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SCANNING PROBE MICROSCOPY (SPM)

Scanning Probe Microscopy (SPM) is a high resolution surface imaging technique. It shows surface topography with true Z-dimension measurements at magnifications from 1,000 X to 1,000,000,000 X. This means that three dimensional measurements of everything from surface roughness to atomic imaging can be attained. Scanning Tunneling Microscopy, Atomic Force Microscopy, and Lateral Force Microscopy are variations of Scanning Probe Microscopy.

Scanning Tunneling Microscopy (STM), measures the tunneling current flowing between the tip and the sample. STM is useful for producing atomic resolution images of conductive materials. Atomic Force Microscopy (AFM), measures the inter-atomic attractive or repulsive forces between the probe tip and the surface being scanned. AFM extends atomic resolution imaging to non-conductive materials. Lateral Force Microscopy (LFM), also known as Frictional Force Microscopy (FFM), measures the friction between the tip and the surface being scanned. LFM is very useful in studying heterogeneous surface films.

SPM Applications include:

1. Surface Topography

Wafer flatness
Prism and grating characterization
Laser ablation studies
Radome erosion characterization
Electro-polished metal surface evaluation
Micro-machined surface characterization

2. Atomic Imaging

Chemically modified surfaces
Ion doped materials
Etched samples
Defect sites in crystals
Biological materials
Chemical and pharmaceutical distributions

3. Surface Metrology

Roughness measurements
Semiconductor device dimension measurements
Critical dimension measurement
Fiber optic face flatness measurement
Grain and particle size analysis

Principle of Operation:

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An SPM uses tip/sample interactions to adjust the SPM tip up or down to maintain the desired vertical (Z) distance between the tip and the sample. A sensitive feedback mechanism controls the separation (in the Z direction) between the tip and the sample to a fraction of an Angstrom. Scanning the tip laterally across the surface of the sample, while monitoring the Z feedback, produces an image. A computer generated display of the array of X, Y, and Z positions produces a topographic map that is a magnified 3D image of the surface.

The lateral resolution in an SPM image is limited by the physical size of the tip. The sharper the tip and the higher the tip aspect ratio, the higher the image resolution capabilities. The largest X and Y scan range possible is 150 by 150 microns with a Z scan range of 15 microns. The smallest area for an image is an area consisting of several dozen atoms on each side.

Data Output:

SPM data output is usually in the form of a 2D or 3D image or a Data Table listing some statistical image information. Image analysis is possible with a range of numerical output, including line and area measurements, roughness and fractal calculations, and particle and grain size histograms. SPM images are currently output on a high quality laser printer as 1200 dpi black and white images.

Sample Constraints:

There are very few sample constraints. Changes in the Z-dimension must be less than about 15 microns for 3D data collection. SPM can be performed on wet or dry, liquid or solid, and large or small samples. While typical high resolution SPM images have generally required small sample sizes, with the advent of Explorer™ SPM heads, SPM can be performed on virtually any size flat surface that can be brought to within a few feet of the instrument.