Physics 7230/4230 “Electron Microscopy and Microanalysis”
Laboratory 3: High Resolution SEM Imaging
September 12th to 16th, 2016
(Due one week from lab session)

INTRODUCTION:
This lab explores the necessary conditions to obtain high quality, high resolution images. These include working distance, detector, spot size and accelerating voltage.

SAMPLE:
Evaporated Gold on Carbon Resolution Standard
MU Logo created by photo-lithography with subsequent growth of Carbon Nanotubes

OBJECTIVES:
High magnification imaging with a cold cathode FESEM. Obtain 8 100 kX images of gold resolution standard, and one high resolution image of the CNTs.

INSTRUMENT PARAMETERS:
Vacc…………………………………. 5 or 20 keV,
Emission Current..………………… 10 μAmps,
Working Mode………………………. Ultra High Resolution,
WD…………………………………... 6 or 12 mm
Condenser lens 1 setting…………… 3 or 8
Detector………………………………..Upper and Lower ETD

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1. Using the operating conditions below, present your images and show your work, then fill in the table below (8 points):

Operating Conditions	Working Distance	V_{acc}	Condenser Lens 1	*Upper Detector* Average of the Closest Particles Measured*	*Lower Detector* Average of the Closest Particles Measured*
1	12 mm	5 kV	3		
2	6 mm	5 kV	8		
3	12 mm	20 kV	3		
4	6 mm	20 kV	8		

* measure 3 pairs of closest particles and report the average.

1. What is meant by the term “resolution”? How does this differ from other image variables, such as signal to noise ratios and contrast/brightness? (2 points)

2. Compare all the images at a WD of 12 mm and 6 mm with the upper and lower detectors. Explain why you think the difference exists and whether resolution is affected. (2 points)

3. What do you observe in the images taken at different accelerating voltages (Vacc)? Discuss your observations in terms of resolution. (2 points)

4. What did you observe in the images taken at the two Cond Lens 1 settings? Define “spot size” and relate this idea to any differences you might have observed. (2 points)

5. Commonly, horizontal field widths (HFW) are reported instead of using scale bars (to reduce the amount of text on image). Report the HFW in this 100 kX image obtained for the carbon nanotube sample? (2 points)

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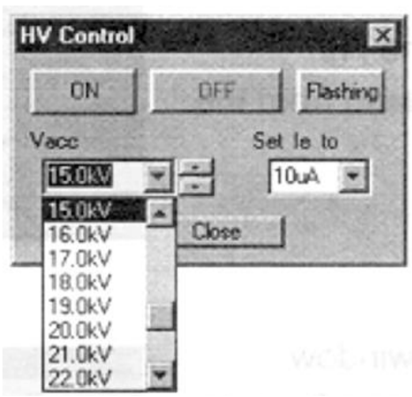
NOTES FOR THIS LAB:

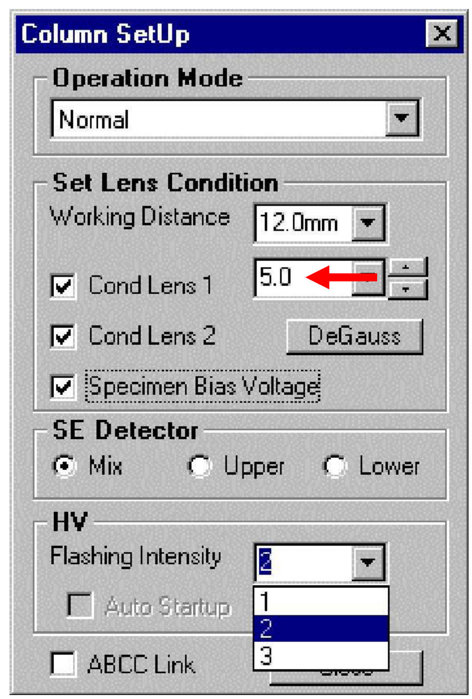
Similar to your last two labs, you will be obtaining and assessing images taken at a combination of different working distances, acceleration voltages (V_{acc}) , and detectors.

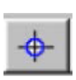
To change V_{acc}, click on this tab:



and change the V_{acc} using this drop down menu:

In this lab you will also be learning the effect of condenser lens 1. To change to condenser lens 1, go to the column setup tab (as shown below). The operation mode (which needs to be in ultra high resolution mode), working distances, and SE detectors are also changed within this tab. Remember the electron optics are set for the setting you choose, however you must manually use the stage micrometer to bring the sample the actual working distance.





Whenever the V_{acc} or condenser lens or emission current is changed the lens alignments (the tab for which looks like this) must be performed! For this lab, to obtain 100 kX images you will need to do the focus and correct the stigmatism at 200 kX. Remember that, the SEM parfaocal so DO NOT refocus at 100 kX. The image is not taken at 200 kX, because you will likely see noise vibrations upon slow scans.

Obtain 8 100 kX images for the different conditions for the Evaporated Gold on Carbon Resolution Standard sample.

Obtain a final 100 kX image for the carbon nanotube sample at the highest resolution setting at working distance of 5 mm, at 5kV, Condenser Lens 1 setting at 5 with the upper SE detector