Physics of Nanotechnologies

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Scanning Probe Microscopy

Introduction

- Scanning probe microscopy covers several related technologies for imaging and measuring surfaces on a fine scale, down to the level of molecules and groups of atoms.

- At the other end of the scale, a scan may cover a distance of over 100 micrometers in the x and y directions and 4 micrometers in the z direction. This is an enormous range. It can truly be said that the development of this technology is a major achievement, for it is having profound effects on many areas of science and engineering.

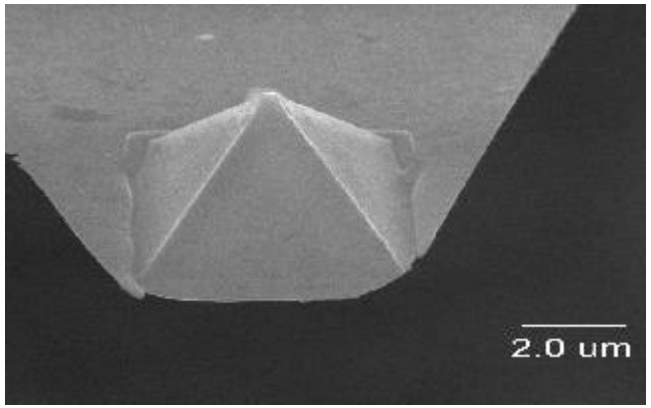
Introduction

- SPM technologies share the concept of scanning an extremely sharp tip (3-50 nm radius of curvature) across the object surface. The tip is mounted on a flexible cantilever, allowing the tip to follow the surface profile (see Figure).
- When the tip moves in proximity to the investigated object, forces of interaction between the tip and the surface influence the movement of the cantilever. These movements are detected by selective sensors. Various interactions can be studied depending on the mechanics of the probe

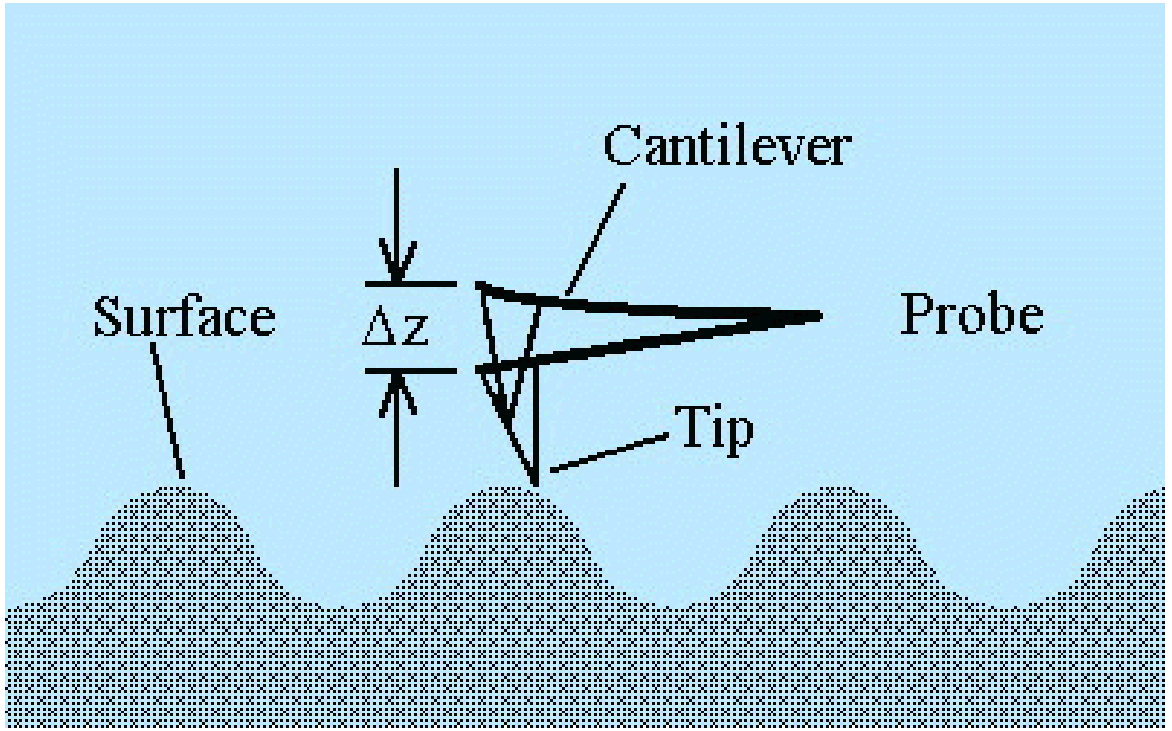
Probe Techniques

Probe Techniques The three most common scanning probe techniques are:

- **Atomic Force Microscopy** (AFM) measures the **interaction force** between the tip and surface. The tip may be dragged across the surface, or may vibrate as it moves. The interaction force will depend on the nature of the sample, the probe tip and the distance between them.
- **Scanning Tunneling Microscopy** (STM) measures a **weak electrical current** flowing between tip and sample as they are held a very distance apart.
- **Near-Field Scanning Optical Microscopy** (NSOM) scans a very **small light source** very close to the sample. Detection of this light energy forms the image. NSOM can provide resolution below that of the conventional light microscope.



A probe used for atomic force microscopy.



Applications

Applications

- These techniques have the ability to operate on a scale from microns down to nanometers and can image clusters of individual atoms and molecules. STM relies on the electrical conductivity of the sample, so at least some features on the sample surface must be electrically conductive to some degree. AFM is used for studies of non-conductors and is the technique more commonly used for studies of macromolecules and biological specimens. AFM has been used for measurements on a wide variety of sample types, including: