Scanning Electron Microscopy (SEM) , Make: Zeiss

- **Scanning Electron Microscopy (SEM)** is a powerful imaging technique used to observe the surface structure and composition of materials at very high magnifications.
- SEM is widely used in materials science, biology, geology, forensics, semiconductor research, and many other fields.
- SEM works by using an electron source, typically a heated tungsten filament or a field emission gun, to produce a beam of electrons.
- The primary electron beam is directed onto the sample's surface. When the beam interacts with the sample, several types of interactions occur, including scattering, absorption, and emission of secondary electrons.

Instrument Capabilities

- SEMs provide high-magnification, high-resolution images of sample surfaces.
- SEM produces detailed 3D-like images of surfaces. Useful of Studying-Fracture surfaces, Particulates, Biological structures, Micro and Nano fabricated devices.
- SEM include additional detectors for chemical analysis. It Provides: Spot analysis, Line scans, Elemental maps.
- SEM is equipped to determine grain orientation, phase identification, and texture.
- It has large Range of Magnification From ~10× to 100000×. It covers macro, micro, and near-nano scales.

Sample Type

- **Conductive Samples:** These are the easiest to image, as they naturally dissipate the electron beam's charge. Examples Metals (Al, Cu, Fe, Au, etc.) Metal alloys Conductive ceramics Carbon-based materials (graphite).
- **Non-Conductive Samples:** Insulators accumulate charge under the electron beam, causing image distortion. Examples Polymers and plastics, Glass, Most minerals and ceramics, Biological specimens (once dried).
- **Biological Samples:** Soft, hydrated samples must be prepared carefully. Examples Cells, tissues, microorganisms, Plant material, Insects.
- **Powdered Samples:** Loose particulate materials. Examples Soil or clay powders, Pharmaceutical powders, Nanoparticles, Metal or ceramic powders
- **Thin Films and Coatings:** Used to study surface morphology and layer thickness. Examples Semiconductor films, Metallic coatings, Oxide layers, Polymer coatings.
- It can also be used for surface and fracture analysis of Geological Samples and many Industrial and Engineering Materials (Manufactured materials for failure analysis or quality control).

Sample Preparation

- **Conductive Samples:** Usually minimal: cleaning and mounting.
- **Non-Conductive Samples:** Often require conductive coating (e.g., Au, Pt, Pd, carbon), Drying or dehydration before imaging
- **Biological Samples:** Fixation, dehydration, drying, Conductive coating.
- **Powdered Samples:** Dispersed on carbon tape or a stub, Sometimes require coating.
- **Thin Films and Coatings:** Mounted directly; cross-sectioning if interior layers need imaging.
- For others samples required sectioning, mounting, or coating as needed.

Applications

- Microstructure analysis of metals, ceramics, polymers, and composites.
- Failure analysis (fracture surfaces, corrosion, wear)
- Phase identification and grain-size measurements
- Surface analysis of coating and thin-films.
- Inspecting microchips, circuits, and nanostructures.
- Identifying defects, contamination, lithography issues.
- Imaging cells, tissues, microorganisms in high detail.
- Studying surface morphology of plants, insects, and biological structures.
- Visualizing nanoparticles, nanotubes, nanowires.
- Characterizing nano-scale surfaces and interfaces
- Surface defect inspection and analysis of wear, machining marks, coatings.
- Studying particulates, aerosols, dust, micro plastics.
- Characterization of implants, biomaterials studying enamel, dentin, and bone microstructure.

References

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