Rm. 23 SEM Operation Guide

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For additional information, and more details on most procedures, see the JSM 6100 manual located in Rm. 23.

February, 2001, Nick McGruer

Cautions!

Do not hit the lens with your sample!

This is the most expensive mistake you are likely to make! The conical objective lens that is visible when you open the chamber is not extremely delicate, but it can be damaged, and is very expensive to repair. The primary danger comes from tilting the sample using the lever attached to the stage. Under normal circumstances (using a conducting sample) an alarm will sound if the sample or stage touches the objective lens, and the sample movement controls on the front panel will automatically stop. To avoid this problem examine the position of your sample relative to the lens before you pump down the chamber, and be certain you understand the movement limits. The danger is least for small samples mounted on the small stubs at the normal height and is greatest for large sample such as wafers. Remember to bring the sample to a safe position before removing it from the chamber. (Usually a long working distance and not tilted.) Also note that the Alarm/AEM switch should be set to Alarm to enable the lens contact alarm. Note that these comments also apply to the Kevex EDS system, especially if the detector is extended for analytical work.

Know how to saturate the filament!

The filament <u>will</u> fail if you turn the filament current up too high. Failure can also be caused by using the manual gun bias incorrectly. (Generally it is not necessary to ever turn on the manual gun bias.) See the start-up section for details on filament saturation.

Put only "clean" samples in the SEM!

Handle all samples, stubs, sample holders, etc with clean, oil-free gloves. Use only samples that will not outgass in a vacuum system. Carbon or silver paint used to attach samples should be completely dry. Outgassing can cause premature filament failure, and can lead to deposits throughout the column, degrading the performance of the SEM for subsequent users. If you have questions about a particular sample, contact McGruer, Krim, Oliver, or Warner.

Retract Kevex EDS system!

Unless you are using the Kevex system, retract it to the 60mm position on the gauge.

Emergency Shut-Down

Usually the SEM is left in the standby mode which is described below in the shut-down section. If an emergency arises, in which it is apparent that something is wrong with the system, and leaving the system running may further damage it, do the following. Turn the power key to off (under the right-hand side of the console table). Turn off the cooling water. Turn off the main power at the wall if this seems necessary. Call Warner, McGruer, Krim, Oliver.

Start-Up

1. **Put clean sample on stage, using gloves to handle anything going in the vacuum system (see cautions for further information). Check lens clearance as described under cautions. (If the chamber is under vacuum, push the vent button once to vent the chamber.)**

2. **Hit pumpdown/vent button, wait for light in the emission current gauge to turn on. This light indicates that the vacuum is sufficient to operate the SEM. If the light is not on after 15 minutes, or the roughing pump continues to "gurgle" for more than 5 minutes the system should be vented and the o-ring checked for dust or hair.**

3. **Turn the filament current knob down (counter-clockwise).**

4. **Set the desired accelerating voltage.**

5. **Turn on the high voltage. (red button) This also turns on the filament supply.**

6. **Turn on the detector (SEI detector - switch is located next to the emission/filament current meter)**

7. **Saturate filament:**

- **Set scanning speed to TV and LSP. Set scanning mode to LSP. The height of the line scan on the screen now will correspond to the emission current. Turn up the contrast and brightness knobs on the lower control panel. The sensitivity of the scan height to emission current may be controlled with the contrast knob and the zero height is set with the brightness knob. (The monitor brightness and contrast controls next to the CRT will probably need to be increased to maximum, the brightness knob must be somewhat greater than zero, and the room lights may need to be dimmed to see the line scan.)**

- **Push the button underneath the filament current meter so that it glows green. In this mode the meter indicates the dc heating current flowing through the filament. (In the other mode, the emission current is indicated.) For now you will be watching the emission current as measured by the height of the line scan on the screen, and the filament current on the meter.**

- **Slowly turn up the filament current while watching the line scan for emission current. Emission should be apparent at a filament current of less than about 2 A. (Check the last few entries to determine typical saturation currents.) If you do not see emission at the expected current, check the contrast and brightness controls on the console for adequate sensitivity. Saturation is reached when the emission does not increase further**

as the filament current is increased. Note that one or more false maxima may be observed as the filament current is increased. Note! - The saturation point looks like another false maximum if the tilt and shift controls are not properly adjusted. To avoid burning out the filament, check the filament current and compare it with typical values recorded in the log. Typical operating parameters are 2-2.2 A of filament current, and 50-80 μA of emission current at 30 kV. The emission current values will be less at lower accelerating voltages. Use the minimum filament current necessary. Using more current will shorten the filament life or immediately burn out the filament!

Operation

In general, the various operations involved in viewing and optimizing the image may be performed in any order. Many of the alignments and optimizations are optional and do not need to be done every time. Some recommendations will be noted below. Remember to make your entry in the logbook every time you use the instrument.

Acquire Image

This is usually the first step! Switch scan mode to PIC, scan rate to TV, adjust monitor contrast and brightness midrange, adjust probe current 10:00 to midrange, decrease magnification to minimum, adjust contrast and brightness on operation panel. Focus, move sample, and stigmate to obtain an acceptable image. If the sample is going to be tilted, the tilt will often increase the contrast and make features easier to pick out.

Focus/Stigmation

Adjust the focus knob and the 2 stigmation knobs alternately for the best image. Several iterations will be necessary. Focusing and stigmation are generally necessary for any change in operating parameters except for magnification. In fact, it is frequently easiest to adjust these controls at an exaggerated magnification, then reduce the magnification to the desired level. The running average digital mode (function key F10, choose MONI) often helps in focusing noisy images.

Probe Current

The clockwise knob position corresponds to a higher condenser lens current, a smaller electron beam current, and a smaller electron beam size at the sample. The basic trade-off is resolution vs signal-to-noise ratio. Generally the picture that looks the worst on the monitor (clockwise on probe current knob) will give the best photograph. Smaller currents hitting the sample can also minimize charging and sample damage.

Accelerating Voltage

The accelerating voltage is selected with the dials above the red high voltage button. This should be selected before tuning the other controls. The basic trade-offs here are between charging, resolution, and surface detail. High voltage gives higher resolution, except with light elements where the electron penetration is deep and obscures surface features. For example, silicon surface roughness is much easier to see at 10kV than at 30kV. Minimum charging of insulating samples usually occurs between 1 and 5 kV. Changing the accelerating voltage generally requires that the filament saturation be adjusted.

Sample and Image Movement

Use the joystick and rotation buttons for physical movement of the stage from the console. The vertical and tilt adjustments are located on the chamber itself and should always be used with caution because they can apply great force to the lens through the sample or sample holder. The image shift knobs and the image rotation module allow electronic manipulation of the position. The dynamic focus and tilt correction may also be used to obtain the desired image.

Brightness and Contrast

The operation panel brightness and contrast may be adjusted for photography or for viewing using the WFM button near the CRT. The normal adjustment spreads the range of brightness over the full range of the lines on the screen. For viewing the image, the monitor contrast and brightness are then adjusted as desired. The automatic contrast and brightness control performs this function automatically, if desired.

Aperture selection.

If necessary, select the aperture using the mechanical selector on the column. Usually this will not be necessary. If the aperture is changed, it should then be aligned using the wobbler control as described below. A smaller aperture gives better depth of field and better resolution. A larger aperture gives a smaller depth of field and better signal-to-noise ratio because more electrons are available at the sample.

Column Alignment

Aperture Alignment

This alignment should be done whenever the aperture is changed, and should be checked for very high resolution work, or when the accelerating voltage, probe current, working distance, or gun alignment have been changed by large amounts.

Procedure: Find a conspicuous feature and center it at 1000X or greater. (higher magnifications give more sensitivity) Turn on the OL wobbler and adjust the mechanical adjustments on the column to minimize image movement as the focus changes. Turn off the switch when the procedure is finished.

Gun Alignment (Shift and Tilt)

These alignments must be done after a new filament has been installed, but are necessary only a few times as the filament ages. Worth checking for very high resolution work.

Procedure, Tilt and Shift: Use the tilt knobs alternately to maximize the height of the line scan (LSP) as in the filament saturation, or maximize the brightness of the image.

Lens Clear

Used to remove hysteresis in lenses after large changes in focus (working distance). This will keep the working distance indication accurate.

Analog Image Manipulation

The appearance of the image may be modified using the video control or the YZ modulation control. The video control may be useful in bringing out detail in very light and dark areas of a high-contrast image, and the YZ modulation control is meant to bring out fine detail.

Alternate Analog Images

Slow scans, the D-Mag button, and reduced area scans are sometimes useful in viewing or focusing the image.

Digital Features

These can be very useful for viewing low signal-to-noise-ratio images, and for storing digital images. MONI A provides a running average image useful in focusing, INTG provides an integrated still image, and SLOW records a still image of a slow scan. Generally the SLOW mode gives the best digital image. The exception is when charging is present, in which case the integrate mode is often better. More details are given in the manual starting on page 5-25. Please do not edit lookup tables 1-10.

Capabilities exist for typing text on analog or digital images, for storing digital images, and for composing dual or quad images.) To save an image to the pc, type SAVE IMAGE.01 while in digital mode. Also note that FM FX, where X ranges from 1 to 4 switches between 4 frame buffers where images may be stored.

Photography

The most common procedure is to set the contrast and brightness as described above, set the Photo-Speed setting to 2, and to press photo. Normal settings on the camera are f16 for ASA 3000 film and f5.6 for ASA 400 film (although some experimentation may be necessary). Photographs of digital images are produced using the photo command in digital mode. Usually the highest resolution is obtained for a small probe size (clockwise probe current, low signal-to-noise ratio). SEM data will be displayed on the photograph depending on the setting of the CHARACTER switch next to the CRT. Multiple and multi-frame exposures are possible.

Shut-Down

1. **Slowly turn the filament current to zero.**
2. **Turn the High Voltage off.**
3. **Turn the Detector off.**
4. **Rectract the KEVEX detector, if used.**
5. **Position sample for removal-to not hit lens.**
6. **Press vent, remove sample after chamber vents to atmospheric pressure and the door can be opened.**
7. **Leave in standby mode if you are not loading another sample.**

Standby: 1-3 above <u>and</u>:

- **Hit pumpdown/vent button, wait for light in the emission current gauge to turn on. This light indicates that the pumpdown has been successful. If the light is not on, or the roughing pump continues to "gurgle" for more than 5 minutes the system should be vented and the o-ring checked for dust or hair. If a good pumpdown cannot be achieved, leave the instrument vented and contact**

someone for repairs.

- **Slow 2 scan mode.**
- **Maximum Magnification.**
- **Monitor contrast and brightness turned down.**
- **Leave power to machine on.**