*Physics 7320/4230 "Electron Microscopy and Microanalysis"*

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

September 6th to 19th, 2016

(Due one week from lab session)

**Introduction:**

Examine the topographic and Z-contrast using secondary and backscattered electron signals.

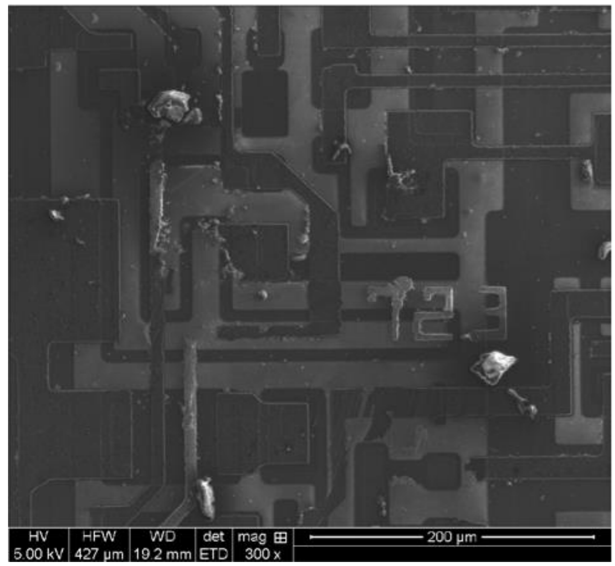


Figure 1. Semiconductor sample.

**Specimens:**

*1. Semiconductor component*

**Objectives:**

1. Determine differences between secondary (SE) and backscattered (BSE) electrons.
2. Effect of accelerating voltage (keV) on SE vs.BSE signal

**Imaging:**

Obtain 6 well-focused and stigmated images of Specimen 1: Semiconductor at increasing accelerating voltages (10, 20 & 30 keV)

One set of 3 images will show secondary electron signal images at increasing accelerating voltage.

The other set of 3 images will show backscattered electron signal images at increasing accelerating voltage.

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**Questions to be answered:**

1. What is a secondary electron? Please describe at least two different mechanisms by which a secondary electron is generated when the SEM's primary electron beam interacts with your sample? (2 points)

2. What type of detector is used to detect a secondary electron? Please describe how the signal detected by this detector can be varied. (2 points)

3. What is a backscattered electron? How is a backscattered electron generated? (2 points)

4. Present the 3 SE images and 3 BSE images in a two by three format.

   (a) In reviewing your images of the semiconductor at increasing accelerating voltages, look at the fine detail in the secondary electron images. What do you notice? Why do you think this is occurring? (4 points)

   (b) Describe the effect of accelerating voltage on the signals displayed in backscattered electron images. (4 points)

5. How does elemental composition affect BSE-signal generation? How does topography affect BSE-signal generation? (2 points)

6. Using Kanaya Okayama equation (analytical expression, the units do not cancel), calculate the electron interaction depth for the following chemistries (Al, Si, SiO2, C) at all of the acceleration voltages (5 points):

$$r(\mu m) = \frac{2.76 \times 10^{-2} A E_0^{1.67}}{\rho Z^{0.89}}$$

   A = avg. atomic wt, $E_o$ is the acceleration voltage, $\rho$ is density, Z = avg. atomic #

7. Given the candidate chemistries Si, SiO2, Al, C, the results of the Kanaya-Okayama calculation and discussion with your lab instructor, please infer what the ID of the features in each of the 3 BSE images (4 points).

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Figure 2. Yttrium aluminum garnet (YAG) backscatter detector.

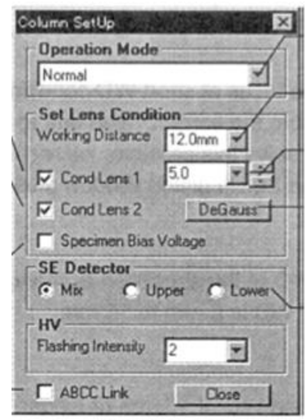
**Specimen 1:** *Semiconductor*

This section will demonstrate topographic (secondary electrons) and Z contrast (backscattered electrons).

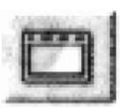
1. Insert Backscatter Detector (Figure 2), on back left of instrument, screw detector fully into the column.

2. Set following operating conditions:
   - Accelerating Voltage…Variable
   - Emission Current....... 20 μAmp
   - Mode.......................... Normal
   - Working distance........8 mm
   - Condenser lens..........5
   - Detector......................Upper (no bias voltage)

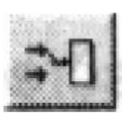
3. Starting at 30 kV, center the numbers on the semiconductor sample in low mag mode. Switch to high mag mode, and adjust sample to 8 mm working distance using the Z-height adjustment knob. Perform focus, alignments, stigmation, & detector auto brightness/contrast




4. At 30kV, take an image with the upper SE detector under "Column Setup". Shown in the graphic to the right



5. Enable "**Split Screen**" Mode[1].



6. Open the "**Signal Select**" window and choose "SE" for the right side and "BSE" on the left. Adjust brightness/contrast.

*****Note, the left split screen can be adjusted with hand-panel controls, right side need to be adjusted with the slider bars*

7. Obtain 8 focused, well-stigmated images of the same area (ex. the numbers) using both secondary electron and backscatter detectors at the following accelerating voltages[2]: **10 kV**, **20 kV** & **30 kV.**

**** *Note: Each time you change kV - focus, alignments, and stigmation must be redone*

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