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Focused Ion Beam (FIB)

The Focused Ion Beam instrument (FIB) combines high resolution imaging by ion induced secondary electrons or ions, comparable to SEM imaging, with localized milling/etching by ion beam sputtering. The etch rates can be enhanced by the use of gases injected towards the sample surface, allowing selective enhancement of the etching of specific materials over that of other materials, and other gases can be used to promote deposition of materials on the sample surface in highly localized patterns with submicrometer precision. The primary use of the sputter etching capability is the preparation of local, site specific, cross-sections in a sample. The FIB is thus a high precision sample preparation tool where cross-sections can be both prepared and imaged *in situ* in the same instrument.

FIB Applications Include:

1. **Preparation of Site Specific Cross-sections**

Microelectronics Process Development:

Layer Thickness
Step coverage and integrity
Etch depth

Microelectronics Failure Analysis

Delaminations
Step continuity
ESD damage

Materials Science

Protective Coatings
Corrosion
Inclusions
Grain Boundaries
Grain Size Distribution

Thin film analysis by FE-Scanning Auger Microanalysis

Grain boundary analysis by FE-Scanning Auger Microanalysis

Thin film interface analysis by FE-Scanning Auger Microanalysis

2. **Microelectronic circuit editing**

   Cutting of vias
   Cutting and isolating electrical traces
   Deposition of conductors

3. **Preparation of Site Specific Thin Sections for TEM imaging**

4. **Micromachining**

Principle Of Operation:

The FIB uses a gallium liquid metal ion source (Ga^+ ions) with a beam focus as small as 7 nm usually operated at 30 kV acceleration voltage. Interaction of the ions with the sample leads to the ejection of secondary particles, primarily electrons, neutral atoms and ions. The instrument can be used to perform several operations:

1. **Imaging**

   By rastering the ion beam across the sample the ejected charged particles can be collected to form a high resolution image of the surface. Two imaging modes are possible: secondary electrons and secondary ions. These have different contrast properties.

2. **Milling/Etching**

   The ion beam can cut trenches or craters in the sample surface with submicrometer precision. This permits the creation of vertical, smooth, cuts into the sample located at selected positions. The cut can then be viewed and imaged at an angle for a cross-sectional view.

3. **Gas Assisted Etching**

   The sputter rate can be increased by injecting certain gases towards the sample surface during milling. The effect of the gases is selective to the materials in the sample: For instance, the sputter rate of metals can be promoted over the sputter rate of insulators, and vice versa. In addition to speeding up the milling the gas assisted etching can be used to produce contrast between layers in the sectioned surface.

4. **Deposition**

   Metals and insulating materials can be deposited on the sample surface. The deposition is the result of interactions by the ion beam with the molecules of gases carrying the desired material to be deposited. The deposits cane be laid down in lines or patches, and other shapes, again with submicrometer precision.

Data Output

The primary output of the FIB is a micrograph. The image is viewed on a monitor, recorded electronically, and submitted on an appropriate medium, usually a CD. Printing is also available.

Sample Constraints

The ideal sample is small, such as an individual die, a small piece of a wafer, or a microelectronic package. Flat samples up to 2 – 3 cm on the side and up to 1 cm thick can be easily accommodated. The sample chamber is large enough to accommodate a 3 inch wafer but mounting this on the stage would require special fixtures. The samples have to be vacuum compatible.

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