Lecture-4. Microscopy. AFM

If you're old enough to remember what a phonograph record was, you know that a crystal-tipped stylus ("needle") would move along in the grooves cut in a spinning vinyl platter, and when the motion vibrated the needle, the machine translated that vibration into sound. In a similar way, an atomic force microscope (AFM) scans the movement of a really tiny tip made of a ceramic or semiconductor material as it travels over the surface of a material, as shown in Figure 3-6. When that tip, positioned at the end of a cantilever (a solid beam), is attracted to or pushed away from the sample's surface, it deflects the cantilever beam — and a laser measures the deflection. The AFM then produces a visible profile of the little hills and valleys that make up the sample's surface.

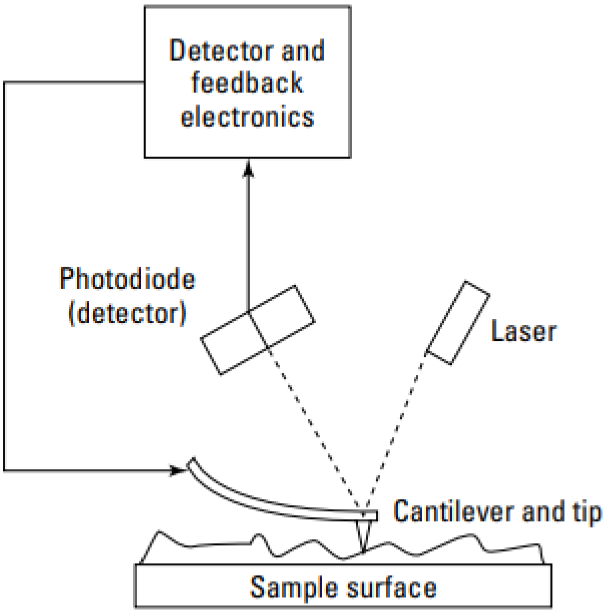
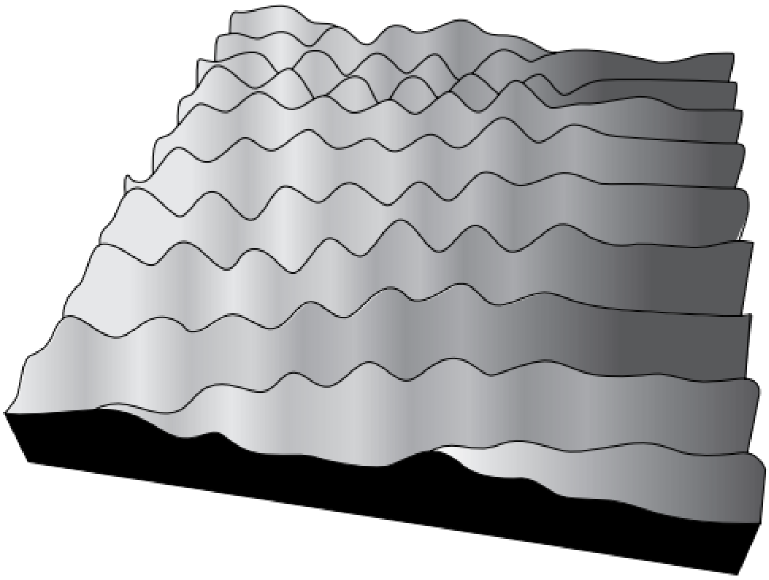


Figure 3-7 illustrates the surface typology shown by an AFM; the hills you see here represent atoms. An AFM can do something you can't do with the electron microscopes we discuss in the next section: It can get images of samples in air and underneath liquids. That's because an electron microscope requires that the sample be in a vacuum — but an AFM does not. Also, an AFM produces a three-dimensional image; electron microscopes produce only two-dimensional images. The fineness of the tip used in an AFM is an issue — the sharper the tip, the better the resolution. That's why scientists hope that the future developments bring the means to produce even sharper AFM tips. It's a natural for nanotechnology: Use of carbon nanotubes as tips for AFMs is in its infancy, but at least one vendor — Nanoscience Instruments, Inc. — already makes them.



Using carbon nanotubes for AFM tips has the following benefits:

Because the nanotube is a cylinder, rather than a pyramid, it can move more smoothly over surfaces. Thus the AFM tip can traverse hill-andvalley shapes without getting snagged or stopped by a too-narrow valley (which can be a problem for pyramid-shaped tips). Because a nanotube AFM tip is a cylinder, it's more likely to be able to reach the bottom of the valley.

Because the nanotube is stronger and more flexible, it won't break when too much force is exerted on it (as some other tips will).