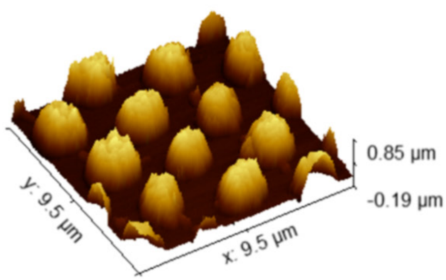
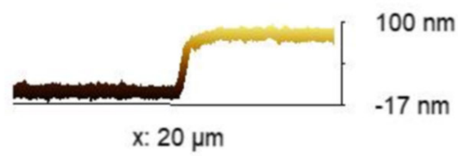
nGauge AFM

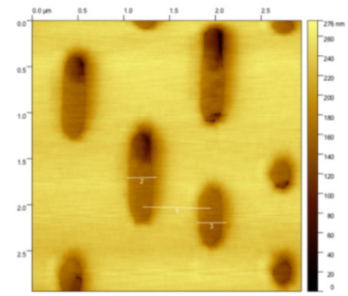
Capabilities of the nGauge AFM



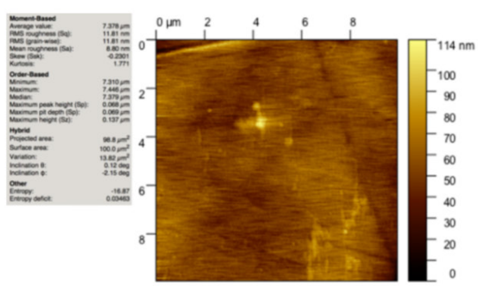
TOPOGRAPHY



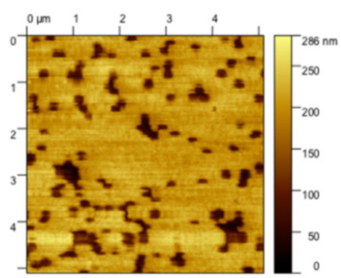
THICKNESS / LINE PROFILE



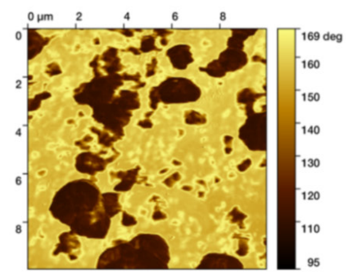
LATERAL MEASUREMENT



SURFACE ROUGHNESS



PARTICLE COUNTING



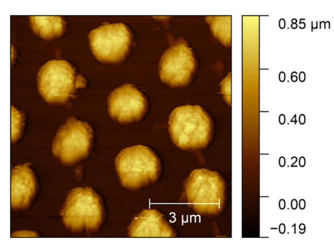
PHASE IMAGES

Topography

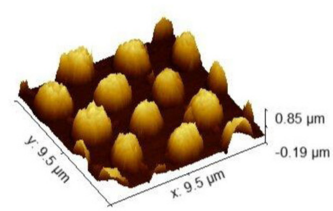
An AFM produces a 3-dimensional representation of the surface that it scans over. Unlike optical or electron microscopes, AFM collects topographic data. That means that you can look at the shape and size of individual features, such as the pits on a DVD, or determine the particle density, such as the number of nanoparticles in a given area.

The image on the left is an AFM topography image of a photonic crystal. The size of this scan is 10 µm × 10 µm.

The colour is not the real colour of the surface. The contrast is used to differentiate between high (light gold) and low (dark) points. A tall feature, like the bumps in the image, are brightly coloured (gold) and the surface is dark.



An AFM topography image of a photonic crystal.

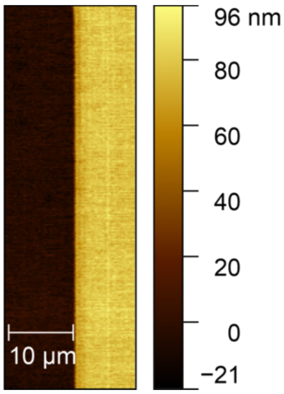


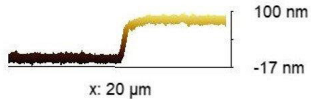
3-dimensional representation of the topography image on the left.

The scale bar on the right is for the vertical dimension. It shows that the tallest feature on the scan is about 800 nm tall. The image on the right is a 3-dimensional representation of the surface, using the topography data from the image on the left.

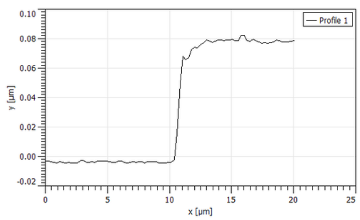
Thickness Measurement / Line Profile

The line profile provides the height information of the surface along a user-selected line. On the left is a 20 µm line scan at the interface of a coating on a substrate. The dark region on the left is the bare substrate (where there is no coating), and the light-coloured area on the right is the coating.





3-dimensional view of the thickness of a coating.



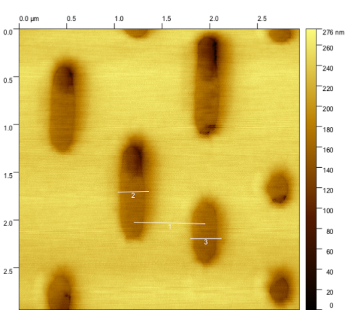
Topography image of a line scan of a polymer

In the top right is a 3-dimensional view of this topography image. And on the bottom is a graph of the line profile across the coating.

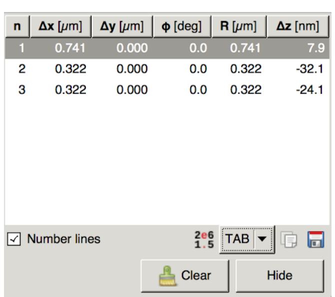
The nGauge can measure thicknesses up to 10 micrometers and down to 1 nm.

Lateral Measurement

Another useful measurement is the distance between features in an AFM image.



AFM topography image of a DVD with three distance lines



n	Δx [µm]	Δy [µm]	φ [deg]	R [µm]	Δz [nm]
1	0.741	0.000	0.0	0.741	7.9
2	0.322	0.000	0.0	0.322	-32.1
3	0.322	0.000	0.0	0.322	-24.1

Number lines TAB Clear Hide

Screenshot of the distance data of the three lines on the AFM scan on the left, from Gwyddion.

In the image, a 3 µm x 3 µm scan of the “pits” of a DVD, we can measure the distance between the pits (the pitch), as well as the width of the pits themselves.

Using the distance tool in the analysis software, we trace lines along the distances that we want to measure. We can see that the distance between the centre of the pits (Line 1) is 741 nm. This is in good agreement with the real pitch of DVD pits (740 nm). DVD pits themselves are 320 nm wide, and we measure 322 nm for Lines 2 and 3.

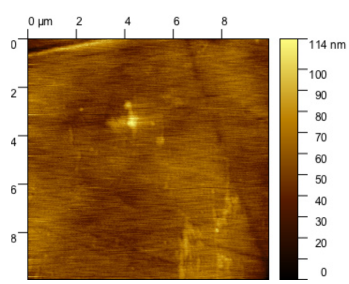
Surface Roughness

Surface roughness is a component of the texture of a surface: a higher value means that the surface is rougher. The arithmetic roughness (Ra) and the root-mean-squared roughness (Rq) are common parameters used to describe roughness.

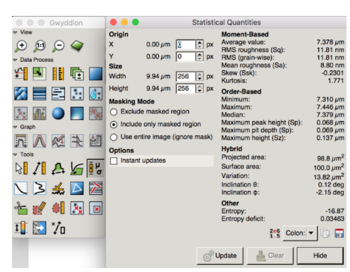
Many types of devices, such as profilometers, use data from a line scan to calculate surface roughness. Because AFM collects topographic data in two dimensions, the surface roughness can be calculated from the entire 2-d scan area rather than just 1-d data. The 2-d/area roughness parameters are arithmetic (Sa) and RMS (Sq).

The surface roughness of a sample can easily be determined in one click of the statistical quantities tool in the analysis software.

An AFM image of a titanium-aluminum alloy is shown on the left with the corresponding output from the statistical quantities tool, where we see that the RMS roughness is 11.8 nm.



Titanium-aluminum alloy surface with a mirror finish



Gwyddion Statistical Tools output with RMS roughness (Sq) as 11.81 nm (0.43 microinch).

Particle Analysis and Counting

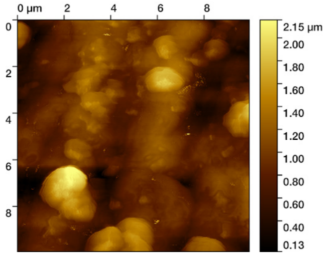
Particle analysis is a very common application of AFM. A line profile can be used to look at individual particles, but for more than a few particles, it's best to automate the routine somehow. A particle segmentation routine does just that by separating the particles from the flat surface that they are on. Segmentation routines can also be used for particle counting.

Phase Imaging

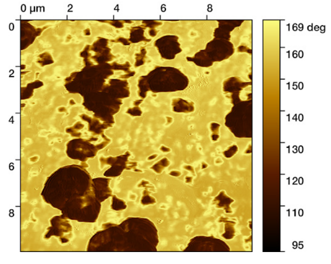
When operating in a mode called Tapping Mode, AFMs generate two different images: the topography image and the phase image. The phase image comes from the phase shift of the signal: the phase shift is the lag between the driving signal and the feedback signal. This lag is caused by the interaction between the probe tip and the surface, which can be affected by adhesive forces, frictional forces and viscoelastic forces.

Regions with different material properties can be distinguished using the contrast of the phase image. Since the topography image and the phase image are generated at the same time, analysis of both images side by side can reveal information that might be hidden from just the topography image alone.

Below is an example of the topography (left) and phase (right) images of a silica-polymer composite. On the left, you can see a few particles that are protruding from the surface. They are bright in the topography image because they are the tallest features. It's unclear what the structure or morphology is of the rest of the image. The phase image on the right makes it clear which areas are silica: the dark areas represent regions with a low phase shift (around -50°). The light areas possess a much higher phase shift (around 30°) and they represent the polymer matrix. This is because the silica particles possess very different properties compared to the polymer matrix.



Topography image of a silica-polymer composite.



Corresponding phase image of a silica-polymer composite.