

SCANNING ELECTRON MICROSCOPE(SEM)

❖ Introduction:

In 1938, Von Ardenne described the theoretical principles of SEM but true SEM was first developed by Zworykin, Hillier & Snyder in 1942.

❖ SEM:

A Scanning Electron Microscope (SEM) is a type of electron microscope that produces images of a sample by scanning its surface with a high-energy beam of electrons.

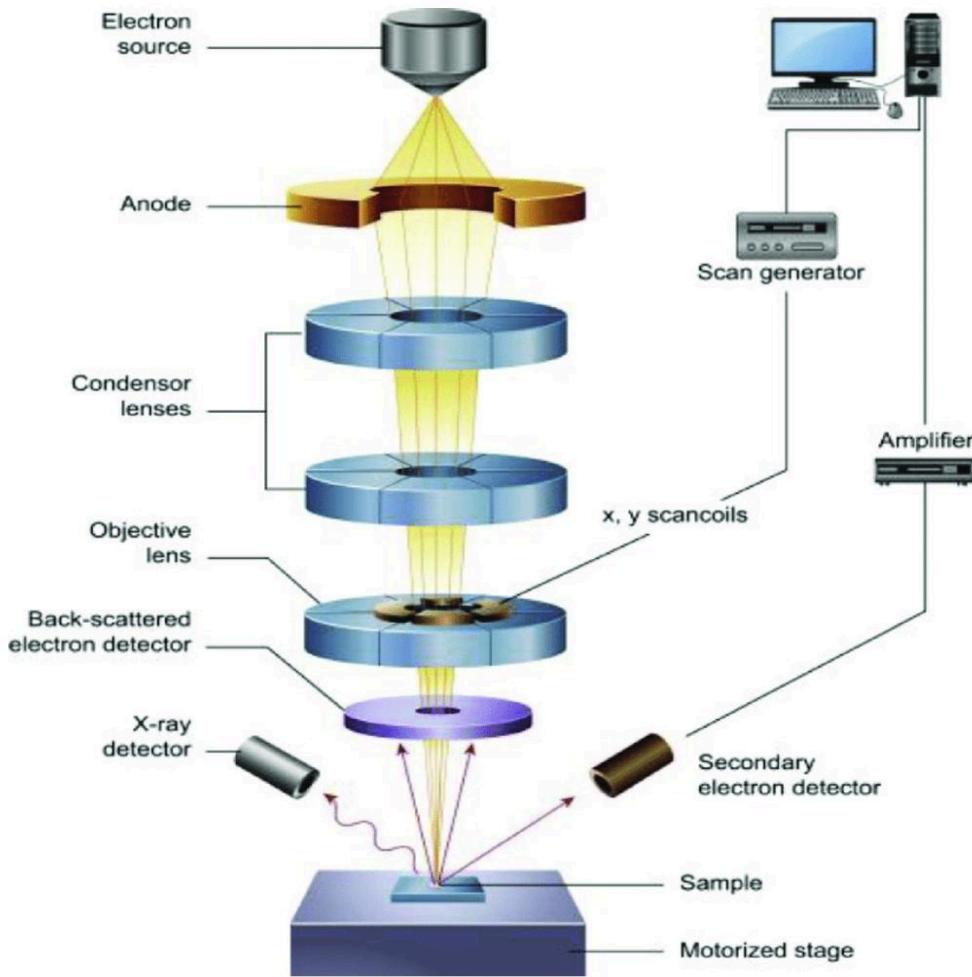
❖ Principle:

The SEM works by scanning the surface of a sample using a high-energy beam of electrons. This interaction generates various signals, such as secondary electrons, backscattered electrons, and characteristic X-rays, which are used to create detailed images of the sample.

Main components of SEM:

- 1. Electron gun
- 2. Anode
- 3. Magnetic lens
- 4. Scanning coils
- 5. Objective lens
- 6. TV scanner
- 7. Detectors
- 8. Specimen stage

➤ **Block diagram / sketch:**



➤ **Construction & Working:**

- ❖ The virtual source at the top represents the **Electron-gun** which produces a stream of high energy monochromatic electrons.
- ❖ These electrons are emitted from a filament (cathode) made up of a thin tungsten wire by heating the filament at high temperature.
- ❖ Now, these electrons are attracted and travel through **Anode** due to directionality.
- ❖ Two magnetic lenses are used as **condenser lenses** to convert the diverging electron beam into a fine pencil beam and the condenser lens eliminates the high angled electrons from the beam so the electron beam becomes thin and coherent.
- ❖ **Scancoils x,y** are used to deflect the electron beam to scan the sample.
- ❖ The **Objective lens** is used to focus the scanning beam on a desired spot on the sample.

- ❖ When the high energy electron beam strikes the sample, some electrons are scattered due to elastic scattering called **Back scattered electrons**, some electrons are knocked off from the surface called **Secondary electrons** and some electrons penetrate deep into the inner shells of the sample atoms to knock off inner shell electrons due to which X-rays are produced.
- ❖ The intensities of secondary electrons, backscattered electrons and X-rays recorded using detectors and the signals are amplified by **Amplifiers** and display the images on a **TV** scanner/monitor.
- ❖ This process is repeated several times (up to 30 times per second) to get accurate results.
- ❖ To record the SEM image, in the past, the SE image appearing on the LCD was photographed with a camera. But recently, the image has been recorded in a digital format called **electronic file** and it is easier to process and convert to send or receive image information.

❖ Characterization of Sample using SEM:

- ❖ Topography: To study surface features & texture
- ❖ Morphology: To study the shape, size & arrangement
- ❖ Composition: To study the ratio of elements & compounds
- ❖ Crystallographic information: Arrangement of atoms & their order in the crystal

❖ Advantages:

- ❖ High resolution 3D images
- ❖ Chemical analysis
- ❖ Versatile information
- ❖ Applications in biology, material science, forensics & microchip assembly.

❖ Disadvantages:

- ❖ Expensive
- ❖ Sample must be solid
- ❖ Require strong insulator coating
- ❖ Require specimen size to fit in chamber
- ❖ Require low pressure / wet organic materials
- ❖ Special training is required.
- ❖ Require special operating environments like vibration free rooms & electromagnetic elements.

❖ **Applications:**

❖ SEMs are versatile instruments used in a wide range of scientific and industrial applications for imaging & analysing the surface morphology of materials at high magnification. Some applications are:

- 1. Material science
- 2. Nanowire for gas sensing
- 3. Semiconductor inspection
- 4. Microchip assembly
- 5. Forensic investigations
- 6. Biological Sciences
- 7. Soil & Rock sampling
- 8. Medical ¹ investigations