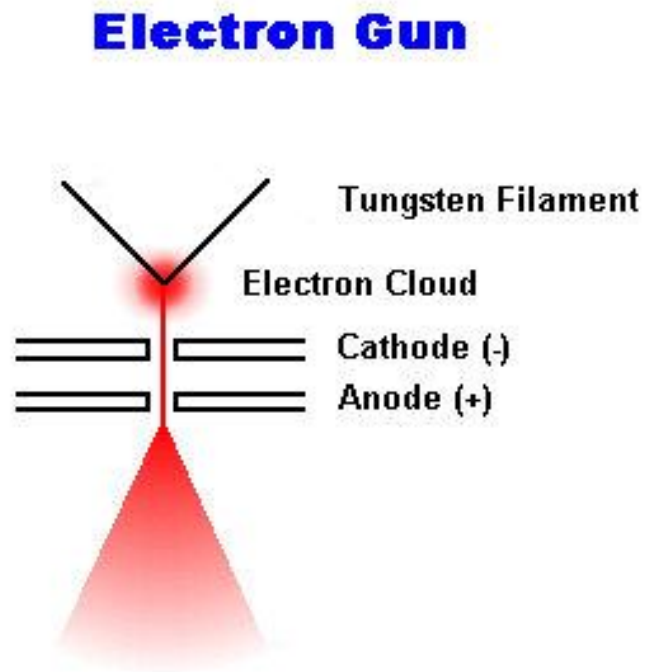# SEM(Scanning Electron Microscope)

Why SEM??

- Main Limitation of Optical Microscopy
  - Large wavelength of visible light($\lambda/2$)
  - Poor depth of field. The main parameter effecting depth of field is the aperture angle.
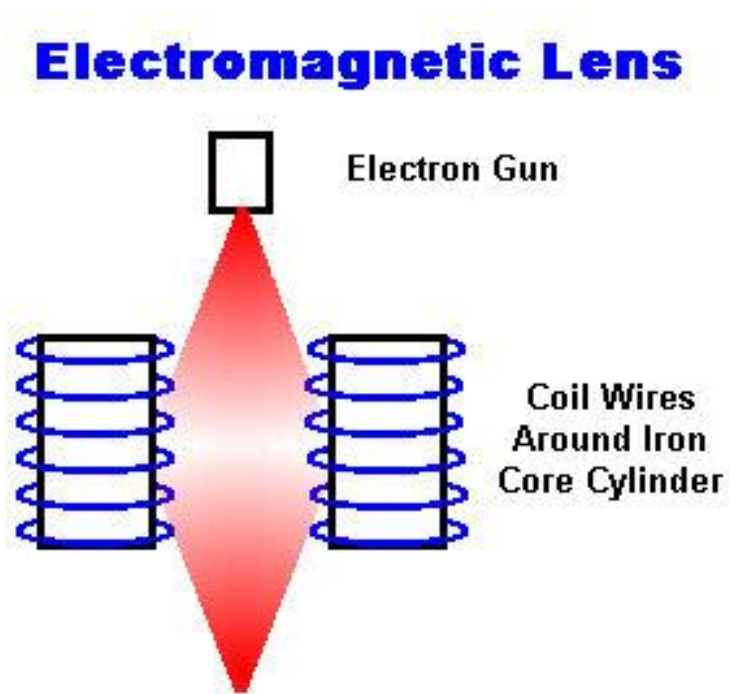
Electron Limitation

- Electron source, lenses and sample must all be under a vacuum
- Since electrons are electrically charged, the sample needs to be conductive enough to dissipate this charge.

Electron Gun

Electron Gun

Tungsten Filament

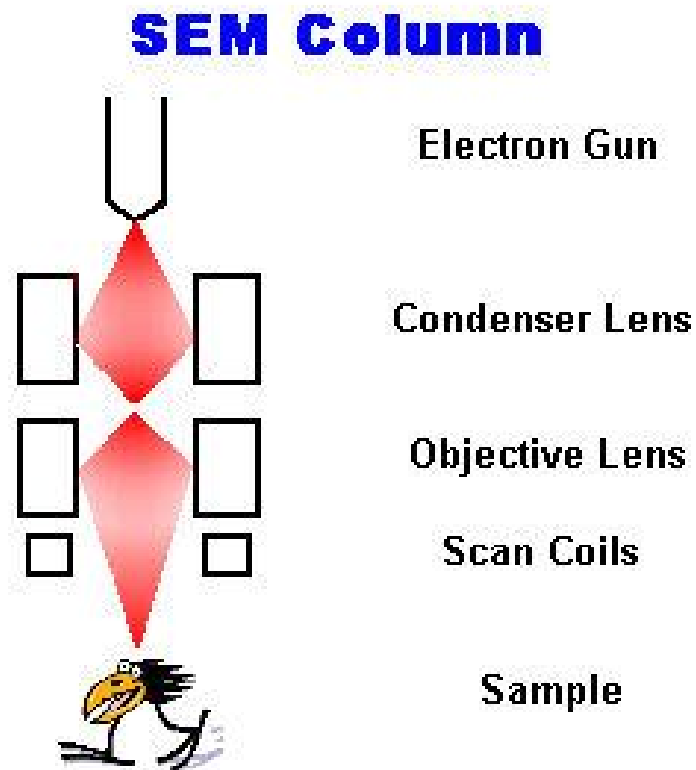Electron Cloud

Cathode (-)

Anode (+)

- Heated Filament makes electron clouds.

- Electrons are attracted by Anode (+)

- The speed of the electrons emitted from this gun is controlled by the Amount of potential (accelerating voltage) applied to the cathode and anode plates.

Electromagnetic Lens

Electromagnetic Lens

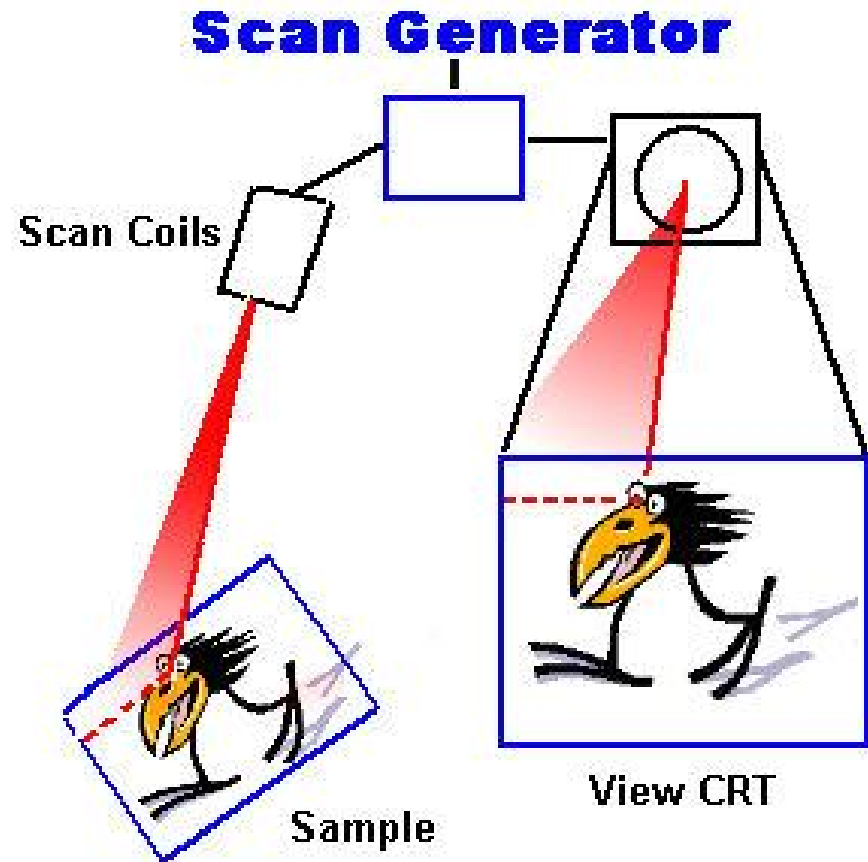Electron Gun

Coil Wires
Around Iron
Core Cylinder

- By applying current to wire coiled around an iron cylindrical core, a magnetic field is created which acts as a lens

- By varying the current through the wires, the lens can have a variable focal length.

SEM Column

SEM Column

Electron Gun

Condenser Lens

Objective Lens

Scan Coils

Sample

- ## The condenser Lens
  - Controls the size of the beam, or the amount of electrons travelling down the column
  - Size of beam : Depending resolution of object

- ## The objective lens :
  - Focuses the beam into a spot on the sample. This is necessary to have an image in proper focus

Scan Coil & Generator

Scan Generator

Scan Coils

Sample

View CRT
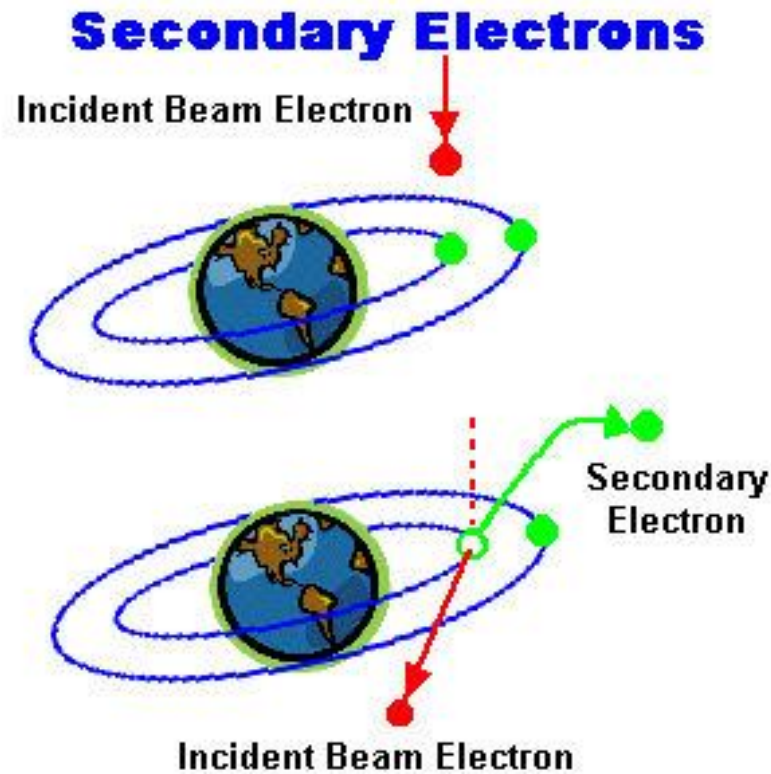
- Scan Coil
  - By varying the potential between set of plates around the beam, electric beam could be deflected.

- Scan Generator :
  - The beam can be made to scan lines across the sample similar to the way a television tube scans.

Interaction electron beam and sample atom

1 Electron beam can pass through the sample without colliding with any of the sample atoms

2 Electron beam can collide with electrons from the sample atoms, creating secondary electrons

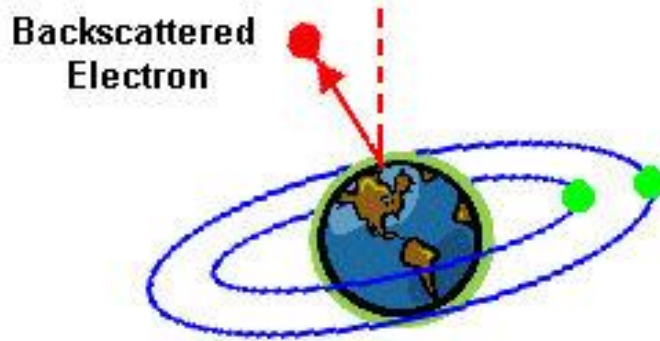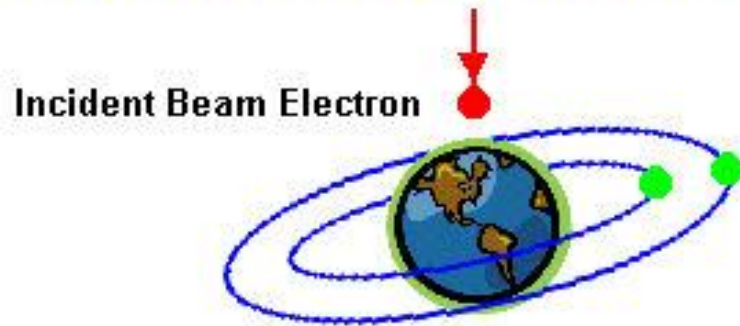3 Electron beam can collide with the nucleus of the sample atom, creating a backscattered electron.

Secondary Electrons

- Incident electron is highly energized.

- These electrons collides with a sample atom electron, it will knock it out of its shell

- These secondary electrons are close enough to the sample surface, they can be collected to form an SEM image.
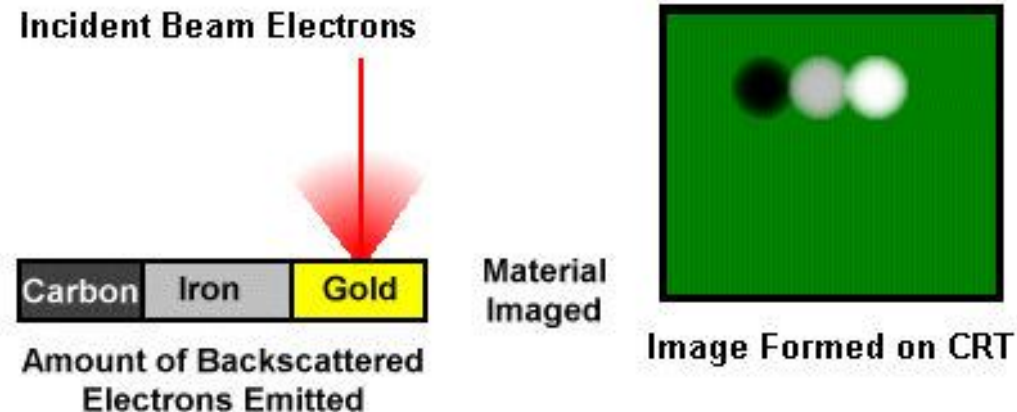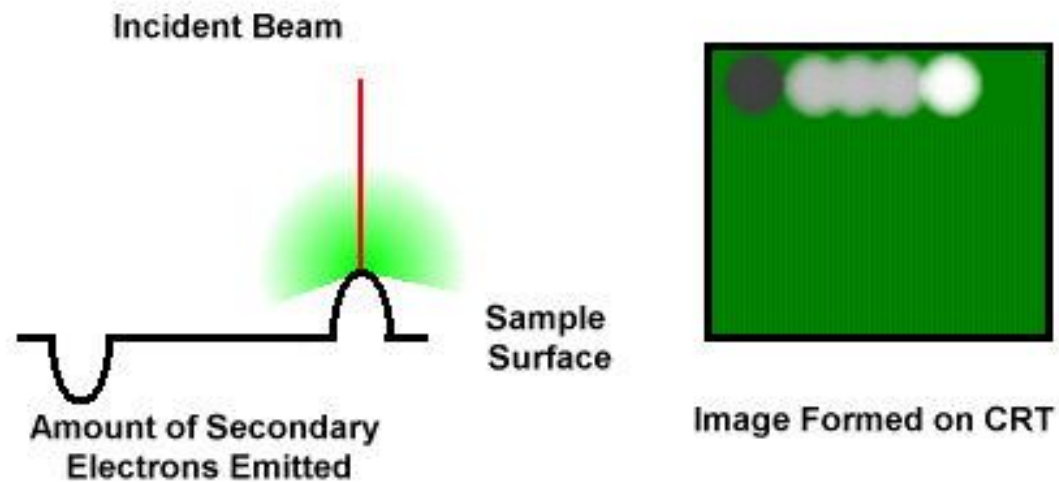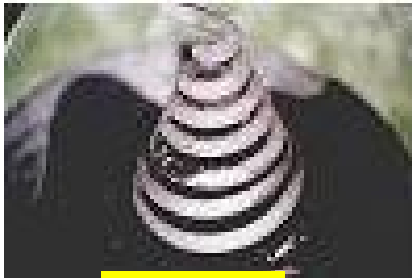
Backscattered Electrons

- Collides with a nucleus of a sample atom, incident electron bounces back out of the sample as a backscattered electron

- Electron has high energy since nucleus has higher density.

- Using for discern the difference in sample densities
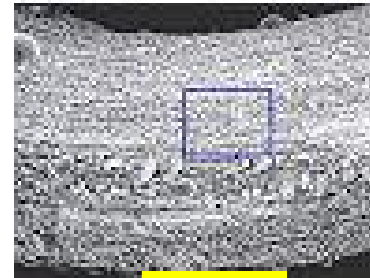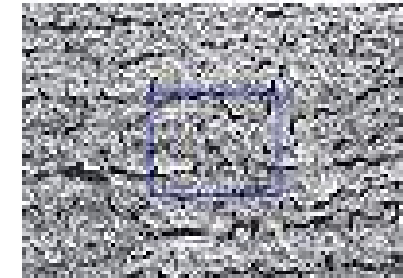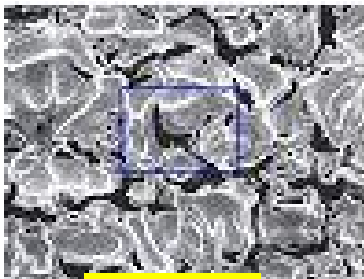
Images of secondary&backscattered

SEM Images

10x opt

10x

100x

400x

1200x

4000x

16000x

45000x