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1 Learning Summary

In the past two weeks, I met Dr. Fraundorf and we discussed current projects that I might work on such as Javascript simulations. We decided to mount a chromite specimen from the Stillwater mining complex in Montana for TEM analysis. Consequently, I learned how to prepare a sample.

I did not have a mortar and pestle, but fortunately chromite is brittle and I was able to pound the mineral to a suitably small and thin size using a spare engine valve. I then transfered the particles onto a lacey grid via touch and observed the grid under a microscope. This was a good refresher on how to use a basic optical microscope since I initially had trouble adjusting focus. With Dr. Fraundorf's assistance, I was able to see the grid lines clearly.

I also learned about the basics of TEM such as the functions of the electron gun, lenses, apertures, specimen holder, and image recorder. In addition, there are various effects that the observer has to account for such as astigmatism. We can correct the oblong shape by applying a correction field in various directions in order to focus the beam. My attempts at optimizing focus and astigmatism from the nanostructure explorer are presented below.

2 Focus and Astigmatism

During the initial attempt (as shown in Figure 1), my goal was to become familiar with the platform by clicking each button several times systematically in order to determine how each variable affects the image. Furthermore, I tried to get an intuitive sense for the Scherzer-defocus result and how it looks before testing my skills. Not surprisingly, my first attempt required a large number of clicks. Subsequent attempts and some statistics on them are shown in Table 1.

Figure 1: Focus and Astigmatism Challenge

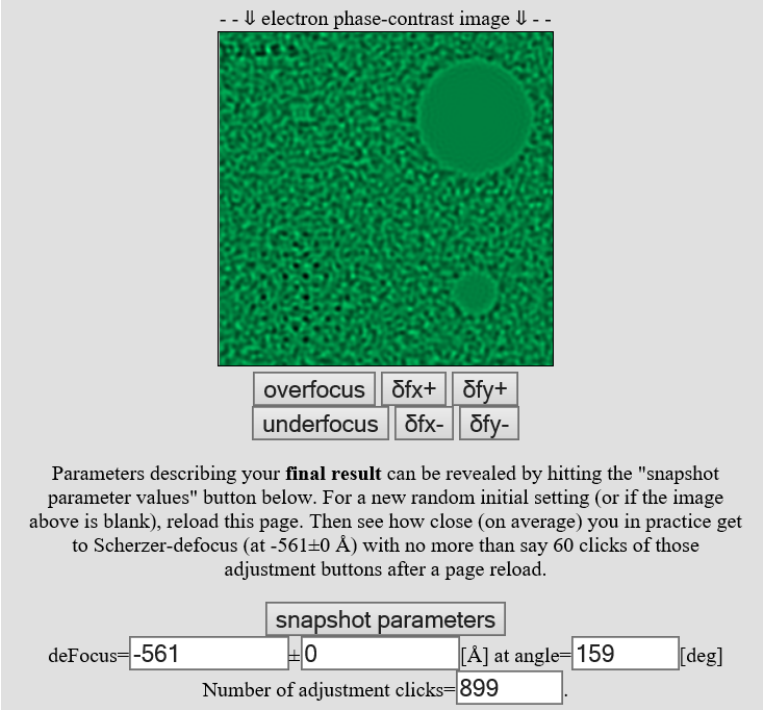


Table 1: Snapshot Parameters

Attempt	Defocus	Astigmatism (Å)	Clicks
1	-511	100	70
2	-111	100	133
3	-561	50	188
4	-511	112	228
5	-511	70.7	225
6	-511	112	200
7	-561	0	156
8	-511	0	113
9	-561	50	143
10	-561	0	102
Average	-491	60	156

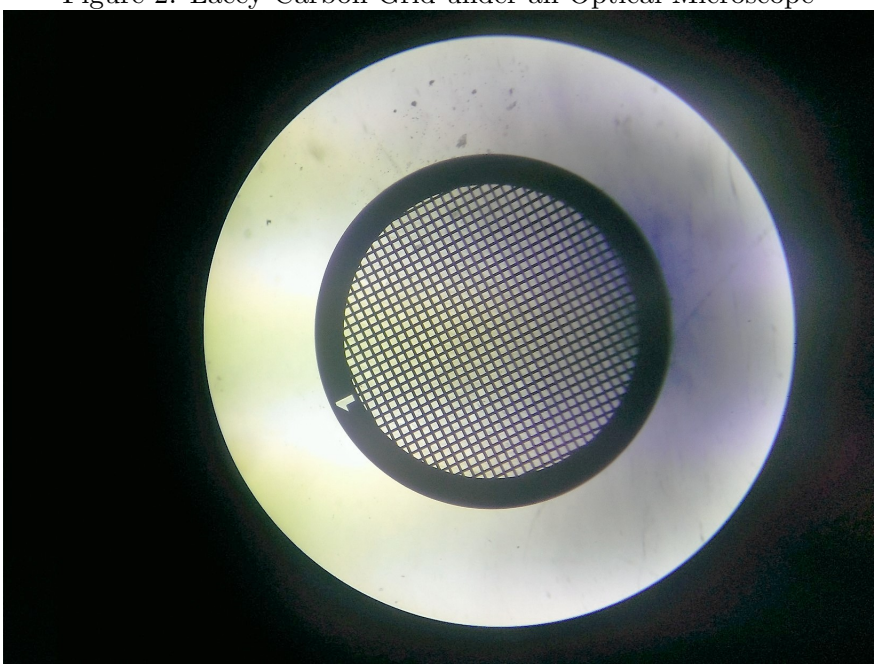
Attempt 2 skewed the data a bit since I falsely believed that I had grasped the pattern during attempt 1. After attempt 2 however, I had a

much better sense of the brightness and signs I should be looking for. My general strategy was to first do a rough adjustment of the x and y values in order to get a somewhat circular shape, then optimize the focus to minimize fringes around the edge, and finally fine tune the δf controls again. As a result, my results improved. Also, I realized that I had a tendency to overfocus, so I adjusted with this in mind to get to Scherzer-defocus (at -561 $\pm$ 0 Å) in 102 clicks.

3 Additional Observations

Upon further magnification under the optical microscope, I was able to see the individual grid lines and specks of chromite as well. There are some pieces outside the grid on the glass slide, although that may be because I accidentally shook some off while moving the grid with tweezers. However, there are also some visible particles near the top of the grid, so I think we may be able to proceed with TEM work.

Figure 2: Lacey Carbon Grid under an Optical Microscope



Out of my own curiosity, I counted 30 holes across the diameter of the grid. Based on the information Dr. Fraundorf gave me, if this has a 300 mesh

screen size or 300 holes per inch, then this grid is approximately $\frac{1}{10}$ of an inch, or 2.5 mm, which is consistent with our expectation.

4 Sources Consulted

I began reading a paper titled, "Introductory Transmission Electron Microscopy Primer" by Bob Hafner posted on the Nanoscale Science and Technology MyGateway page. This was an extremely useful and straightforward presentation on the basics of how a electron microscope works. It includes a review of a few mathematical models such as the distance between minima on an Airy disk and Bragg's scattering, types of aberration to consider, and examples of image power spectra.

Other useful websites with some excellent visualizations and additional material regarding TEM include the following:

ZEISS Interactive Tutorials
http://zeiss-campus.magnet.fsu.edu/tutorials

TEM Basics - MATTER (The University of Liverpool)
http://www.matter.org.uk/tem/

5 Follow-up Tasks and Goals

I plan to finish reading the TEM primer, and explore some more resources available online. If I have time this week, I may also take a look at the Week 4 exercise on the Wiki. Lastly, I would like to analyze my sample using TEM, and then discuss and decide on a project in order to continue.