is from the lens.

7. **Obtain SEM image, set height:**
   With "primary beam – E" icon highlighted, choose either the SED or CDM-E detector. **Start scanning**. Adjust your contrast/brightness knobs to give you an image. Focus it as you move up to the 5000 – 8000X magnification range. Focus well, and the free working distance "FWD" (bottom of the screen) will now read the focal length of the objective lens, which should be set as the sample height. Click "OK" on the pop-up window to calibrate Z to FWD.

   At this point, the SEM capabilities are set up for basic use. Translate to your sample using the joystick, mouse, and/or stage table, reconfirm Z as necessary, refocus/stigmate, and you can perform any SEM imaging you need.

8. **Set eucentric height:**
   Eucentric height is about 5 mm for this machine. On the workpage, set the sample height to 5 mm and refocus if necessary. At 12 – 20KX, place a recognizable feature on the center crosshair. Tilt the sample a few degrees. Re-center the feature (vertically with respect to the screen) using the "Z" knob on the stage door. Increment up a few more degrees and repeat. Continue (you can increase the size of the increments) until you get to 52º (perpendicular to the ion beam). Check that the feature is vertically centered at 0º and 52º.

9. **Obtain ion-beam image, adjust electron/ion-beam coincidence:**
   After setting the eucentric height, and while still at 52º, select a relatively non-destructive ion beam aperture (generally 10 pA). Check that your ion beam and electron beam mags are coupled. At 12 – 20KX, center a recognizable feature while still in e-beam mode. Choose “primary beam – I” icon. Adjust contrast/brightness and focus. Re-center the feature using the beam shift knobs.

10. **Proceed with your sample:**
    To obtain a good image and good ion etching/deposition results, you must stigmate and focus both the electron and ion beams properly. This takes practice. As you learn how to operate the instrument, make sure you are learning these procedures as well.

Aligning the Beams

Focusing and astigmatism corrections should be made at least one magnification step above where you want to take a final image.

These procedures are identical for both beams.

Be aware of possible beam damage as you align, so you may want to adjust these a little bit away from your area of interest.

Focusing: Use the hardware knobs or right-click and drag the mouse. Be aware of the sensitivity of the coarse and fine focus knobs, as one or the other will make more sense depending on your magnification. Also, if you are grossly out of focus, re-set the focal length to something that makes sense (about 5 mm + difference in height between your highest point and where you're looking) and work from there.

Astigmatism: If the out-of-focus image is streaky, and the streakiness changes direction 90º on either side of focus, there is astigmatism. Astigmatism also causes a loss of resolution at focus. With the specimen at focus, adjust the stigmators one at a time to obtain the sharpest image. Check focus (and check for streakiness), re-iterate as needed. If necessary, start at a lower mag and repeat the adjustment at the higher mag. Check your final focus.

If the image moves as you change focus, focus as best you can, then choose the lens alignment icon. This will fluctuate the focus from that point. Click and drag on the crosshairs in the pop-up window to minimize image movement. De-select the lens alignment icon, and check that the image no longer sweeps.

Remember that you should do your image corrections a magnification step greater than where you want to take your final image. Depending on your sample and microscope conditions, you may get better results either with a slow scan or by integrating fast scans.

Milling and Pt Deposition with the Ion Beam

Milling: Choose the appropriate aperture for your feature. Adjust contrast/brightness, focus, and coincidence (you may have to work very quickly if you use a large aperture). Freeze the image or grab a 1–Ion beam frame. Select the pattern shape(s) from the icons along the menu bar and draw what you want. On the work page, select serial (sequential) or parallel milling. Make sure "ion beam" is selected as the beam you will use (and is the primary beam). Choose the appropriate material resource file (generally si.mtr, regardless the actual material). Adjust the milling dimensions as required; the computer will determine the approximate milling time. Note that the milling will align with the continuous scan, and will be slightly offset from the 1-I frame. Click "start/stop patterning" icon to begin the mill. You can take 1-E and 1-I frames as you mill.

Pt Deposition (ion beam): almost identical to ion milling. Turn on the Pt heater and allow it to warm up (indicator becomes red) before use. **Make sure you are at eucentric** and insert the Pt needle. Inserting the needle may cause a small shift in the image (both location and contrast/brightness), so check pattern positioning after inserting. Choose the ion beam aperture via the following rule:

$$2 * \text{Area}_{\text{pattern}}(\mu m^2) \leq \text{Aperture size (pA)} \leq 6 * \text{Area}_{\text{pattern}}(\mu m^2)$$

Retract the needle when you are finished depositing. Do not translate or change tilt with the needle inserted.

Shutdown

1. Make sure any GIS needles are retracted and their heaters are turned off.
2. Return to the first 10pA ion beam aperture.
3. Return sample tilt to 0º.
4. If using “UHR” mode, return to “SRH” (search) mode. Reduce magnification all the way.
5. If using CDM-E, reduce contrast and brightness fully. Select SED detector to ensure CDM-E is off.
6. Set both x and y to 0 µm.
7. Turn off electron and ion high voltage by deselecting “HV” for each.
8. Leave the ion source on if the next user will be on within 4-6 hrs; else turn off the ion source.
9. Vent the chamber. Select OM.
10. Loosen the set screw (do not remove it completely), remove your sample.
11. Pump the chamber down again (following the appropriate steps); make sure you obtain “Vac OK” status.
12. Select SED to turn off the OM.
13. Log out of the system.
14. Clean up after yourself as you leave the room.
15. Disable the FIB from Badger.

Saving and Retrieving Files

To save an image, take a final image and choose File → Save. Save as a .tif file in your directory on the users drive on the buffer computer.

No image files are to be stored on the microscope control computer.

The buffer computer is networked, and has various slots available for removable media. Bring in **clean** media and do not disable the virus scanning.

Any image files more than 3 months old are eligible for immediate deletion. Any image files found on the microscope control computer may be deleted immediately. Do not assume the buffer computer will not crash randomly; get your files as soon as you can.

Restarting the Computer

Occasionally, things get corrupted and the Microscope Control computer needs to be shut down and restarted. **Note: this is for the computer only, not for the microscope itself.**

1. If possible, follow the shutdown procedures to take out your sample and put the chamber back to vacuum.

2. Close the Microscope Control program.

3. Double-click “Stop XP Services”. A window will pop up; check that all the services are indeed stopped when the program finishes.

4. Close all other applications.

5. Select “Shut Down” from the NT Start menu. **Do not simply restart the system.** ** See note below.

6. When the computer tells you it is safe, turn off the computer (the black one). Wait 30 seconds. Power it back up. It will automatically log you into NT.

7. Double-click “Start XP Services”.

8. Double-click “Microscope Control” to start up the control program; you will need to click through an event logging dialog box.

9. Log in.

10. Click on IGP to have the system read the gauges.

11. Click “Yes” to initialize the stage. The stage will drive to the various x, y, and tilt maxima, then return to zero.

12. Turn on the HT hardware button.

13. Start up the ion source.

14. Proceed as normal. **Note** The Microscope PC operates as toggle #1 on the box under the monitor. The EDAX computer is #2. Do not shut down the EDAX computer by accident when restarting the microscope computer.

Turning on and Heating the Ion Source

The ion source sometimes gives error messages when turned on that say the emission current cannot be reached. If the emission current is in the range 2.0 – 2.3 μA, you may click “OK” and proceed.

If the emission current is low, you can try increasing the suppressor **very gradually** to see if the source reaches 2.2 and stabilized. If the current is high, depress the suppressor **very gradually**. (The extractor is a coarse adjustment of the extraction voltage. **Do NOT change the extractor**).

If the suppressor is positive and at its maximum (+2150V) and you cannot achieve a stable 2.2 μA emission current, the source **may** need to be heated. Also, if you find the current going through the aperture when the beam is blanked is significantly lower than the nominal aperture size, this is indicative that the beam needs to be heated.

Do NOT heat the ion source if you have not been given authorization by a Lab Manager for this procedure.

Heating the ion source should only be done once every week or two. Please do not heat unnecessarily as this depletes the source. As already mentioned, the source is often OK even if error messages appear. Also, no more than 2 heats of the ion source may be done within an hour’s timespan.

There is a separate clipboard log in the FIB room for the source heating.

More detailed information about the source is contained in the FEI handout entitled “LMIS Heating”. LMIS stands for liquid metal ion source.