OPERATION PROCEDURE:

1. Log into the tool by using FOM, it will turn on the monitor.

Startup:

1. Login to Zeiss Computer, choose SEM user, PW guest

2. Start SMART SEM USER INTERFACE Software

3. Login to software [User: your SEM user ID, Password: your SEM password]. EM Server will automatically start up.

4. VAC and GUN are ON ✅ and operational, and EHT is OFF ❌. See the bottom right corner.

5. Toggle Data Zone if not visible <CTRL + D>.

NOTE: ✅ ON; ❌ Changing Status; ❌ OFF

IMPORTANT

There are multiple ways to activate the desired commands:

- Icons
- Pull-down Menus
- Double-clicking in the Datazone or Status Bar (i.e. Mag., WD, EHT, Signal)
- <key> combinations.

Preparing the specimen holder

IMPORTANT

Contamination caused by fingerprints can lead to vacuum deterioration or prolonged pumping times. Always wear lint-free gloves when touching specimen, specimen holder or stage.

1. Attach the specimen to the stub by using conductive carbon, adhesive metal or carbon tape. Ensure that the specimen area to be analyzed is in good contact with the stub. This will ensure high electrical conductivity between the specimen and the stub.

2. Use the tweezers to insert the stub into the specimen holder.

3. Use the Allen key to tighten the location screw and secure the specimen.

Loading the specimen chamber

1. Click the TV icon in the toolbar or press the Camera button on the keyboard.

CAUTION: Risk of damaging the objective lens and/or your specimen Ensure not to hit the objective lens while driving the stage. Change to TV mode to observe the moving stage.

2. Select Tools/Goto Control Panel from the menu, the SEM Control panel opens.
3. Go to the Vacuum tab and click VENT to vent the specimen chamber. The same can be achieved by left-click on VAC indicator in the status bar and click VENT.

4. A message appears asking: ‘Are you sure you want to vent?’ Confirm by clicking on YES.

5. When vented slowly open the chamber door.

**IMPORTANT: Keep the chamber door open as short as possible.**

All specimen holders are fitted with a dovetail fitting so that the position of the specimen holder is exactly defined.

6. Mount the specimen holder:
   a. Make sure that you place the dovetail fitting in the correct orientation onto the holding device on the specimen stage.
   b. Make sure that the flat side of the dovetail fitting of the specimen holder is flush with the milled edge of the stage.

7. When closing the chamber door check the chamber scope to ensure the specimen does not hit any components when it is introduced into the specimen chamber.

8. Carefully close the chamber door and click PUMP in the SEM Control panel. The same can be achieved by left-click on VAC indicator in the status bar and click PUMP.

   **NOTE:** Go to VP control tab and verify that High Vac (HP) mode is grayed out.

**Locating the Specimen**

Carefully move the specimen closer to the objective lens by using the dual joystick. The distance between objective lens and specimen surface should be less than about 10 mm.

**General Operating Parameters:**

**InLens Detector:** WD 3mm optimal
**SE2 Detector:** WD 6-8mm optimal, and longer
**STEM, EDX and RBSD detector:** please see MNTC staff to get additional training before use.

**Switching on the EHT**

**Note:**

- EHT stands for Extra High Tension. This voltage has to be applied to the gun in order to make it emit electrons.
- Gun should be always on.

1. Watch the vacuum status messages on the Vacuum tab of the SEM Control panel. When the required vacuum has been reached you will see the message **Vac Status = Ready**.

2. Go to the Gun tab and set the acceleration voltage: a move the EHT Target slider to the desired value. Alternatively click **EHT Target =** and type in the desired value. **Typical value =3 or 5kV.**

3. Switch on the EHT:
a. Click EHT in the status bar.

b. Select EHT On from the pop-up menu. The EHT will run up to the target value.

The status bar buttons are merged and the ALL button appears. Now, the electron beam is on.

Generating an Image

1. Go to the Detectors tab and select SE2 or InLens from the Detectors drop-down list.

2. It is recommended that you select the SE2 detector to obtain the first image, as this detector provides a good signal-to-noise ratio even at large working distances.

3. Go to the Scanning tab and select a fast scan speed, e.g. Scan Speed = 3 from the drop-down list.

NOTE: The lower the scan speed number, the faster the electron beam is scanned across the specimen. If the image displayed is noisy then change the Scan Speed to 4 or 5 but no higher than 5. This will allow you to move the specimen stage using X or Y controls on the joystick to a suitable location for imaging.

4. Set a low magnification e.g. Mag = 500 x:

   Click the Magnification/Focus icon in the toolbar. Use appropriate knob on the keyboard to adjust the magnification. The current magnification Mag is indicated in the status bar.

5. Set the focus: Use appropriate knob on the keyboard to adjust the focus. The current working distance (WD) is indicated in the status bar.

6. Adjust contrast and brightness by using the Brightness and Contrast knobs on the keyboard. Alternatively, use the Auto BC = On option for Signal Adjust in the Detectors tab.

   Click on the Contrast/Brightness icon in the toolbar. The current Brightness and Contrast are indicated in the status bar.

7. Select a detail on the specimen surface. Focus the detail. Use slower scan rate to reduce the signal-to-noise.

8. Adjust contrast and brightness again.

Optimizing the Image

1. Set Coarse by toggling the Coarse/Fine button in the status bar. This can also be achieved by pushing <TAB> on the keyboard.

2. Slowly increase the magnification to the value required (e.g. Mag 50.000 x). It is prudent to refocus the image if and when required whilst increasing the magnification.
3. Click the **Reduced Raster** icon or press the **Reduced** button on the keyboard. A small scan frame is shown. The image outside the scan frame is frozen. Use the mouse to change size, shape and position of the reduced raster area.

4. Focus the image in the reduced raster.

5. **Aperture alignment (OPTIONAL):**
   
   a. In the **Apertures** tab, tick the **Focus Wobble** checkbox.

   The Focus Wobble is a function that sweeps the focus of the objective lens backwards and forwards through the focus on the specimen plane. If the aperture is slightly misaligned, a lateral shift in the image will be observed.

   Intensity of wobble can be adjusted by using the **Wobble Amplitude** scroll bar. Set Wobble Amplitude to between 60 % and 70 %. Wobble speed can be accelerated by ticking the **Wobble Fast** checkbox.

   b. Align the mid column aperture by carefully adjusting the X and Y micrometer gauges to eliminate lateral image shift. The specimen should be seen to pulsate and not to shift.

   c. Untick the **Focus Wobble** checkbox.

6. In the **Scanning** tab, set **Scan Speed = 7**.

7. Bring the image into focus at a higher magnification than the desired final magnification. Typically double the desired magnification.

8. Toggle to **Fine** in the status bar. Use **Coarse** and **Fine** mode of adjustment where appropriate.

9. **Correct astigmatism:**
   
   a. Select a detail (e.g. a mark or an edge) on the specimen surface.

   b. Click the **Reduced Raster** icon. Ensure the selected detail is in the raster

   c. Use **Stigmator X** and **Stigmator Y** knobs on the keyboard to obtain the sharpest possible image. This is similar to focusing. In order to obtain a well-focused image, it is prudent to adjust focus and stigmation a number of times before moving to the next stages of image recording.

10. Deactivate the reduced raster and reduce the magnification to the required value.

**Saving Images:**

1. When the desired image is captured, change the **Scan rate to 6 or higher** and **Noise Reduction=Line int.** to get the clean and crisp image.

2. Wait until the red dot appears at the right bottom of the image area that indicates the image is frozen.

3. You can skip previous step and save the image by selecting **File/Save Image** or left-click on the image and choose **Send to**. You would have a choice to save you image in **tiff, jpg, or bmp** format. Choose **tiff** format since it also saves metadata.

**NOTE:** Available image resolution

- 512*384 - rapid scan mode
- 1024*768 - **normal operating mode**
- 2048*1536
- 3072*2304 - **High Resolution mode**
4. Capture Control: Middle-click camera icon select “End of Frame” or “Freeze Now”

Finishing the Work Session

1. To finish your work session, switch off the EHT:
   a. Click the All: button in the status bar.
   b. Select EHT Off from the pop-up menu.

2. Back off/Remove STEM, RBSD and EDAX detectors if you used any of them.
3. Bring the stage down or go to Stage Initialization, wait until stage is stops at initial position.
4. Click on VAC indicator and click VENT.
5. When vented roll out chamber door slowly, careful and watch out for gun.
6. Always, use gloves to remove your Samples.
7. Close chamber door and click PUMP. Wait until VAC is ready.
8. Don’t forget to collect log data and log out from tool by using your FOM account.
10. Exit EM Server (optional)

SUPRA SPECIFICATION

<table>
<thead>
<tr>
<th>Resolution</th>
<th>GEMINI column with 4 pA - 20 nA probe current</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.0 nm @ 15kV</td>
</tr>
<tr>
<td></td>
<td>1.3 nm @ 15kV</td>
</tr>
<tr>
<td></td>
<td>1.9 nm @ 1kV</td>
</tr>
<tr>
<td></td>
<td>2.1 nm @ 1kV</td>
</tr>
<tr>
<td>GEMINI column with 12 pA – 20 nA probe current</td>
<td></td>
</tr>
<tr>
<td>1.2 nm @ 15kV</td>
<td>1.5 nm @ 15kV</td>
</tr>
<tr>
<td>2.2 nm @ 1kV</td>
<td>2.3 nm @ 1kV</td>
</tr>
<tr>
<td>Acceleration Voltage</td>
<td>0.02 V-30 kV, continuously variable in 10 V steps</td>
</tr>
<tr>
<td>Magnification</td>
<td>&lt; 12 - 1,000,000 x</td>
</tr>
<tr>
<td>Chamber</td>
<td>330 mm (Ø) x 270 mm (h)</td>
</tr>
<tr>
<td>5-Axes Motorized Specimen Stage</td>
<td>X = 130 mm</td>
</tr>
<tr>
<td></td>
<td>Y = 130 mm</td>
</tr>
<tr>
<td></td>
<td>Z = 50 mm</td>
</tr>
<tr>
<td></td>
<td>T = -3 - 70°</td>
</tr>
<tr>
<td></td>
<td>R = 360° (continuous)</td>
</tr>
<tr>
<td></td>
<td>Stage control by mouse or optional joystick and control panel</td>
</tr>
</tbody>
</table>
## CHEAT SHEET

### To increase depth of field:
- Increase working distance
- Decrease aperture size
- Use collimated beam mode

### Better S/N:
- Larger aperture
- Slower scan rate
- Use collimated beam mode

### Surface Sensitivity:
- Lower accelerating voltage
- Use the right detector!

### Charging or Insulating Sample:
- Lower accelerating voltage
- Use a VP system
- Sputter coat with Au-Pd (last option)

### High Resolution:
- Reduce spot size
- smaller aperture • or condenser lens
- Short working distance
- Slower scan rate
- Use the right detector!

### Focus and Stigmation:
- Adjust focus and stigmation at higher mags than working mag
- Adjust to best focus
- Adjust 1 or both stigmator controls
- Iterate between focus and stigmation (roundish structures helpful in adjusting stigmation)
- Center apertures after changes in accelerating voltage or aperture

### Analysis:
- Use as high of a beam current as your sample can take

### KEYBOARD COMMANDS:
The following keys are shortcut keys and have special meaning

- `<F2>`: Toggles **Tool Bar** on/off
- `<CTRL + D>`: Toggle **Data Zone** ON/OFF
- `<CTRL + G>`: Switches **SEM Control Panel** ON
- `<F2 + SHIFT>`: **Hysteresis** removal
- `<Shift + Tab>`: Performs **Center Point** function
- `<F3 + SHIFT>`: Toggles **PC Plane** ON/OFF
- `<CTRL + A>`: Switches **Annotation panel** ON

**Image Buffer keys**
- `<Alt + buffer #>`: Saves Images to **Buffer # 1-8**
- `<Alt + N>`: Saves Image to **Next Buffer**
- `<F4>`: Step to **next Magnification** Table entry, or Undo Centre Feature Magnification
- `<F4 + CTRL>`: Step to **previous Magnification** table entry.
- `<F4 + SHIFT>`: **Exit** from Magnification Table mode.

**Keypad keys**
- `Keypad < + >`: **Faster Scan**
- `Keypad < - >`: **Slower Scan**
- `<SCROLL LOCK>`: Toggles **Freeze/Unfreeze**
<HOME> Resets Beam Shift to zero.
<F12>, <F12 + SHIFT> Aborts Stage Movement.
<CTRL + F> Starts Auto Focus fine
<CTRL + SHIFT + F> Starts Auto Focus coarse
<CTRL + S> Performs Auto Astigmatism Correction
<CTRL + SHIFT + S> Performs Auto Astigmatism Correction with Auto Focus
<F9> Keys help (displays this information)

FULL KEYBOARD COMMAND SET:
The following keys are shortcut keys and have special meaning
<F9> Keys help (displays this information)
<F2> Toggles Tool Bar on/off
<CTRL + B> Display Toolbar View dialog
<CTRL + D> Toggle Data Zone ON/OFF
<CTRL + G> Switches SEM Control Panel ON
<CTRL + I> Switches SEM Status Panel ON

Operations:
<F2 + SHIFT> Hysteresis removal
<F3> Closes all windows except the Tool Bar and Status Bar
<F3 + SHIFT> Toggles PC Plane ON/OFF
<F4> Step to next Magnification Table entry, or Undo Centre Feature Magnification
<F4 + CTRL> Step to previous Magnification table entry.
<F4 + SHIFT> Exit from Magnification Table mode.
Keypad < + > Faster Scan
Keypad < -- > Slower Scan
<PAUSE> Causes currently executing macro to continue

Stage movement:
< Shift + Tab > Performs Center Point function
<SHIFT + double click> Stage movement (See Use of ARROW Keys)
<F12>, <F12 + SHIFT> Aborts Stage Movement.
<HOME> Resets Beam Shift to zero.

Imaging:
< SCROLL LOCK > Toggles Freeze/Unfreeze
Image Buffer keys See Image Buffer
<Alt + buffer #> Saves Images to Buffer # 1-8
< Alt + N > Saves Image to Next Buffer
< CTRL + C > Freezes & Saves Display to temporary buffer
<CTRL + V> Displays Temporary Image buffer
<CTRL + 2> Loads Second Image Window from display
< ’ > Performs Find Image function.

Annotation:
<CTRL + A> Switches **Annotation panel** ON
<CTRL + T> Calls **Text Annotation**
<CTRL + M> Switches to Annotation and inserts **Point to Point Marker**
<CTRL + E> Calls the **Export TIFF** dialog
<CTRL + O> Calls the **Import TIFF** dialog
<CTRL + P> Performs the Print Image function.

**Autofunctions:**

<CTRL + F> Starts **Auto Focus** fine
<CTRL + SHIFT + F> Starts **Auto Focus** coarse
<CTRL + S> Performs **Auto Astigmatism Correction**
<CTRL + SHIFT + S> Performs **Auto Astigmatism Correction** with **Auto Focus**

**User defined macros**

<F5>, <F5 + SHIFT>, <F6>, <F6 + SHIFT>, <F7>, <F7 + SHIFT>, <F8>, <F8 + SHIFT> <F11>, <F11 + SHIFT>