REFLECTIVE COATING OF THE CANTILEVER IN ATOMIC FORCE MICROSCOPY (AFM)

Atomic force microscopy (AFM) images nanoscale and atomic surfaces using a tip at the end of a cantilever raster scanned over the surface.

In its simplest form, forces between the tip and the surface cause the cantilever to deflect. A laser beam is focused onto the side of the cantilever facing away from the surface (the backside), and reflected back onto a photodetector, as shown in the simplified schematic of an AFM setup in Fig. 1. The deflection of the cantilever will be different depending on the height of the surface features. This variation in deflection causes the position of the reflected laser beam incident on the photodetector to move accordingly, as displayed in Fig. 1. An image of the surface is built up from the position shift of the beam as the tip is scanned over the surface.

The backside of the cantilever is often coated with a reflective metal coating of a few tens of nanometres, as illustrated in Fig. 1, to increase the signal of the laser beam reflecting off the cantilever. This improves the signal-to-noise ratio of the photodetector and consequently, its sensitivity.

When the cantilever is made from silicon, part of the laser light will be reflected from the backside and some from the tip-side because of the semi-transparency of silicon to the utilised light wavelength. Furthermore, if the sample is highly reflective, there may be some reflection of the laser light from the sample surface. The reflective coating acts to prevent interference between the reflected beams from these surfaces. Figures 2 (a) and (b) show AFM images of a platinum thin film taken using an AFM probe with a coated and uncoated cantilever, respectively.

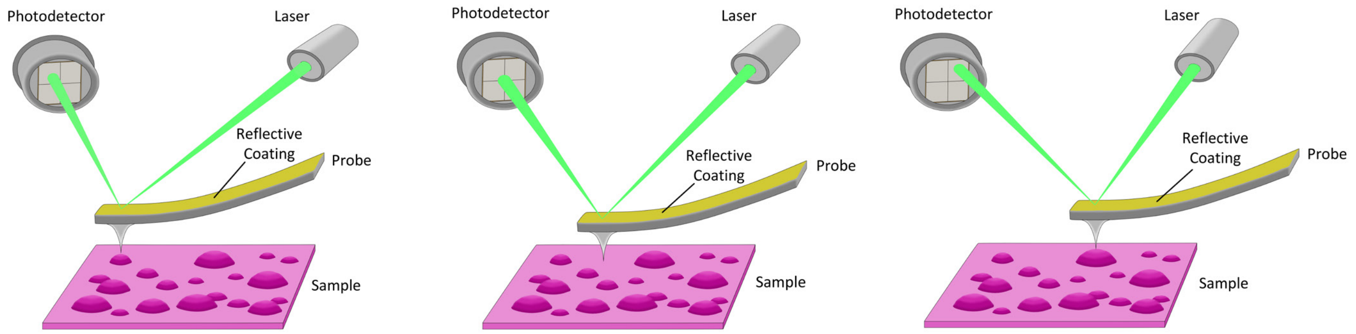

Figure 1: Simplified AFM setup showing position shift of laser incident on the photodetector as the tip moves across the sample surface.

The periodic pattern of lines in Fig. 2 (b) is characteristic of laser beam interference, which is not visible in Fig. 2 (a) when a coated cantilever is utilized for imaging.

It should be noted that using a reflective coating has some disadvantages. It may cause the cantilever to become strained, causing it to bend. When the laser beam hits the backside of the cantilever, it heats up, which leads to temperature gradients through the cantilever. This leads to thermal drift, in which the laser beam may drift in position on the photodetector and thermal stress, which increases the cantilever noise. A reflective coating also reduces the Q-factor (quality factor) because there is an increase in damping of the cantilever. As well as the strength of the laser signal, potential corrosion of the reflective coating because of other experimental conditions should be considered when choosing to use a coated or uncoated cantilever. Furthermore, it is important to calibrate the properties of a coated cantilever before imaging is performed.

Aluminium and gold films are commonly used as reflective coatings for silicon AFM probes. Aluminium is cheaper and more reflective but is not suitable for use in some biological buffers and solvents because of its instability and dissolution into the liquid environment. Gold, on the other hand is chemically and biologically inert, and therefore, a gold-coated cantilever is most commonly used for the study of biological samples.

NuNano provide AFM probes with or without a reflective backside coating, which increases the laser signal incident on the photodetector by about 2.5 times.

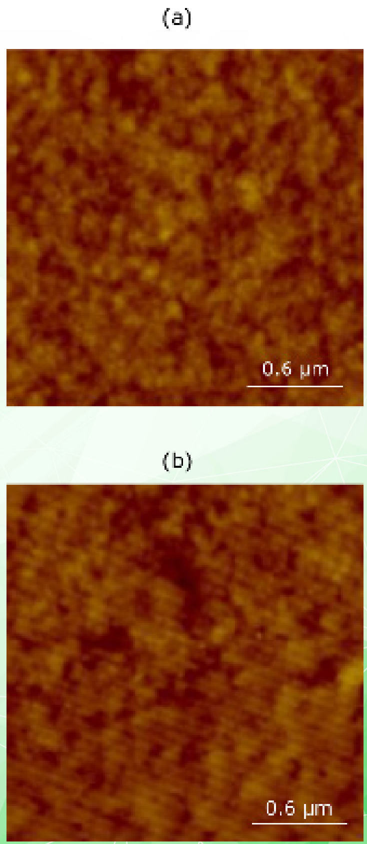

Figure 2: AFM image of a platinum thin film taken using a probe with an (a) coated and (b) uncoated cantilever.