University of Minnesota Nano Fabrication Center
Standard Operating Procedure

Equipment Name:	Focused Ion Beam (FIB)		
Coral Name:	fib	**Revision Number:**	2
Model:	FEI Quanta 200 3D	**Revisionist**:	Kevin Roberts
Location:	Area 3	**Date:**	9/17/2013

1 Description

The Quanta 200 3D is a DualBeam system (fitted with both an E-beam and an Ion Beam) comprised of a tungsten electron column and a Ga ion column that uses either high vacuum or environmental SEM (ESEM) technology to section, image, and analyze a wide range of conducting and non-conducting samples. This system offers the capability for in-situ dynamic experiments, 3D imaging and analysis, and transmission electron microscope (TEM) sample preparation for more in-depth analysis.

2 Safety

a Must be a qualified user who has taken the short course and the follow-up with an NFC instructor before operating the machine independently.

3 Restrictions/Requirements

b Must be a qualified user who has taken the short course and the follow-up with an NFC instructor before operating the machine independently.

4 Required Facilities

a 240 VAC, 30 amps
b 10 psi nitrogen

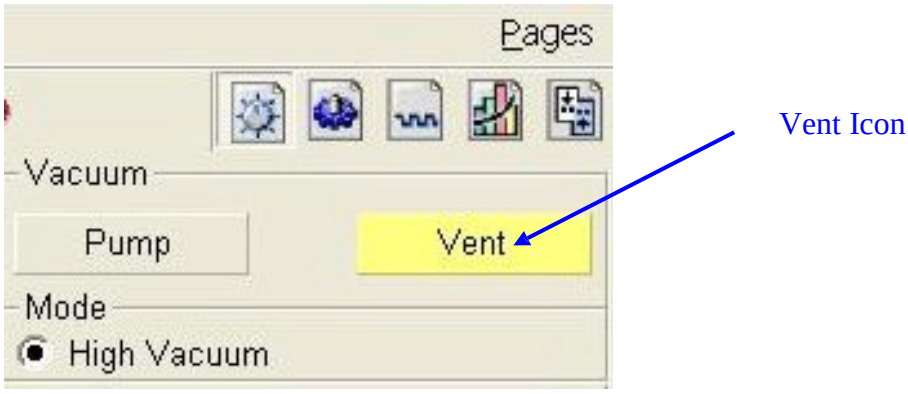
5 Definitions

a Working Distance (WD) — physical distance between the sample surface and the pole piece of the e-beam column.
b Focused Working Distance (FWD or 'WD' on Data Bar) — working distance as determined by the electron optics of the column. This value is displayed on the data bar of the image. This value changes as one adjusts the focus knob.
c Eucentric Height — the height at which the specimen can be tilted and no projection of the image is seen in the vertical axis of the screen. This is related to the design of the electron optics. This is approximately 15 mm from the Electron Beam's pole piece in the Quanta 200 3D, but may vary slightly based on the acceleration voltage used. This is also the height at which the Ion Beam has been engineered to cross paths with the Electron Beam in the Quanta 200 3D
d Beam Coincidence — making the Ion Beam coincident with the E-beam. This is usually done using the Ion Beam's 'beam shift' capability with the E-beam's 'beam shift' set to zero. However, the E-beam's beam shift may also be adjusted if necessary. Note that the Ion Beam can only be made coincident with the E-beam at the Eucentric Height. At other z-heights, the distance needed for adjustment will be outside the range of either one or both beam's beam shift limits.

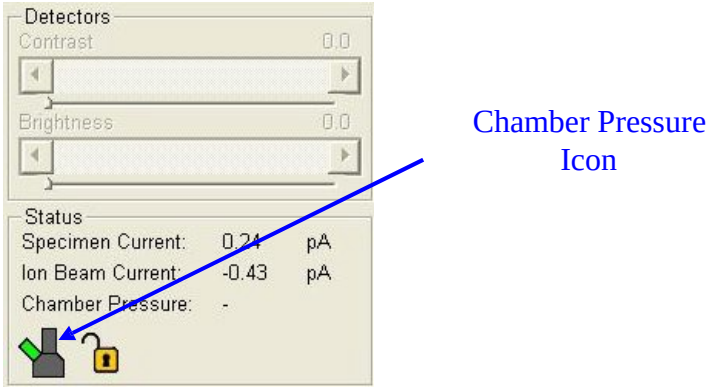
6 Setup

a) Log into Coral.
b) Enable 'fib' under the 'E-Beam, SEM, & Mask Making' node in Coral.
c) Log into the Support PC. This involves logging into the Windows 2000 operating system of the computer which may require going through the Start Menu and selecting the Shut Down option.
d) Log into the Quanta PC (also called the Quanta Server). This involves logging into the application 'xT' which is the user interface for operating the FIB instrument.
e) Select the Vent icon on the Quanta PC. It will take approximately 3 minutes to vent. The Chamber Pressure Symbol will go from green to orange during the venting process, then finally to black when it is fully vented.

Vent Icon (upper right of 'Beam Page')

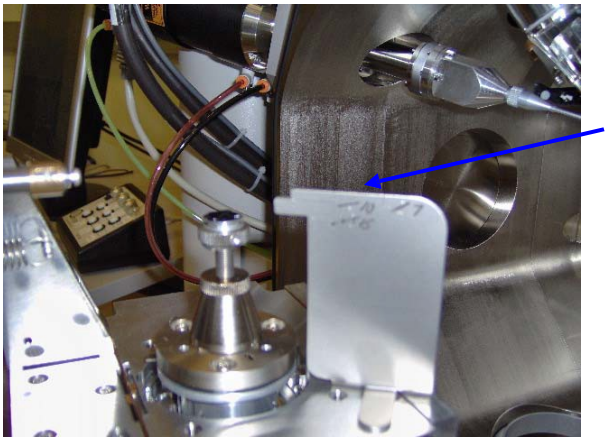


Chamber Pressure Icon (lower right of 'Beam Page')

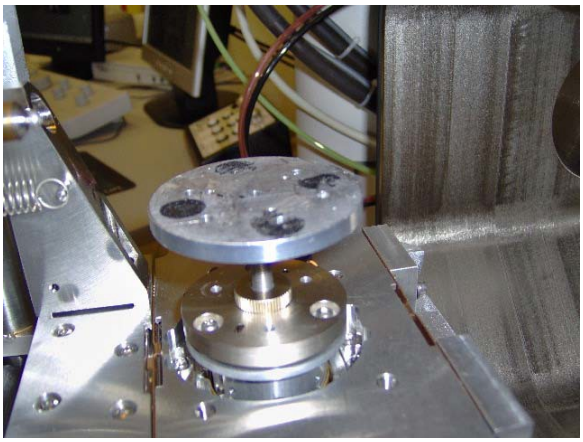


f) Load one of the following three stages —

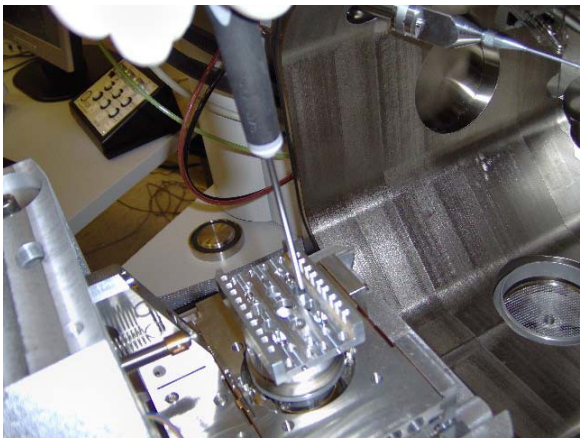
1) Single Stub Holder:



2) Multiple Stub Holder / Large Sample Holder

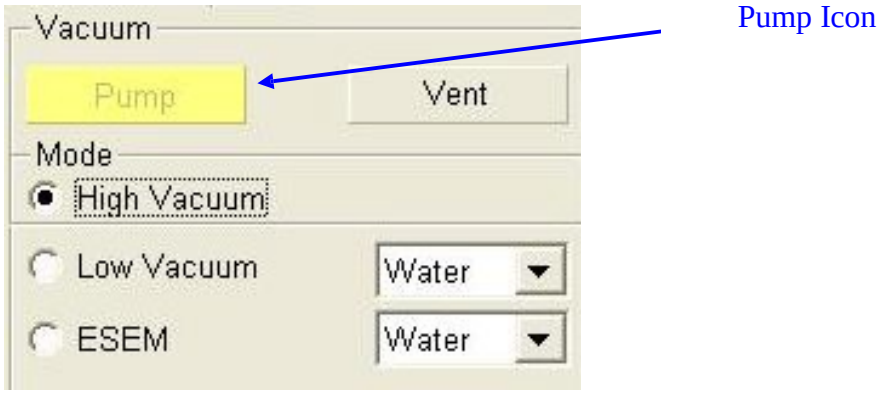


3) Universal Mounting Block ('UMB')



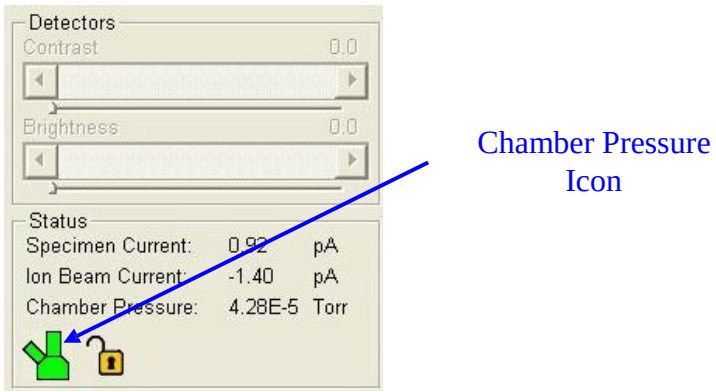
g) Attach sample to stage. Usually this involves carbon tape, but it might involve Au coating of the sample in Chase 4, painting with carbon or silver paint, and/or taping with Cu tape.
h) Using the 'Elephant' height indicator, make certain the top of the sample has a Working Distance (WD) of 15 mm or greater. This assures it will not run into anything when the door is closed.
i) Close chamber door. Note you can watch on the CCD camera quadrant of the Quanta PC's screen as the door closes to insure nothing will be damaged when closing the door.
j) Select the Pump icon on the Quanta PC.

Pump Icon



It will take approximately 4 minutes to pump to 2 x 10^-4 or lower. Once this vacuum is achieved, then the sources can be turned on. The chamber icon will go from orange to green during the pump down process. Green indicates desirable vacuum has been achieved.

Chamber Pressure Icon (lower right of 'Beam Page')



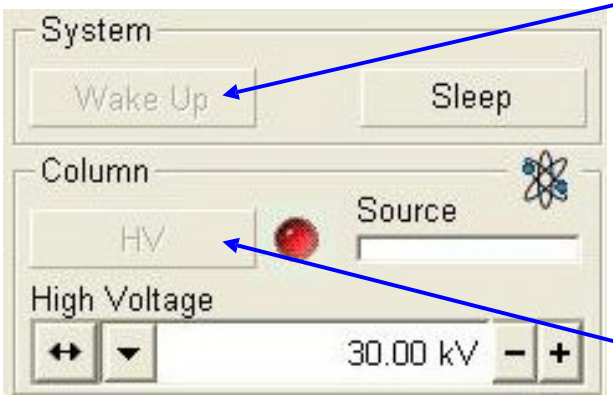
7 Operating Instructions

a) Turning on the Sources

1) Select Wake Up to initiate warm-up of the E-beam and the I-beam sources. The E-beam will take 5 sec. to warm up, but the I-beam will take 4 to 5 min.

Alternatively, one can choose to turn on the E-beam or the I-beam separately. This can be done by selecting the HV symbol for each beam.

Wake Up Symbol and HV Symbol



2) In the E-beam quadrant, un-pause the screen. Adjust focus and magnification accordingly to determine where one is on the sample. Move to the region of interest on the sample to perform 'Find the Eucentric Height'.

b) <u>Find the Eucentric Height</u>

1) Place top of sample at "15mm" yellow marker.

2) Focus @ 2000+ X magnification on some horizontal feature in the area of interest.

3) Link Z to FWD. Use Icon.

4) Adjust the Tilt Angle with small, incremental changes (2^o, 5^o, 10^o, 25^o, 52^o). With each incremental change in Tilt, adjust the Stage Height (Z-Knob) to bring the horizontal feature back to the cross-hair.

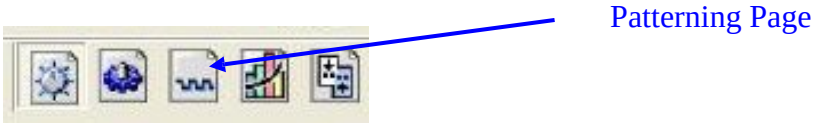
5) Repeat this procedure until 0^o (ctrl-E) and 52^o (ctrl-I) remain within a couple of microns of your horizontal feature.

6) With the sample normal to the Ion Beam, make the Ion Beam image coincident with the E-beam image by adjusting the Ion Beam's Beam Shift.

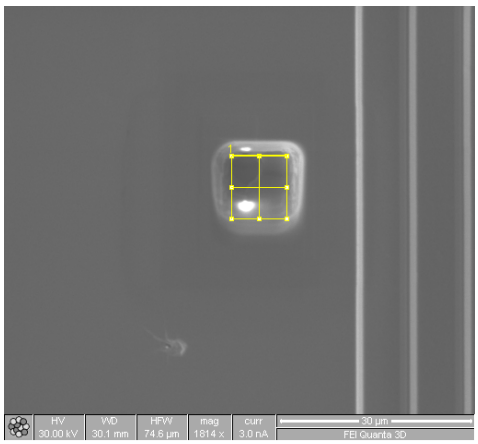
c) Patterning

1) In the Ion Beam quadrant, locate the section of the sample you would like to pattern; this could be either an etch or a deposition with Pt.

2) Patterns are drawn on the Ion Beam quadrant using the Patterning page.

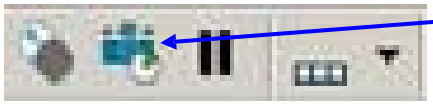


3) Choose and draw the desired pattern from the list of pattern functions on the Patterning Page. Once drawn, the pattern at hand can be dimensioned by adjusting the boxes for x, y, and z.



4) When choosing an ion current between 1 pA and 20 nA for a patterning job, keep in mind a good 'rule of thumb' is to have the job take between 3 and 8 minutes.

5) To monitor the progress of the patterning, one can take snapshots of the region of interest using the Snapshot Icon in the either the E-Beam or Ion-Beam quadrant. Most of the time, the E-Beam will be the preferred method of taking snapshots, as it does not impart damage to the sample as the Ion-Beam does.



d) Shutting Down the System

1) Return the stage to Tilt = 0.

2a) If one wishes to keep the Ion Source warm because another sample is going to be loaded, or another user is about to use the system, one can simply click on 'Vent'. The High Voltage (HV) will be shut down for both sources, and the E-beam source (filament) will be shut off, but the Ga source will stay warm. Upon re-loading and pumping down again, all that will have to be done is clicking on the HV icons for each source. Be sure to shut off the Pt source warmer if it is not to be used again, otherwise it will remain on.

2b) On the other hand, if one no longer wants to use the system, and no other user is waiting to immediately use the system, one can simply click on the 'Sleep' Icon. This will turn of the HV for both sources, turn off the E-Beam source (filament), and allow the Ga source to cool down. In addition, 'Sleep' will also turn off the Pt source warmer.

3) Remove sample stubs from the stage, then remove the sample from the stubs.

4) Close door.

5) Click on 'Pump' icon. Allow to pump down until the Vacuum Status Icon turns green (2 x 10^-4 Torr or lower).

6) Log off the Quanta PC's xT User Interface application (under the File menu heading).

7) Log off the Support PC's OS (Windows 2000 — can be found under the Shut Down window).

8) Disable the FIB in Coral.

8 Problems/Troubleshooting

a Problem: System locks up when stage is moving.
Solution: Avoid performing other functions when the stage is moving. Allow stage to come to a complete stop before initiating the other functions.

b Problem: System locks up when frequent scans or snapshots are performed.
Solution: Avoid scanning a new quadrant or selecting a new snapshot too frequently. Allow the scan or the snapshot in progress to complete before selecting another. Frequent selecting of the scanning or the snapshot function overloads the video card and the video processing software.

9 Online Appendices (see http://www.nfc.umn.edu/equipment/)

FIB Appendix 1: TEM Lamella Formation