Nanomaterials

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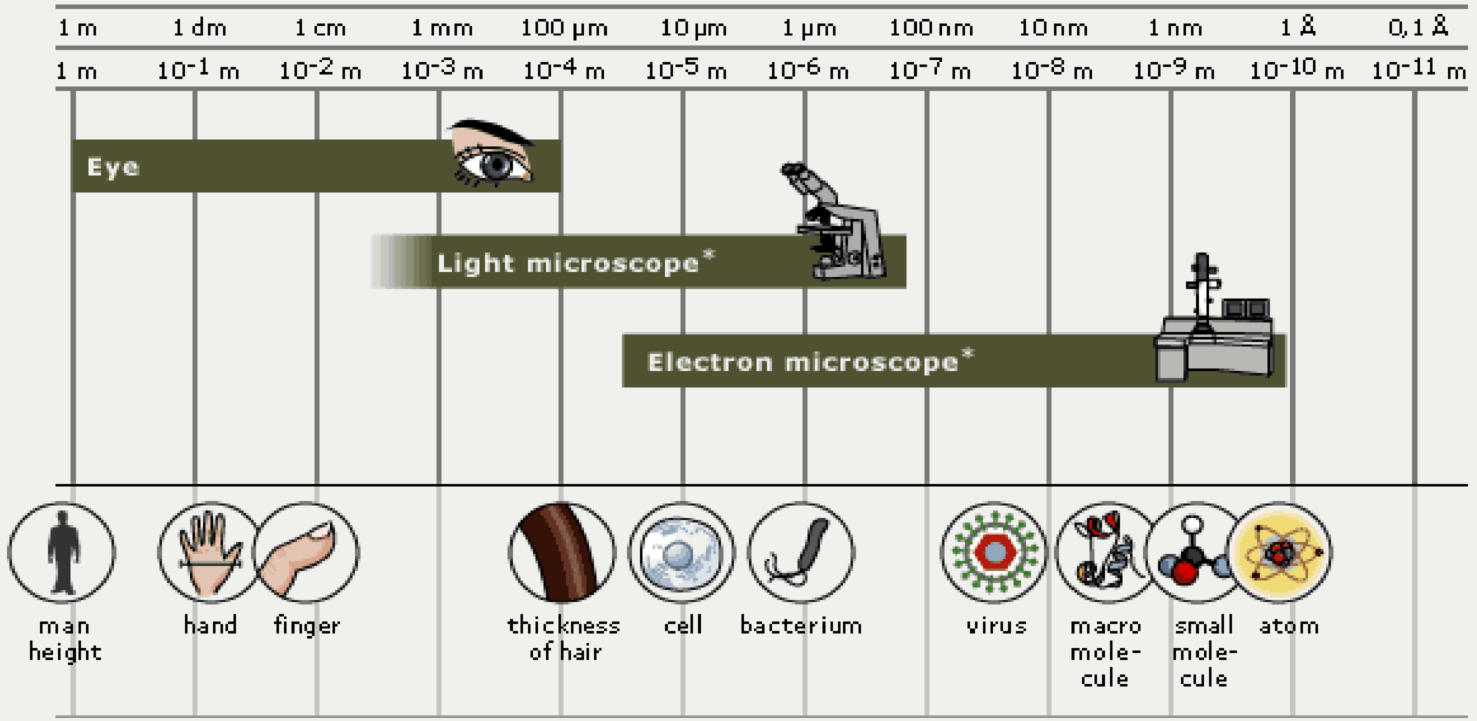
Techniques for Characterization of Nano Materials

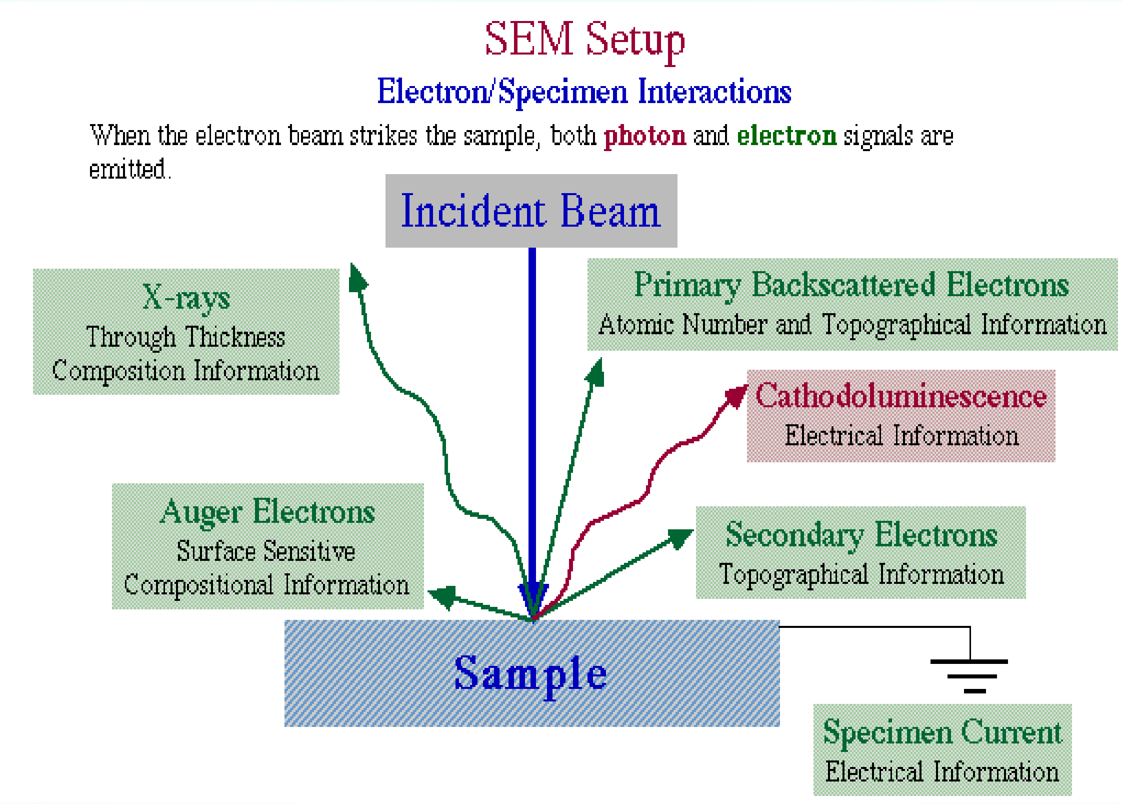
Resolving power line



* Light microscope includes phase contrast and fluorescence microscopes. Electron microscope includes transmisson electron microscope.

1. Scanning Electron Microscopy

The scanning electron microscope (SEM) is a type of electron microscope that images the sample surface by scanning it with a high-energy beam of electrons in a raster scan pattern. The electrons interact with the atoms that make up the sample producing signals that contain information about the sample's surface topography, composition and other properties such as electrical conductivity .



- e- beam strikes sample and electron penetrate surface
- Interactions occur between electrons and sample
- Electrons and photons emitted from sample
- Emitted e- or photons detected

SEM components

Main parts of Scanning electron microscopy (SEM) include an electron gun, lenses (a condenser lens, an objective lens, stigmator lenses), coils for the x-y scan movement, specimen chamber and detection device for image formation.

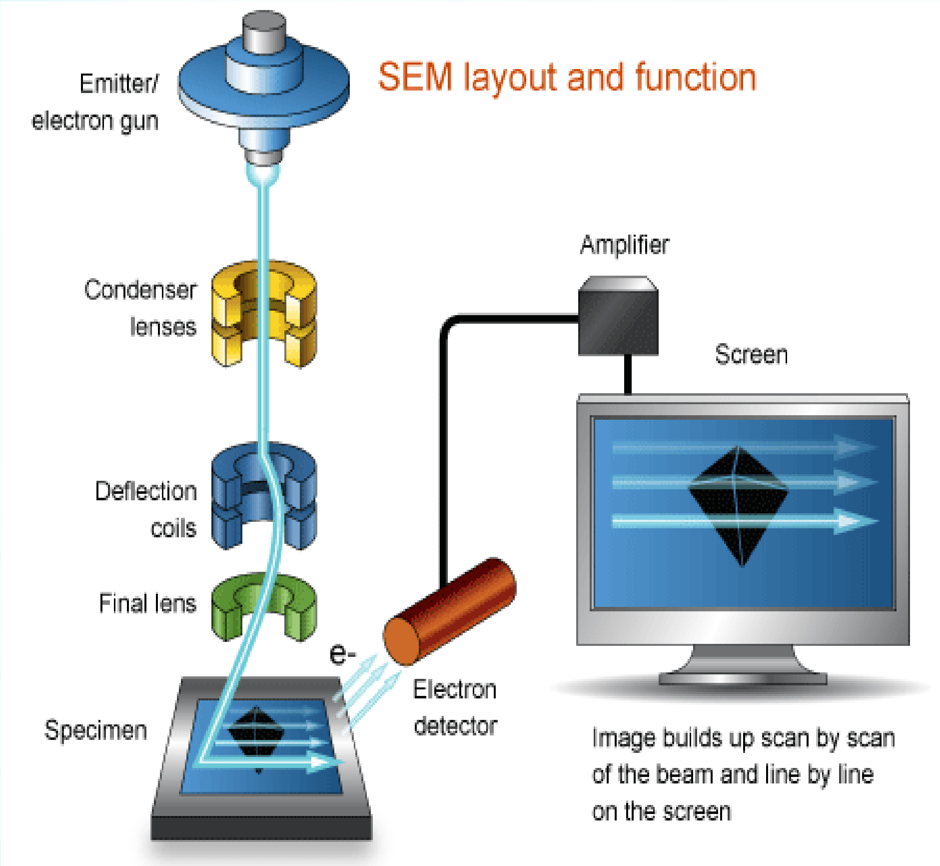


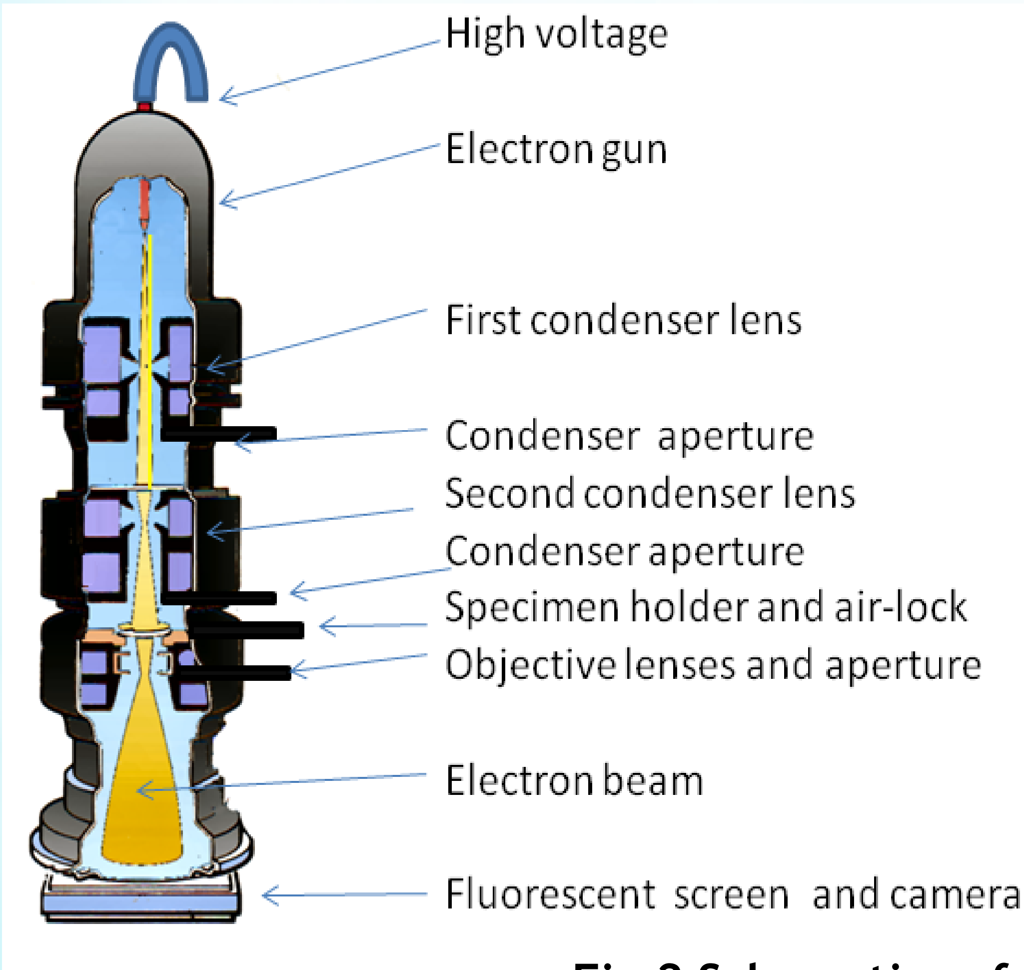
Fig.1 SEM Equipment

2. Transmission Electron Microscopy

Transmission Electron Microscope (TEM)

- e-beam strikes sample and is transmitted through the sample
- Scattering occurs
- Un-scattered electrons pass through sample and are detected

Transmission Electron Microscopy



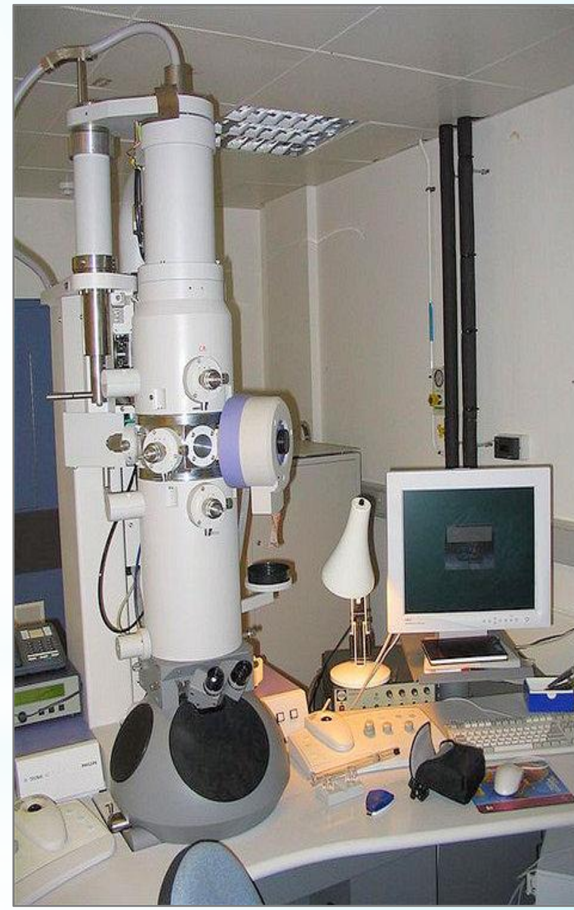


Fig.2 Schematics of a TEM

Transmission Electron Microscopy

Typically a TEM consists of three stages of lensing. The stages are the condenser lenses, the objective lenses, and the projector lenses. The condenser lenses are responsible for primary beam formation, whilst the objective lenses focus the beam down onto the sample itself. The projector lenses are used to expand the beam onto the phosphor screen or other imaging device such as photographic film. The magnification of the TEM is due to the ratio of the distances between the specimen and the objective lens' image plane.

3.Energy dispersive X-ray spectroscopy (EDS)

*The techniques include Energy Dispersive X-ray spectroscopy (EDS) for the identification of phases containing light elements like carbon, nitrogen, oxygen etc at high spatial resolution of ~1nm.

*EDS systems can be attached to both TEM and SEM for carrying out elemental analysis.

4. Scanning Probe Microscopy

Measure feedback from atomically defined tip
Many types of feedback (dependent on tip)

a) AFM (Atomic Force Microscopy) - **Forces between sample and tip**
b) STM (Scanning Tunneling Microscopy) - **Tunneling current between sample and tip**

a) AFM (Atomic Force Microscopy)

a) AFM (Atomic Force Microscopy) – Forces between sample and tip

Atomic force microscopy (AFM) used to image surface structures. In addition, as its mechanism depends on the force of attraction between molecules, it is also possible to measure surface forces, i.e., attractive or repulsive forces between tip and sample.
In AFMs, the probe is a tip at the end of a cantilever which bends in response to the force between the tip and the sample. Figure 3 illustrates a simple schematic of an AFM.

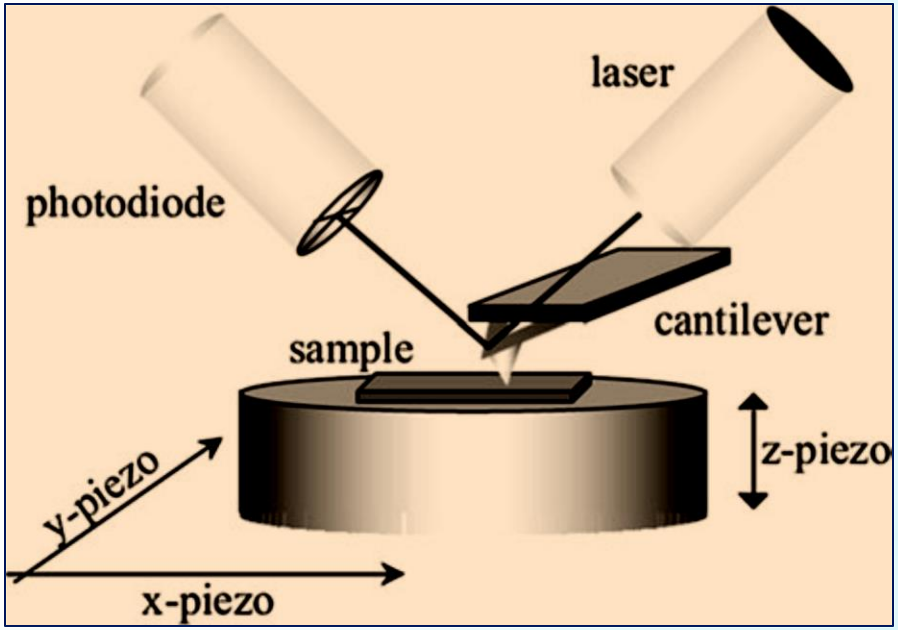


Fig. 3 Schematic diagram showing AFM principles

b) STM (Scanning Tunneling Microscopy)

b) STM (Scanning Tunneling Microscopy) – Tunneling current between sample and tip

A schematic view of an STM is given in Fig. 4. The components of an STM include scanning tip, piezoelectric controlled height and **x,y scanner**, coarse sample-to-tip control, vibration isolation system, and computer . The tip is often made of tungsten or platinum-iridium, though gold is also used. Tungsten tips are usually made by electrochemical etching, and platinum-iridium tips by mechanical shearing.

Scanning Tunneling Microscope

- Tip scans just above surface of stage
- Electrons have a small probability of escaping material to tip creating tunneling current
- Tunneling current is depends on distance between tip and sample

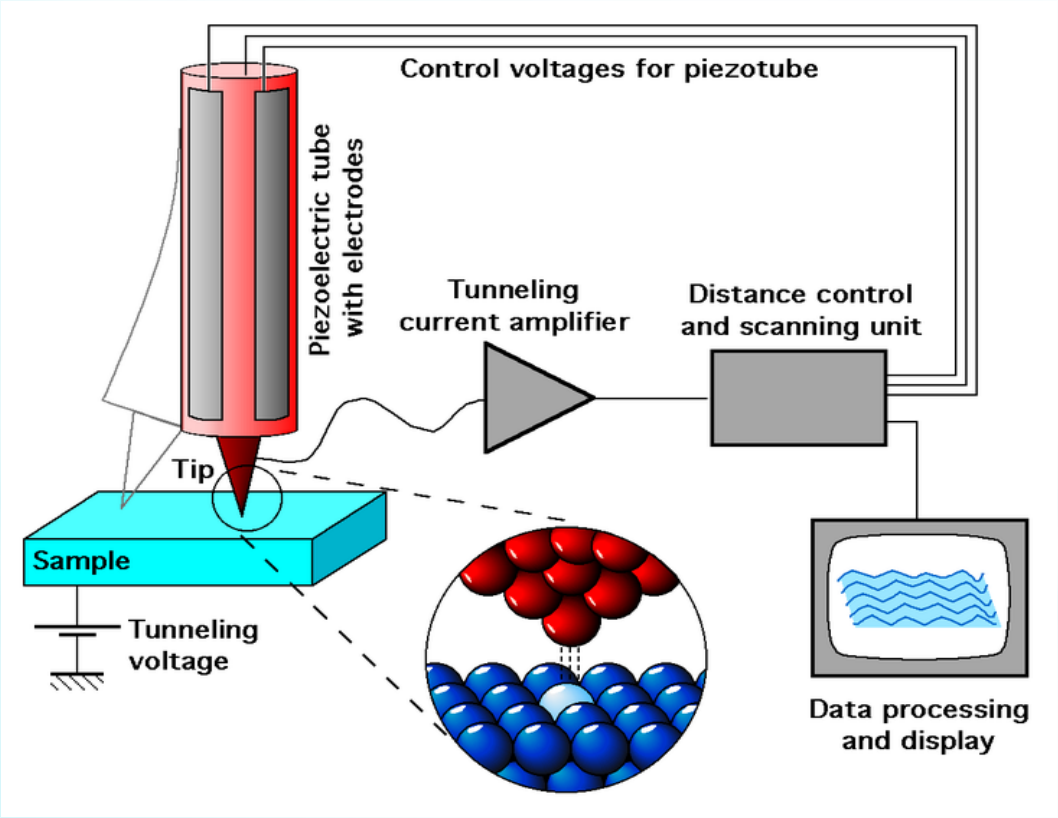


Fig. 4 Schematic diagram showing STM principles