Welcome to Michigan State University

SEMED

Scanning Electron Microscope Education Program

Sponsored by the National Science Foundation (NSF)
Definition

• Motivational science program

• Established in 1991 by Air Force Research Laboratory (AFRL) Materials Directorate

• Initiated at Alfred University in 2002

• Local junior and senior high school students and their teachers

• Spend time learning about and using latest technology in scanning electron microscopes (SEMs)

• Started at Michigan State University in 2002
Goals

• Demonstrate that science is fun
• Show that scientists and engineers are real people
• Identify career opportunities in science and engineering
• Provide teachers with resources in electron microscopy
• Demonstrate how science is used in a working environment
• Establish a connection between the classroom and the real world
Description

- Rare opportunity for students and teachers
- Hands-on experience with the latest high tech equipment
- Fun and informative
- Students meet and work with scientists and engineers
- Run by MSU volunteers
- Conducted at the end of the work day
Organization

• Informational meeting for teachers at start of school year
• Teachers meet the volunteers
• Program organization discussed
• Teachers sign up for sessions
• Teachers taken through a typical session
• SEMED representative contacts teacher several weeks prior to scheduled session to confirm
Program History

- A Challenger Center survey revealed teachers desired working with SEMs above any other scientific instrument
- Challenger Center contacted the AFRL Materials Directorate
- Meetings were conducted and a formal program was conceived and implemented
- Students responded positively to hands-on work only
- Program was quickly adapted to fill customer needs
Current and Future Status at AFRL

- Twenty-two sessions per year
- Expand number of schools involved
- Tech Trek - SEMED on wheels
Session Description

• Teachers arrive with students and are greeted by SEMED Volunteers

• Volunteers introduce themselves and talk briefly about what they do

• Group is given a 20 minute talk on what makes the microscopes work and what they are used for
Session Description

• Group goes to lab
  (4-6 students per SEM)

• Volunteers explain how to operate the microscopes

• Volunteers stand back and let the students drive

• Typical session lasts about 1.5 hr

• Students are encouraged to explore

• Specimens are provided
SEMED

• Excites teachers, parents and STUDENTS
• Motivates students to consider science as a career
• Increases exposure of Michigan State University to local region
• Increases volunteerism
Light Microscope

- 5-1000x
- Two dimensional - limited depth of focus

Mitochondria in Paramecium
Scanning Electron Microscope (SEM)

- 10-75,000x
- Surface textures
Leica 360 SEM
• Phillips 515

Scanning Electron Microscope (SEM)
• **Electron Backscatter Diffraction (EBSD)**

  - Samples Polished thru 0.06\(\mu\)m finish; 20 minutes w/colloidal silica.
  - The 3 Sheet Orientations were investigated.

  - EBSD performed on a Phillips 515 SEM with LaB\(_6\) filament
  - 0.5\(\mu\)m step size; typical area mapped: 400\(\mu\)mx300\(\mu\)m.

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**Diagram:**

- F – Rolling Face
- CS – Cross Section
- L - Longitudinal

**Images:**

- Digiview Camera
- SEM Chamber
Bohr’s Atom
Electron Gun
Electron Gun or Filament

- Filament
- Cup
- Anode
- Electron Stream
Electromagnetic Lenses
Electromagnetic Lenses

“Focus the stream into a beam”
SEM Construction
Television vs. SEM

**Television**
- Vacuum Tube
- Electron Filament
- Anode
- Condenser Lens
- Scan Coils
- Phosphor
- Screen

**SEM**
- Vacuum Chamber
- Electron Filament
- Anode
- Condenser Lens
- Scan Coils
- Secondary Electron Detector
- Specimen
Secondary Electrons

Primary Electron

Secondary Electron

Primary Electron
Secondary Electron Detection

Primary Electrons

Sample Surface

Secondary Electron Escapes to detector

Secondary Electron loses energy and is reabsorbed

Secondary Electron Detector
Secondary Electron Detector Image
Backscattered Electrons, are Electrons from the incoming beam which have been Elastically Scattered back out of the sample. The number of backscattered Electrons generated increases with the Atomic Number of the specimen.
Example of a Secondary Electron Image and a Backscattered Electron image. The image is from the glaze body interface of a coffee cup.

Notice that the glaze is much brighter in BSE and that there are crystals in the glaze which are seen in the BSE image and not in the SE image. Another thing to observe is the particle of dust (very low atomic number) seen in the SE image is not seen in the BSE image. Also, you can see bright rims around the pores in the SE image which are not present in the BSE image.
X-ray Production Diagram

- Ejected Orbital Electron
- Scattered Primary Electron
- Electron Relaxation and Photon Generation
- X-Ray Photon Emitted
- Photon Internally Converted and Auger Electron Emitted
Top six pictures show earwig parasites
Bottom two pictures are of a sand dollar