Physics 7320  
Laboratory 2: Effect of Accelerating Voltage and Secondary vs. Backscattered Electron Signal Processing

Introduction:  
This is a two part lab. The first section examines effects of accelerating voltage. The second part examines topographic and Z-contrast using secondary and backscattered electron signals.

Specimens:  
1. U.S. penny  
2. Aluminum powder and graphite particles  
3. Optional sample if time allows: Fruit flies

Objectives:  
1. Determine contrast differences between secondary (SE) and backscattered (BSE) electrons.  
2. Effect of accelerating voltage (keV) on SE vs. BSE signal  
3. Topographic contrast by SE and BSE at different keVs

Imaging:  
1. Obtain 4 well-focused and stigmated images of Specimen 1: President Lincoln's face on a US penny.  
2. Obtain 8 well-focused and stigmated images of Specimen 2: aluminum and graphite powder particles at increasing accelerating voltages (use naming convention with your last name_kV_magX_AlCpowder.tif).  
   • One set of 4 images will show secondary electron signal images at increasing accelerating voltage – save these images named with your last name_SE_kV_AICpowder.tif.  
   • The other set of 4 images will show backscattered electron signal images at increasing accelerating voltage – save these images named with your last name_BSE_kV_AICpowder.tif.
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Laboratory 1: Introduction to SEM

Questions to be answered:

1. What is a secondary electron? How is a secondary electron generated? What type of detector is used to detect a secondary electron?

2. In reviewing your images of the penny at various accelerating voltages, look at the fine detail in the secondary electron images at the various accelerating voltages. What do you notice? Why do you think this is occurring?

3. Use Monte Carlo simulations to support your observations to answers given in question 2.

4. Why is the entire edge of Lincoln’s face bright? What is this called?

5. What is a backscattered electron? How is a backscattered electron generated? Why do we need a special detector for backscattered electrons? Do you think the phenomenon from question 4 would appear when visualized with backscattered electrons?
Part 1. Penny
This section will demonstrate differences in accelerating voltage on secondary electron signal.

1. Set the following operating conditions
   - Accelerating Voltage……Variable
   - Emission Current………….10 µAmp
   - Working distance………12 mm
   - Condenser lens………5
   - Mode……………………..Normal
   - Detector…………………Mixed

2. Find President Lincoln’s nose and chin on the specimen.
3. Obtain a focused, well-stigmated image at an accelerating voltage of 2 kV.
4. Change your accelerating voltage to 5 kV and obtain a focused, well-stigmated image of the same area.
5. Change your accelerating voltage to 15 kV and obtain a focused, well-stigmated image of the same area.
6. Change your accelerating voltage to 30 kV and obtain a focused, well-stigmated image of the same area.
   Note: Each time you change accelerating voltage, focus, alignments, and stigmation must be redone.

Part 2. Aluminum and Graphite powder particles
This section will demonstrate topographic (secondary electrons) and Z contrast (backscattered electrons).

1. Insert Backscatter Detector.
   - On back left of instrument (if you are unsure, ASK!)
   - Screw detector fully into the column.
   - Go to low magnification to center detector, retract by unscrewing if need be.

2. Set following operating conditions:
   - Accelerating Voltage........Variable
   - Emission Current.............20 µAmp
   - Working distance...........12 mm
   - Condenser lens..............5 (1)
   - Aperture........................3 (2)
   - Mode..........................Normal (YAG BSE)
   - Detector......................Mixed (lower/upper)

3. Enable “Split Screen” Mode.

4. Open the “Signal Select” window and choose “SE” for the right side and “BSE” on the left.
5. Obtain 2 focused, well-stigmated images at an accelerating voltage of \(2 \text{kV}\) using both secondary electron and backscatter detector.

6. Change your accelerating voltage to \(5 \text{kV}\) and obtain 2 focused, well-stigmated images of the same area using both secondary electrons and backscatter detector.

7. Change your accelerating voltage to \(15 \text{kV}\) and obtain a focused, well-stigmated image of the same area using both secondary electrons and backscatter detector.

8. Change your accelerating voltage to \(30 \text{kV}\) and obtain a focused, well-stigmated image of the same area using both secondary electrons and backscatter detector.

Note: Each time you change accelerating voltage, focus, alignments, and stigmation must be redone.

9. Retract backscatter detector fully by unscrewing **BEFORE** venting and removing sample.