

1. Scanning Electron Microscope (SEM)

Introduction

A Scanning Electron Microscope (SEM) is an advanced imaging tool used to examine the surface morphology and composition of materials with high resolution and magnification.

Working Principle

The SEM uses a focused beam of high-energy electrons to scan the surface of a sample. The interaction between the electrons and the sample generates various signals, which are captured to form detailed images. The key steps are:

1. **Electron Emission:** Electrons are emitted from the electron gun.
2. **Beam Focusing:** Electromagnetic lenses focus the beam onto the sample.
3. **Interaction:** The electrons interact with the sample's surface, producing signals such as:
 - **Secondary Electrons:** Provide surface details.
 - **Backscattered Electrons:** Give compositional contrast.
 - **X-rays:** Reveal elemental composition.
4. **Detection:** The signals are detected and processed into images.

Features

- Magnification: 10× to 300,000×.
- Resolution: Up to a few nanometers.
- Depth of Field: Creates three-dimensional surface visuals.

Applications

- **Material Science:** Surface analysis and failure inspection.
- **Biology:** Studying cells and tissues.
- **Nanotechnology:** Nanoparticle characterization.
- **Industrial Applications:** Quality control and forensic analysis.

Advantages

- High resolution and depth of field.
- Provides detailed surface morphology.
- Multiple imaging modes (e.g., secondary and backscattered).

Limitations

- Samples must be vacuum-compatible.
- Non-conductive samples require a thin conductive coating.

Diagram

Below is the simplified SEM setup:

1. **Electron Gun:** Source of electrons.
2. **Condenser Lenses:** Focus the electron beam.
3. **Sample Stage:** Holds the sample under analysis.
4. **Detectors:** Capture secondary and backscattered electrons.
5. **Output:** Produces high-resolution images.