5.6 Scanning Tunneling Microscope Introduction (STM)

A microscope is a device which is used to view smaller object which cannot see through naked eye.

In 1981 Gerd Binning and Heinrich Rohrer developed the scanning microscope (STM)significantly superior tool for observing surface atom by atom.

STM is the highest resolution imaging and nano fabrication technique available. It depends on quantum tunneling of electron from sharp metal tip to a conducting surface.

Principle

The basic principle used in Scanning Tunneling Microscope (STM) is the tunneling of electron between the Sharpe metallic tip of the probe and surface of the sample.

STM has a metal needle that scans a sample by moving back and forth and gathering information about the curvature of the surface. It follows the smallest changes in the contours of a sample.

The needle does not touch the sample,however,but stays about the width of two atoms about it.

Instrumentation

A schematic of STM is shown in figure. It has the following components. Piezo electric tube with the tip and electrode. Capable of moving in X,Y, Z direction. Fine needle tip for scanning the sample surface. A macro scale image of an etched tungsten STM tip is shown in figure.

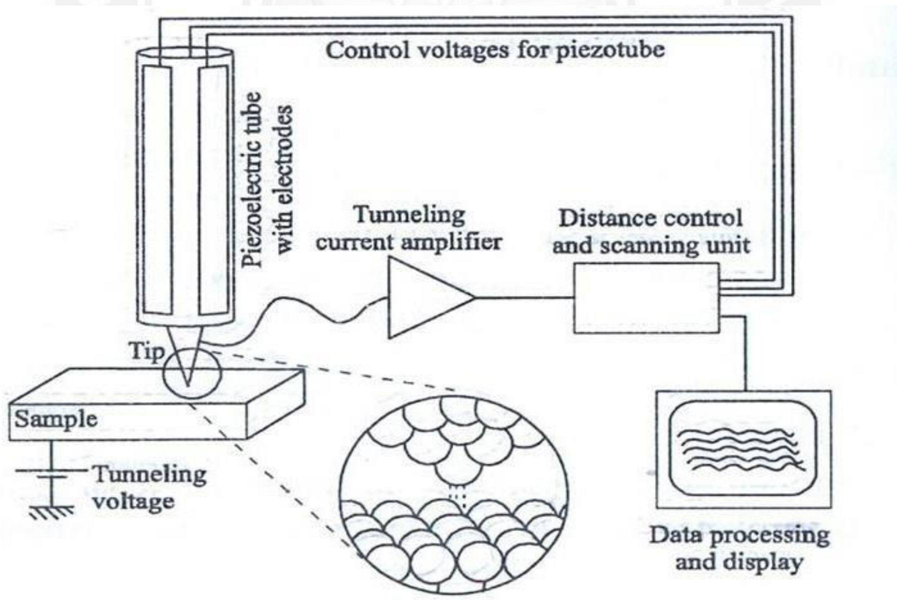
Tip is affixed to the piezoelectric tube in order to control it position and movement on an atomic scale. Piezoelectric materials exhibit an elongation or contraction along their length when an electric field is applied.

Working

The tip is mechanically connected to the scanner, an XYZ positioning device. The sharp metal needle is brought close to the surface to be imaged. The distance is of the order of a few angstroms.

A bias voltage is applied between the sample and the tip. When the needle is at a potential with respect to the surface, electrons can tunnel through the gap and set up a small tunneling current in the needle. This feeble tunneling current is amplified and measured.

With the help of the tunneling current the feedback electronics keeps the distance between tip and sample constant. The sensitivity of the STM is so large that electronic corrugation of the surface atoms and the electron distributions around them can be detected.



5.6 Scanning Tunneling Microscope

Applications of STM

1. The STM shows the positions of atoms more preciously.
2. STMs are versatile.
3. STMs give the 3 dimensional profile of a surface, which allows researchers to examine a multitude of characteristics , including roughness, surface defects and molecule size.

4. STM is used in study of structure , growth ,morphology, electronic structure ,thin films and nano structures.

5. Lateral resolution of 0.1nm to 0.01nm of resolution in depth can be achieved.

Disadvantages

1. It is very expensive
2. It needs specific training to operate effectively.
3. A single dust particle could damage the needle.
4. A small vibration, even a sound, could smash the tip and sample together.