Engineering Small Worlds: Micro and Nano Technologies

Atomic Force Microscope

COM:
As micro and nano engineering has advanced rapidly, so has the need to be able to make measurements and record images at such a small scale.

The Atomic Force Microscope, or AFM as it is known, allows three dimensional imaging of a surface with nanometre resolution. This has opened up a whole new way of 'seeing' into the Small-worlds that have been engineered.

The AFM is one type of scanning probe technique that is particularly useful, as it can be used to image a large range of surfaces. It can be applied across many disciplines including engineering, materials science, physics, chemistry and biology. It is even possible to image samples of DNA under liquid making the device particularly useful for medical research.

At the heart of the AFM is a very small, sharp, micro-machined tip just a few micro-metres in size, which directly probes the specimen under investigation.

Examining such a small tip is a challenge in itself. Another scanning probe technique; the scanning electron microscope, can help us to do this.

Gordon Imlach :
The Atomic Force Microscope tip has to be mounted in a suitable holder before we can insert it into the chamber of the microscope. The tips are very small indeed and can't really be seen by the naked eye. So they come to us, mounted on a semi-circular metal plate, which makes handling easier

COM:
The scanning electron microscope focuses and scans a beam of high energy electrons across the sample under investigation; in this case the AFM tip. Low energy electrons emitted from the sample are counted, and an image is constructed on the computer screen.

Gordon Imlach :
Electron microscopes use high vacuum in the chamber because if there were any gas molecules present they would interfere with the electron beam and obviously affect the quality of the imaging.

After a few minutes the chamber is at high vacuum and we can switch on the electron beam and adjust the brightness and contrast to suit.

At low magnification we can only see the edge of the mounting plate and particularly the grub screws of the specimen holder. As of yet we can't see any detail of the very, very small tip. As we increase the magnification we can begin to make out the cantilever arm in which we are most interested. We can bring that to the centre of the screen and increase the magnification further.

Then we can fine focus the image before we slow the scanning rate down to see the image as we want to.

The resolution depends on a number of factors, particularly the width of the electron beam, which is typically about five nano-metres or thereabouts. But it's also dependent on the energy of the beam and the working distance; that's the distance between the objective lens and the specimen itself.

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The scanning electron microscope is capable of magnifying many hundreds of thousands of times. (pause).

Apart from imaging, the device can be used to perform a rapid elemental analysis of the sample through the use of X-rays.

Gordon Imlach
Materials Engineering – Open University :
For analysis purposes we capture the image but instead of scanning the beam back and forth across the specimen we can position it in one particular spot of interest and derive an analysis from that point. By increasing the beam energy we can stimulate the specimen to emit X-rays and these X-rays are characteristic of the elements that are present in the specimen.

These signals are processed into the form of a spectrum, which indicates not only what elements are present but also in what relative quantities.

The software identifies that the tip is made of silicon.