Introduction to scanning electron microscopy:

- Electron microscopes are scientific instruments that use a beam of energetic electrons to examine objects on a very fine scale.
- Electron microscopes were developed due to the limitations of Light Microscopes which are limited by the physics of light.
- In the early 1930's this theoretical limit had been reached and there was a scientific desire to see the fine details of the interior structures of organic cells (nucleus, mitochondria...etc.).
- This required 10,000x plus magnification which was not possible using current optical microscopes.
- **The first scanning electron microscope (SEM) debuted in 1938 (Von Ardenne) with the first commercial instruments around 1965. Its late development was due to the electronics involved in "scanning" the beam of electrons across the sample.**

SEM Information:

- Topography

The surface features of an object or "how it looks", its texture; direct relation between these features and materials properties

- Morphology

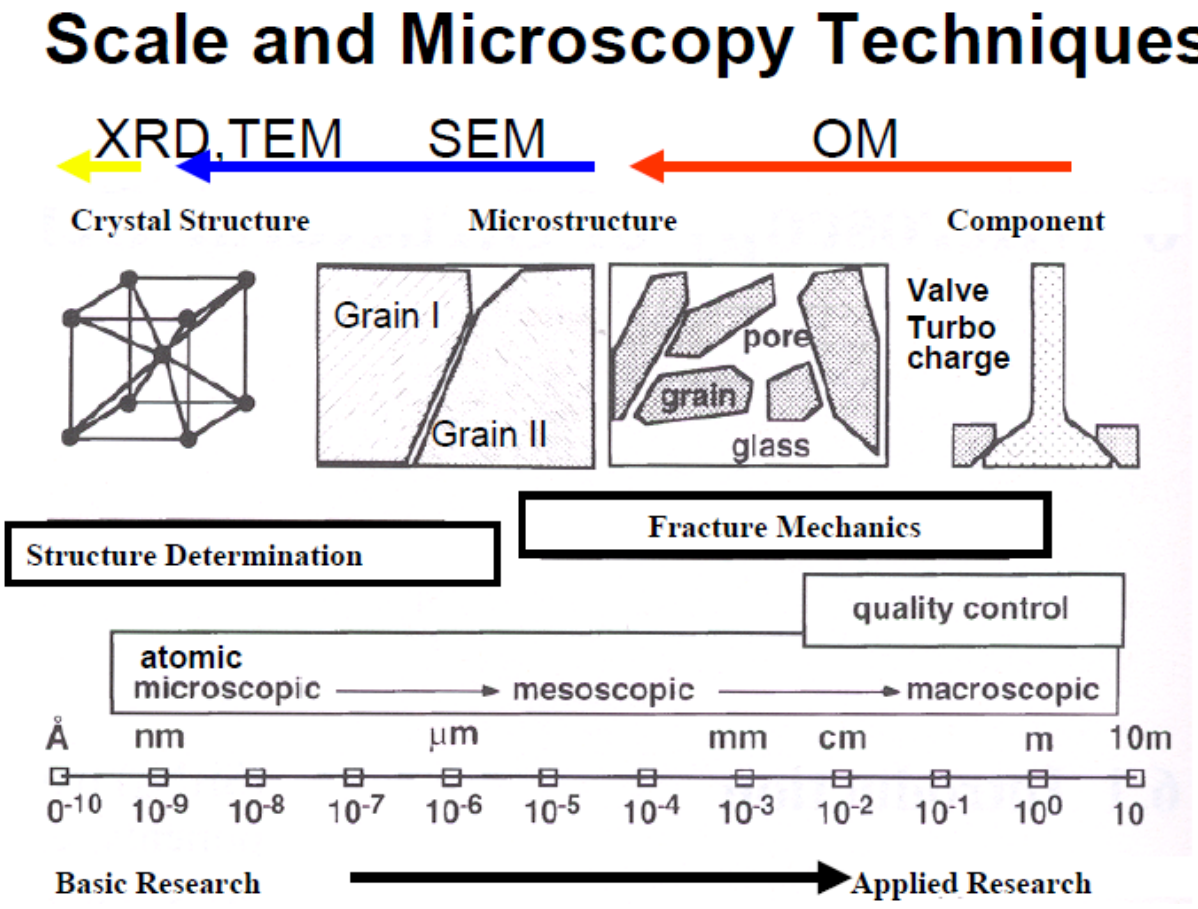
The shape and size of the particles making up the object; direct relation between these structures and materials properties

- Composition

The elements and compounds that the object is composed of and the relative amounts of them; direct relationship between composition and materials properties

- Crystallographic Information

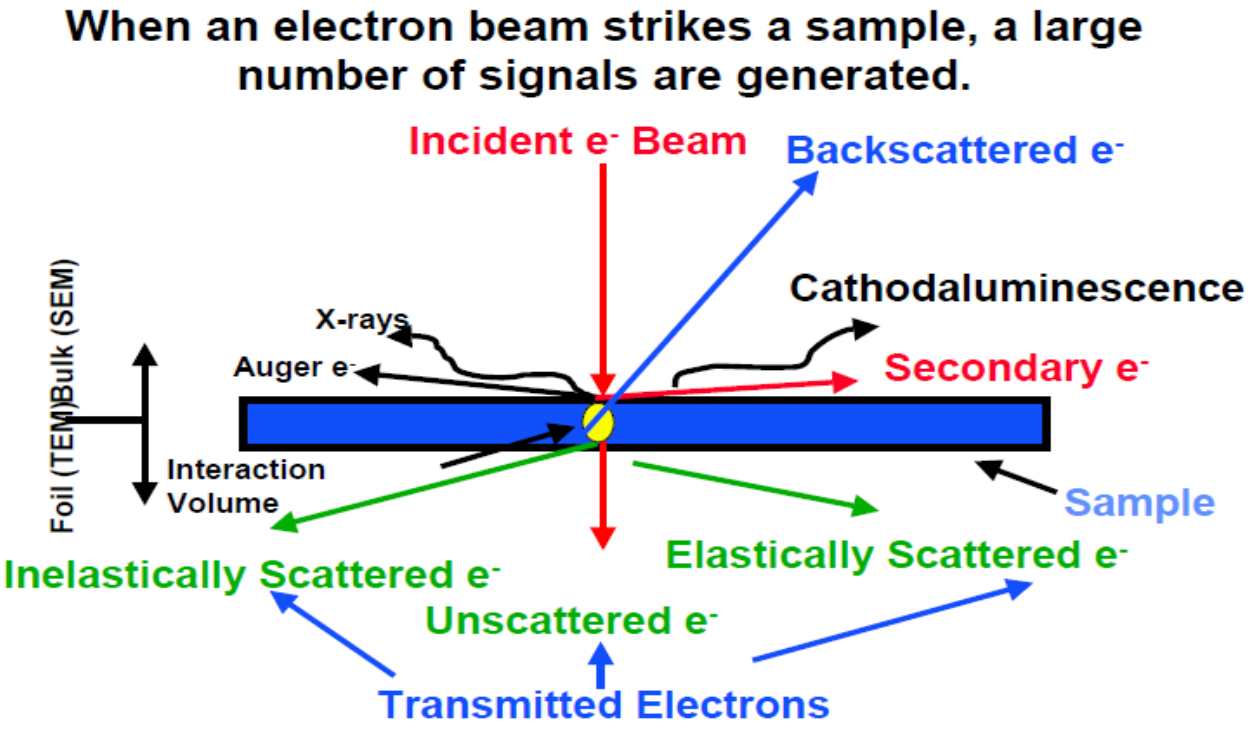
How the atoms are arranged in the object; direct relation between these arrangements and material properties



Advantages of Using SEM

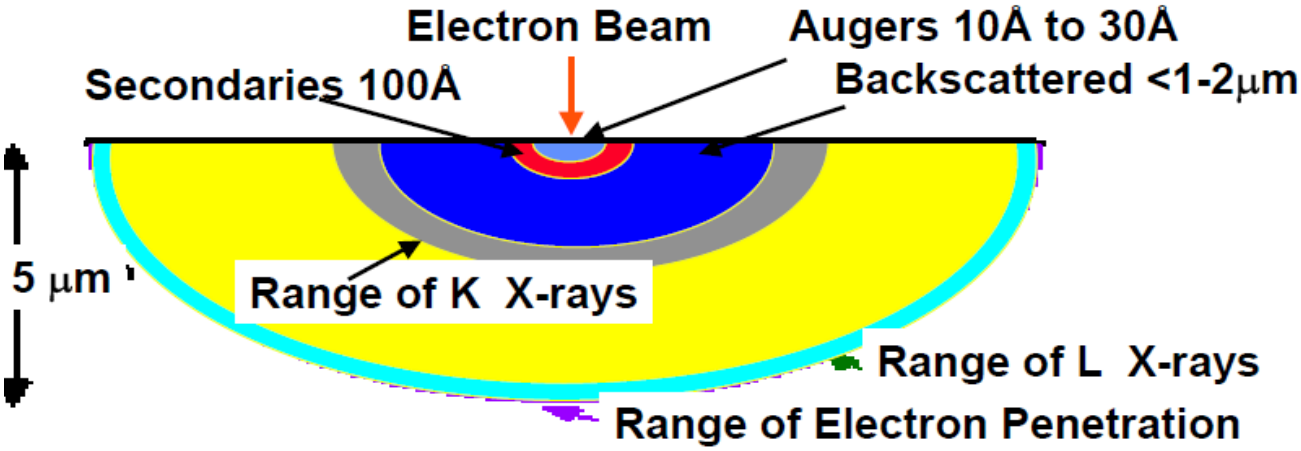
	Mag	Depth of Field	Resolution
SEM:	10x – 500Kx	30mm	1.5nm

The SEM has a large depth of field, which allows a large amount of the sample to be in focus at one time and produces an image that is a good representation of the three-dimensional sample. The combination of higher magnification, larger depth of field, greater resolution, compositional and crystallographic information makes the SEM one of the most heavily used instruments in academic/national lab research areas and industry.



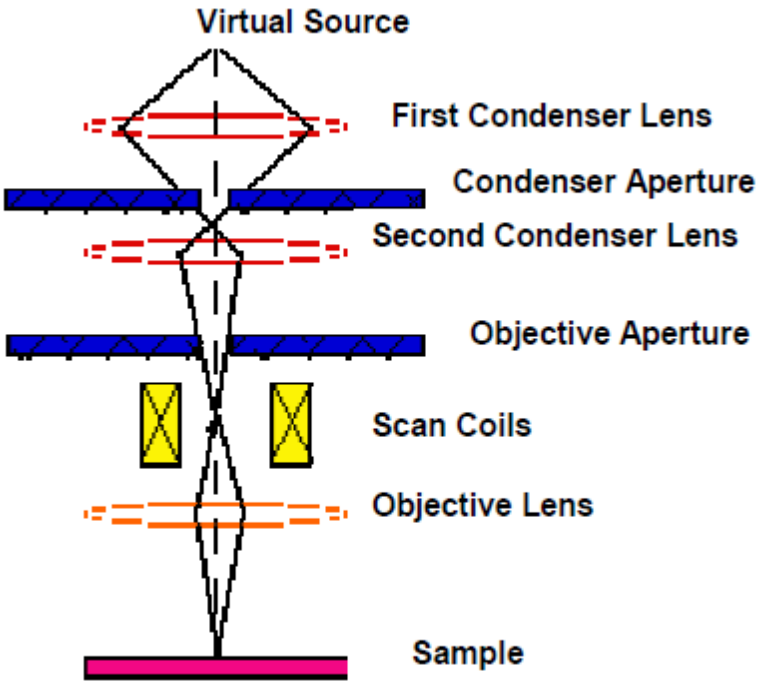
Below is an example of a typical Interaction volume for:

- **Specimen with atomic number 28, 20 kV**
- **0° degrees tilt, incident beam is normal to specimen surface noting the approximate maximum sampling depths for the**



The SEM Instrument Components:

1. Electron optical column consists of:
– electron source to produce electrons
– magnetic lenses to de-magnify the beam
– magnetic coils to control and modify the beam
– apertures to define the beam, prevent electron spray, etc.
2. Vacuum systems consists of:
– chamber which “holds” vacuum, pumps to produce vacuum
– valves to control vacuum, gauges to monitor vacuum
3. Signal Detection & Display consists of:
– detectors which collect the signal
– electronics which produce an image from the signal



1) The "Virtual Source" at the top represents the electron gun, producing a stream of monochromatic electrons.
2) The stream is condensed by the first condenser lens (usually controlled by the "coarse probe current knob"). This lens is used to both form the beam and limit the amount of current in the beam. It works in conjunction with the condenser aperture to eliminate the high-angle electrons from the beam.
3) The beam is then constricted by the condenser aperture (usually not user selectable), eliminating some high-angle electrons.
4) The second condenser lens forms the electrons into a thin, tight, coherent beam and is usually controlled by the "fine probe current knob".
5) A user selectable objective aperture further eliminates high-angle electrons from the beam.