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.

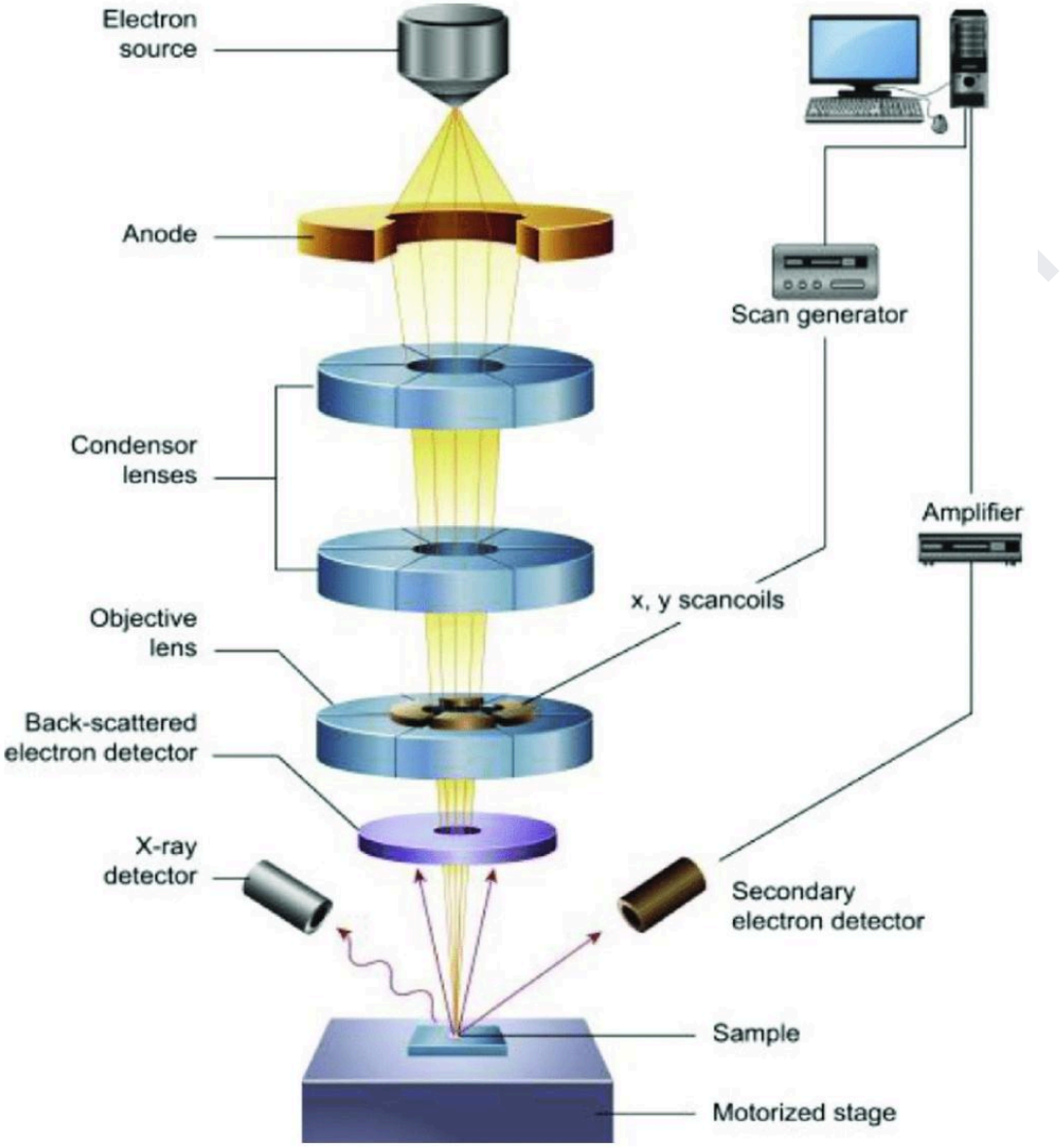
Principle:

- 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

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