Tescan VEGA3 Scanning Electron Microscope

Standard Operating Procedure

Faculty Supervisor: Prof. Robert White, Mechanical Engineering (x72210)
Safety Office: Peter Nowak x73246 (Just dial this directly on any campus phone.)
(617)627-3246 (From off-campus or from a cell phone)
Tufts Emergency Medical Services are at x66911.

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Warnings:
The SEM utilizes high voltage components, do not open the chassis.

While scanning your specimen it is possible to drive the stage into the microscope optics. Please exercise extreme care as you drive the stage around the chamber. Crashing the sample into the optics is the most likely way to damage the tool. Keep a close eye on the camera view and be sure not to allow this to happen. Be especially careful when tilting the sample.

1.0 Material Requirements:

1.1 Equipment: specimen mounted on a 12.5mm stub with carbon tape and coated with conductive material (sputtered Au for example), stub tweezers

1.2 Personal Protective Equipment: nitrile gloves, safety glasses

2.0 Procedure:

Important Note – There are multiple ways to work with the user interface –

• Control Panel
• Trackball
• Mouse

This procedure generally describes how to use the mouse but feel free to use the other input devices.

Log in and load configuration:

1. The SEM should be powered, under vacuum with PC running. If not, notify management. If logging into the PC no password is required
2. Start and log into the Vega software. The first time you log in please change your password immediately. Logging into your account will allow the software to save all your preferences. Using the SEM without logging into your account will disqualify you from future use
3. If the filament has been changed since your last login, please load the SEM_USER configuration. This will load the beam parameters (they are unique to each filament) then load your personal configuration file.
4. If you have logged in since the last filament change simply load your personal config file.
   Configuration files location - Options>Configurations>Load>YourFolder>YourFile.cfg.
   Preferences and Settings saved in your config file include the screen panels/locations, the default saved image size, etc.

Load/Unload Specimens

1. Vent the chamber by using the VENT button on the Vacuum panel portion of the screen (image below) and open the N2 cylinder by the instrument. Do adjust N2 pressure
2. Send the stage to the Home position (0 tilt, maximum distance from optics)
3. Once the pressure is at atmosphere open the chamber door with a gentle pull and close the N2 cylinder
4. Use the Stage Control panel (image below) to rotate the specimen holder as needed. NOTE – the specimen holder should not be removed!

5. Loosen the screw securing the specimen (the appropriate screwdriver should remain near the SEM) and remove using the tweezer.
6. To load new specimens, place into specimen holder and gently tighten the screw. Rotate holder using Stage Control panel as necessary
7. Inspect stage and holder – is everything secure? Will any specimens touch the chamber walls, or other components?
8. Gently close the chamber door
9. Initiate pump down by pressing PUMP on the vacuum panel. Once the Column Pressure indicates green you may proceed.
10. Use the Stage Control panel to center the specimen of interest. Click on the appropriate number and the carousel will rotate to that specimen

**Powering Up Optics:**
1. In the SEM Detectors & Mixer panel select a detector (images below) –
   a. SE – secondary electrons, basic SEM detector appropriate for almost all specimens
   b. BSE – back scattered electrons, scintillation type. Enhances material contrast, retractable, used for difficult to image samples. We recommend using the SE detector – easier to use, the vast majority of samples will not benefit from the BSE detector. If you wish to use the BSE, contact management first
2. Using the Electron Beam panel select an accelerating voltage (there are four factory presets (5kV, 10kV, 20kV, 30kV, image below). This will turn on the high voltage and begin heating the tungsten filament. Higher voltage will give greatest resolution but it is possible to achieve excellent resolution at lower voltages. You may notice greater “charging” effect at higher voltages.

Acquiring an Image (the following assumes you are using the SE detector)

1. Set your default scan window and Image Save parameters – SEM>Image Parameters> Select window size, etc
2. Right click in the SEM scanning window to open a menu and select Minimum Magnification
3. Right click in the SEM scanning window and select Auto Signal to set brightness and contrast
4. If the SEM scanning window remains black go to the Electron Beam panel, click Adjustment and select Auto Gun Heating
5. Click on the Scan mode function on the Info Panel and select Resolution

5. To autofocus – right click in the scanning window and select Auto WD. To focus manually click on the WD icon and turn the track ball right and left
6. To set Beam Intensity left click on the BI icon, BI = 10 is recommended
7. To magnify, click on the Magnify icon and turn the trackball left to right

Now you are in the main part of the process – trying to get a high quality image. These are the things to work with:

A. Set the z-height so your sample is approximately 5-15 mm from the optics. Move up slowly, don’t do it all in one shot – you don’t want to crash.
B. Adjust x and y position to see the part of your sample you want.
C. Zoom in and out as needed.
D. Adjust working distance (WD), similar to focus, to focus your sample
E. Adjust the x and y stigmators as needed to reduce distortion of the image. If these get very far from 0 and you get lost trying to improve the image, set them back to 0.
F. Adjust beam intensity (BI) as needed. A lower beam intensity will require you to use a slower scan speed (in order to get more averaging with the lower signal level) but may improve resolution at higher magnifications or with samples that are charging. BI of 10 is the default and recommended by the manufacturer.

G. Adjust scan speed to get a high resolution image. This will take a slower scan with more averaging.

- **Note** – if you wish to rotate the image, select rotation as the trackball parameter, and use the trackball to rotate the image angle by fine increments. This is *not* a physical rotation of the sample – it is an image processing rotation of the image only.

- **Note** – if you wish to tilt the stage to get a tilted image, be very careful – this is where it is easy to crash. First, set x=0 y=0 to center the stage, then set the stage z height to be as far from the sample as possible. Now change the tilt – slowly – go in increments … 30° then 45° then 60° up to a max of 70°. If needed. Once the stage is tilted, now, at low mag, move x and y to get to the region of interest. Finally, change z to bring the sample closer to the optics… ideally about 10-15 mm away… be very careful here and do not crash (!!), pay careful attention to the chamber camera. When adjusting the tilt back to zero – FIRST go to x=y=0 and increase the z-separation to bring the stage far from the optics. Then set tilt back to 0.

8. To acquire an image click on the Acquire button on the Info Panel or the Icon on the toolbar. Fill in the fields, select a folder. To change the image parameters use Image Parameters in the main SEM menu.

Generating good SEM images requires experience and skill and a simple SOP cannot replicate. If you are having issues getting good images, talk to more experienced users. Optimum parameter settings will vary depending on a number of factors, please keep in mind –

- Shorter WD will give greater resolution but sacrifices depth of field. Tall, out of plane objects may require longer WD.
- Greater accelerating voltage will improve resolution at the expense of greater edge effect, possible specimen damage and charging effect. Lower accelerating voltage will reduce resolution but reveal more surface structure detail. Recall that higher energy electrons will penetrate deeper into the specimen when determining the optimum accelerating voltage.
- Specimens with greater atomic weight typically respond well to higher accelerating voltage, low atomic weight specimens typically require lower accelerating voltage for optimum imaging.
- It can be useful to image the test specimen (Au on carbon) at high resolution (objects down to 50nm or smaller can be resolved) first and then switch to your intended specimen, tweaking parameters as needed.

**Back Scattered Electron Detector**

1. Select the BSE detector from the SEM Detector panel
2. Drive the specimen stage to the home position (maximum distance between stage and optics)
3. Manually drive the BSE detector into position, there is a hand crank on the backside of the electron column, crank all the way in (it does not require much torque, if you are cranking very hard something is wrong)
4. Follow the motion using the chamber view camera. Once in position you can see the detector occupies space very close to the optics, minimum sample distance is 10mm or greater. Whatever WD you use, approach it incrementally and confirm the move with the camera view beforehand
5. Proceed with your image acquisition
6. Once complete, manually drive the BSE detector back to its home position
7. Follow the When you are Finished instructions below
8. Reconfirm that the BSE detector is fully retracted
9. Confirm that the chamber is tightly closed and pumping down
When you are finished

1. Turn off the high voltage by clicking on the HV button on the Electron Beam panel
2. Remove your specimens, see the Load/Unload portion of the SOP
3. Make sure the chamber is sealed, the SEM is pumping back down and the N2 cylinder is closed
4. If you used the BSE detector confirm that it is fully retracted
5. Log out.
6. Make sure the tools – screwdriver and stub tweezer – are there for the next user
7. **Before walking away, ensure that the chamber vacuum status is** *GREEN*

If at any time you feel unsure about how to use the tool, please stop work and contact a qualified user or faculty advisor. Please don’t forge ahead when you are unsure, you may end up damaging the tool.

**Report all accidents or tool issues to Prof. White at x72210, r.white@tufts.edu.**