SCANNING ELECTRON MICROSCOPY (SEM)

Scanning Electron Microscopy (SEM) is a high resolution, high depth of field imaging technique that shows topographical, structural and some elemental information at magnifications of 10X to 800,000X. It can be combined with multiple detection modes to reveal many different characteristics of a sample.

SEM Applications include:

Materials Evaluation

Grain size distribution
Surface roughness
Surface porosity
Particle sizing
Materials homogeneity
Inter-metallic distribution
Characterization of elemental diffusion

Failure Analysis

Contamination location
Examination for mechanical damage
Electrostatic discharge determination
Micro-crack detection

Quality Control

Comparison of good to bad samples
Material thickness determination
Dimension verification
MIL-standard screening

Principle of Operation:

A finely focused electron beam is scanned across the surface of the sample generating secondary electrons, backscattered electrons and x-ray signals. These signals are collected by specific detectors and displayed on a viewing cathode ray tube or computer monitor. The raster on the display corresponds to the raster on the sample, while the brightness varies according to the amount of signal generated at each point on the sample. A number of modes in SEM are possible giving different types of information:

- **Secondary Electron Imaging (SEI)** shows the topography of surface features as small as 6 nm. The production of the SEI signal is primarily dependent on surface roughness.
- **High Resolution Secondary Electron Imaging (HRSEI)** shows the topography of features as small as ~1 nm. HRSEI can also image films and stains as thin as a few atomic monolayers. An HRSEI equipped SEM can evaluate electron beam sensitive and charging sensitive materials at magnifications up to 800,000X, often without the need for sample coating and without sample damage.
- **Backscattered Electron Imaging (BEI)** shows the lateral distribution of elements or compounds within the top micron of the sample. An SEM equipped with a high resolution Robinson type detector (RBEI) can analyze features as small as 10 nm and composition variations of as little as 0.2 percent. The production of the RBEI signal is primarily dependent on surface composition. The Robinson Backscattered Electron Signal is sorted by intensity to produce images which show the distribution of elements and compounds within the top 0.5 microns of the sample's surface.
- **Electron Beam Induced Current (EBIC) Imaging** shows the location of sub-surface opens or shorts in microelectronic devices. It is a useful failure analysis diagnostic tool.

- **Voltage Contrast (VC) Imaging** shows presence of applied bias on the surface of a circuit or device. It identifies opens or shorts as well as voltage drops across a circuit.
- **Electron Channeling Patterns (ECP)** show localized crystallinity in a 3 micron area. It can analyze the crystalline structure of a material on a microscale and locate defects within structures.

Data Output:

The SEM images are viewed on a TV screen and captured as high resolution (2000 lines per inch) digital images.

Sample Constraints:

The sample constraints vary depending on the instrument and sometimes on the type of imaging required. For most of our instruments, the sample can be up to 15 cm x 10 cm x 7.5 cm in size. For the Hitachi S-4800 the sample can be up to 6" in diameter (for a silicon wafer), or for smaller diameter samples up to 2.5 cm thick.

The sample must be compatible with a 10^{-6} torr vacuum; i.e., non-volatile and not susceptible to electron beam induced damage.