# Atomic Force Microscopy and Scanning Probe Microscopy

In general, a scanning probe microscope (SPM) can make height images of the surface of solid sample and can be used to determine mechanical, electrical, and magnetic properties of said surfaces. The instrument works by placing a small physical probe in close proximity to a sample and observing the reaction of the probe as it scanned laterally over the surface. Scanning probe microscopy is a very general name that can describe most any probe technique. Examples include scanning tunneling microscopy and magnetic force microscopy. Atomic force microscopy (AFM) generally implies imaging the surface to determine the morphology or roughness or mechanical properties. Most commercially available probes are made from Si. The so-called probe is generally a cantilever beam with an integrated protruding sharp tip made from etched Si. The data collected depends on the type of probe used. For most generally purpose height images, a standard etched Si cantilever/tip is used. For other types of data, a specialized tip may be required. For example, if magnetic data is desired, a magnetized tip is fabricated by coating the standard tip with a magnetic material.

The most common mode of operation is the so-called tapping mode. In tapping mode, the cantilever is oscillated vertically. When the tip is close enough to the sample that it can touch the sample (at the bottom of the oscillation stroke), the tip is said to tap the sample. A feedback loop is used to maintain a constant oscillation amplitude, which in turn maintains a constant force between the tip and sample. The most common type of AFM data is a height map. That the data is called a "height" image is somewhat misleading because the height map is determined by mapping how far the feedback back loop of the system moves the probe up or down to maintain a constant force between the tip and sample.

Most atomic force microscope (AFM) images are taken with a field of view of less than 10 micrometers. The maximum scan size for most AFMs is on the order of 100um and the minimum scan size can be small enough to observe atoms. Atomic resolution AFM imaging is generally only done under UHV conditions. Resolution is limited by the sharpness and shape of the physical probe used. Unlike other microscopy techniques, AFM images do not specify the magnification but rather the field of view.

Since images are in the form of absolute height, as determined by the feedback loop, it is easily possible to calculate the roughness of a sample from an image of the sample. Because of the physical nature of the tip, the data can be limited by the morphology of the tip. That is, a protrusion will appear to be larger than the actual size by the diameter of the tip and a well will appear to be smaller than the actual size by the diameter of the tip. It is possible for the sharp protrusions from the sample to image the tip. This sort of tip artifact is generally easy to spot and the operator should always be observant for evidence that the tip is damaged. Tips are consumables and will be used during AFM imaging. The type of tip, and the properties of the cantilever are generally defined by the type of data desired and the modulus of the sample.