AFM PROBE SELECTION

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Choosing the AFM Right AFM Probe

At its core, Atomic Force Microscopy (AFM) involves scanning a probe tip attached to a cantilever over the surface of a sample. Atomic forces between the tip and the sample will cause the cantilever to deflect to varying degrees as the sample surface changes from area to area during the scan. While this is happening, a laser is reflected off of the back (flat) side of the cantilever and onto a photomultiplier. As the cantilever is deflected during the scanning operation, the position of the laser on the photomultiplier is also changing. These changes in position are what then build the image that is seen.

This is a vast over-simplification, of course. There are many parameters that have to be set up ahead of time to ensure that the data being recorded is real, and not an artifact of experimental error. One of those is making sure the right probe is being used. With so many options and styles available, sometimes it can seem difficult to know which AFM probe will generate the best data from your samples. Our goal is to describe some of the options and variations, and present why you may (or may not) want to use them. Some of the key things to consider are: tip sharpness, geometry, aspect ratio, spring constants, and reflective coatings. We will discuss each of these attributes individually below.

It should be noted that these tips are designed to be used in AC (tapping) modes and non-contact modes.

Tip sharpness (or tip apex) is probably the first thing that comes to mind for users when selecting their AFM probes. This refers to the radius at the very end of the tip. For most users, the smaller this number (sharper tips), the better. Sharper tips generally yield higher resolution, though there are some specialized applications that use broader tips.

Probe Geometry refers to the overall shape of the probe. Common geometries include pyramidal, tetrahedral, and conical. Pyramidal and tetrahedral tips feature straight, steep sidewalls. They are typically made using wet etching techniques along the crystal plane, and can sometimes end up asymmetrical when finished. Conical tips can be fabricated with a higher aspect ratio (see below) using dry etching methods, allowing for greater uniformity in their geometry. As seen in the images, conical probes tend to provide better surface resolution than pyramidal or tetrahedral probes.

Aspect Ratio is the ratio between the height and width of the AFM probe tip. In order to truly view features such as trenches or (relatively) tall structures, the tip must be able to get as close as possible (laterally) to the trench/feature wall. Probes offered by SPI Supplies with the HAR (High Aspect Ratio) feature an increased aspect ratio along the final portion of the probe leading to the tip apex.

Spring Constant is the stiffness of the probe (or the amount of deflection that occurs during sample interaction). Higher spring constants will have less deflection than lower spring constants. Generally, lower spring constants are better suited to softer sample materials, and vice-versa.

Reflective Coatings (either gold or aluminum) can be applied to the backside of the cantilever. There are reasons to use coated probes, and also reasons not to.

> **Advantages** – Silicon (the probe material) can be partially transparent to the wavelength of light used in the laser. If this is happens when scanning a reflective sample, there is a possibility of interference from light reflecting off the sample in addition to the light reflecting off of the back of the cantilever. A reflective metal coating can prevent the light from passing through the cantilever and reflecting off of the sample surface.
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> **Disadvantages** – Reflective coatings may produce additional strain on the cantilever, which could cause it to slightly bend. There is also the possibility of thermal drift, due to the metal heating from interaction with the laser. Users also have to take care to make sure that no variables from the experimental design will negatively interact with the coating, as well as making sure their instrument is calibrated for using coated cantilevers.
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> **Aluminum Coatings** are more reflective and generally less expensive than gold coatings. The downside to aluminum coatings is that they can react with certain chemicals in some experimental environments. **Gold Coatings** are inert, and thus, are preferred for use in biological experiments, or other environments where a coating is needed, but an aluminum coating cannot be used. As mentioned, they are less reflective than aluminum, and generally more expensive.

Should you have any questions regarding tool selection or process, contact our technical staff at support@2spi.com any time.

JAH
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