Engineering Small Worlds: Micro and Nano Technologies

Types of tip

COM:
The tip is the business end of an Atomic force microscope. Different designs and compositions of tips enable AFMs to be used for a wide range of applications from the electronics industry to cancer research.

Dr Andrew Murray
Veeco Instruments:
At Veeco we develop tools to characterise materials that are micro and nano scale. Going right down to the atomic level our scanning probe microscopes can both visualise and characterise the properties of surfaces.

Scanning Probe Microscopy is the umbrella phrase given to a whole range of techniques. The first was developed in 1982 when scientists from IBM invented the scanning tunnelling microscope to give you for the first time a genuine atomic resolution. Today the most commonly used method is Atomic Force Microscopy. This uses essentially a minute record stylus to raster backwards and forwards across the surface. The stylus is on the back of a cantilever and by firing a laser on to the back of the cantilever we can track the vertical motion of the probe as it moves over the surface in a detector.

COM:
Piezo (pī-ē'zō) (pete-so) ceramic technology enables the tip to be moved across a surface with Angstrom level accuracy. A feedback loop is then used to generate a three dimensional image of the surface on a computer.

Dr Andrew Murray:
The two most common modes of operation of the atomic force microscope are contact mode and Tapping Mode. In contact mode the tip is brought into feedback with the surface at a constant deflection and hence a constant force between the probe and surface. This force is maintained a just a few nano Newtons between tip and substrate, which enables most materials to be scanned without any surface damage. However some soft materials, soft polymers, or some biological materials could be swept away by the probe or alternatively could be picked up and themselves contaminate the end of the tip.

COM:
To overcome this problem with soft materials the Tapping Mode of operation was developed. In tapping mode the probe is oscillated at its resonant frequency; now when the probe approaches the surface the amplitude of oscillation is damped, initially by electrostatic and Van der Waal's forces, and then potentially by the surface itself.

Dr Andrew Murray:
We control our feedback in Tapping Mode by keeping constant amplitude of oscillation hence a constant damping of our probe. This eliminates lateral interactions between the tip and the surface allowing soft materials to be imaged with very high resolution.

COM:
Phase imaging is a powerful extension to Tapping Mode operation.. By detecting the phase of the tip oscillation near the surface, properties other than surface topography can be mapped, such as surface adhesion or hardness. Using a probe tip coated in another material further extends the range of applications.

Dr Andrew Murray:

With a probe coated with either a magnetic or an electrically conducting material we can look at the variations in phase due to the change in the gradient of the magnetic or electrical field above a surface. In the data storage industry this is used to characterise disc drives, read write heads. In the component industry we can use this to identify leakage in transistors gates for example.