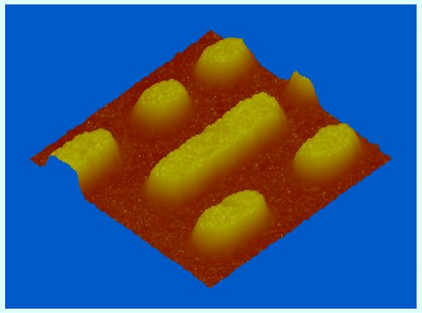
Advanced Surface Microscopy, Inc.

Helping Solve Processing and Materials Problems using Scanning Probe Microscopy since 1990.



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Atomic Force Microscopy

Introduction

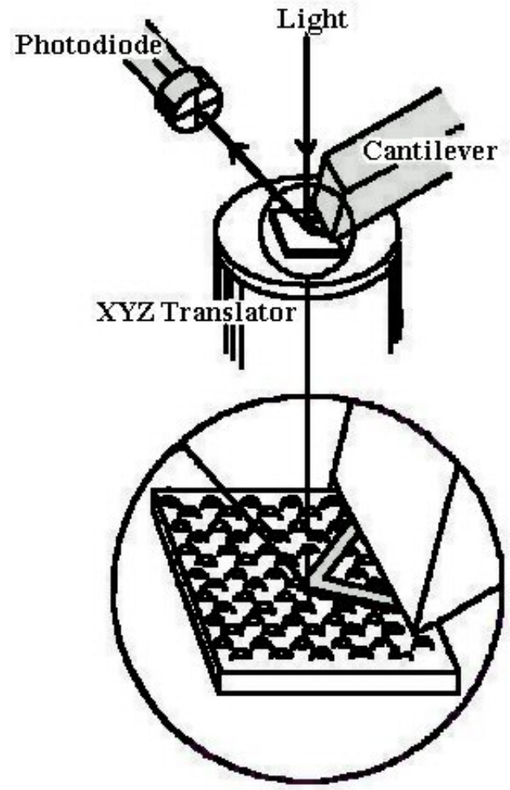
The Atomic Force Microscope (AFM) is being used to solve processing and materials problems in a wide range of technologies affecting the electronics, telecommunications, biomedical, chemical, automotive, aerospace, and energy industries. The materials under investigation include thin and thick film coatings, ceramics, composites, glasses, synthetic and biological membranes, metals, polymers, and semiconductors. The AFM is being applied to studies of phenomena such as abrasion, adhesion, cleaning, corrosion, etching, friction, lubrication, plating, and polishing. The real-world examples presented on our web page indicate the breadth of AFM applications for problem solving; yet they represent only a fraction of our experience at Advanced Surface Microscopy.

Technical Capabilities

AFM images show critical information about surface features with unprecedented clarity. The AFM can examine any rigid surface, either in air or with the specimen immersed in a liquid. "Minor" (and major) differences between "smooth" surfaces are shown dramatically. On one hand, the AFM can resolve very tiny features, even single atoms, that were previously unseen. On the other hand, the AFM can examine a field of view larger than 125 microns (0.005 inch), so that you can make comparisons with other information, e.g. features seen in the light microscope or hazes seen by eye. The AFM can also examine rough surfaces, since its vertical range is more than 5 microns. Our analytical reports of AFM results include three-dimensional images and quantitative data analysis (such as feature sizes, surface roughness and area, and cross-section plots), integrated and interpreted in the context of your problem.

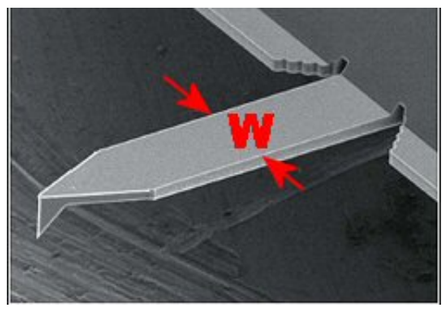
Large samples fit directly in the microscope without cutting. We can examine any area on flat specimens up to 8" (20 cm) in diameter and up to 0.5" (12.7 mm) thick. We have designed custom adapters to accommodate SEM stubs, microtomed blocks, metallurgical mounts, and other odd shapes and sizes (up to 1.5" thick and 42" wide). We can quickly find and document the location of interest using the built-in optical microscope (with magnification up to 2000x). For comparative studies using different probes and scanning modes, we can find the spot within one micron.

How the AFM makes a 3-D image

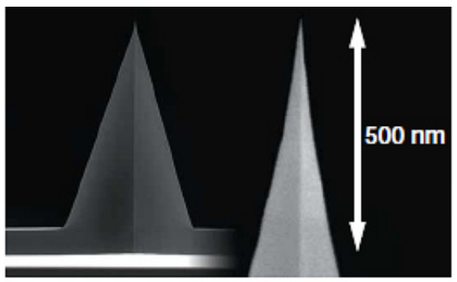


Basic parts of an AFM. As the tip is scanned over the surface, the cantilever deflects upward, changing the angle of the beam of light reflected to the split photodiode. This allows the tip to accurately track the surface. (After Hansma)

In contact mode, a tiny stylus gently contacts the specimen. As the XYZ translator scans either the specimen or the stylus horizontally in a raster pattern (XY), the stylus rides up and down the surface hills and valleys. The deflection of the stylus is registered by the laser/photodiode sensor and the XYZ translator adjusts stylus or specimen (depending on microscope) up or down (Z) to restore the stylus to its original orientation. The computer stores the vertical position at each point and assembles the image.



SEM image of typical AFM cantilever and probe. Width "W" is approximately 30 um.

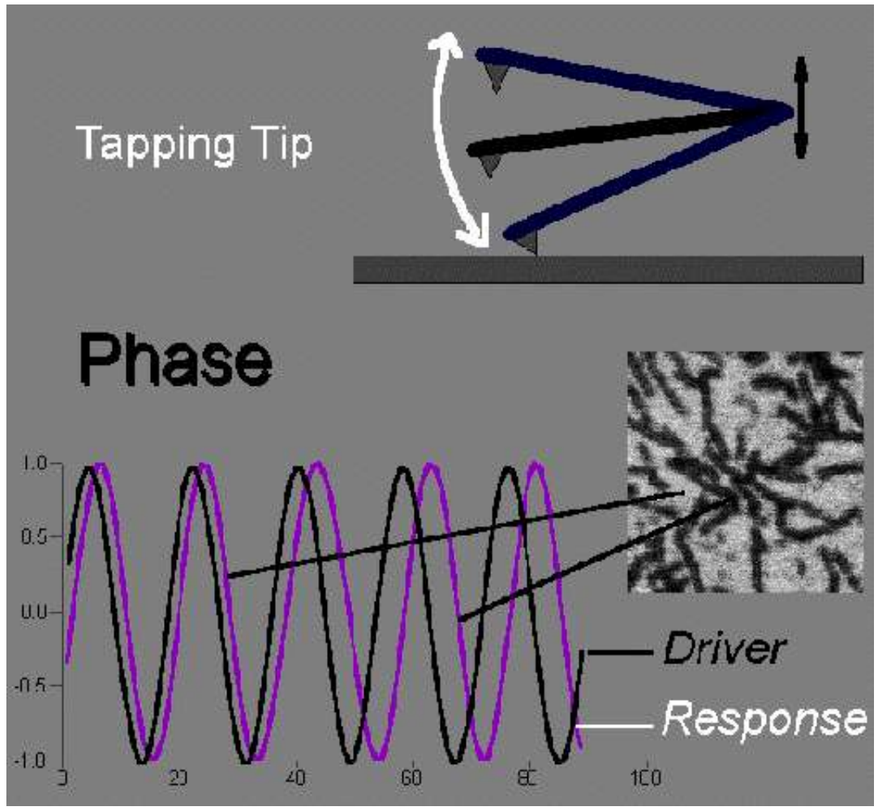


Enlarged image of the probe tip

High resolution SEM image of typical AFM probe with detail of extreme tip showing sharpening.

SEM images courtesy of Olympus Micro Cantilevers.

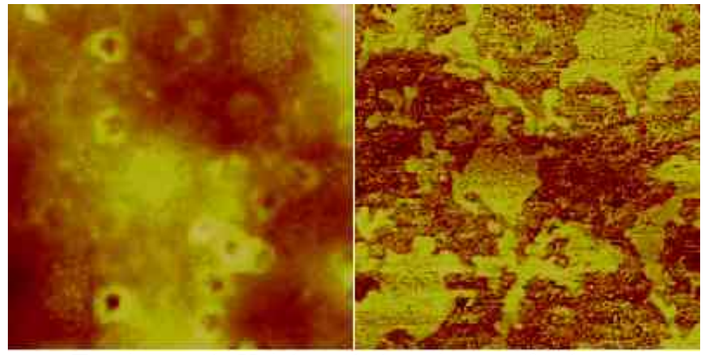
Another imaging mode is TappingMode.



In TappingMode the tip is vibrated vertically at near resonance. As the tip taps on the surface, the amplitude of the vibration is damped. By raising or lowering the tip to keep the amplitude at a constant "setpoint" we can accurately track the surface shape. Additional data is available from the phase lag between the drive amplitude and the tip response.

For image display, we select the vertical (Z) and horizontal (XY) ranges independently, to best present the surface structure. Using "dual magnification," the AFM combines the wide field view of a Scanning Electron Microscope (SEM) with vertical resolution which exceeds that of a Transmission Electron Microscope (TEM). The ratio of the vertical to horizontal magnification can be very large (1000 or more) to allow easy perception of differences between very smooth surfaces.

Aluminum can coating



Tapping mode Height and phase image of polymer coating on inside of aluminum beverage can.

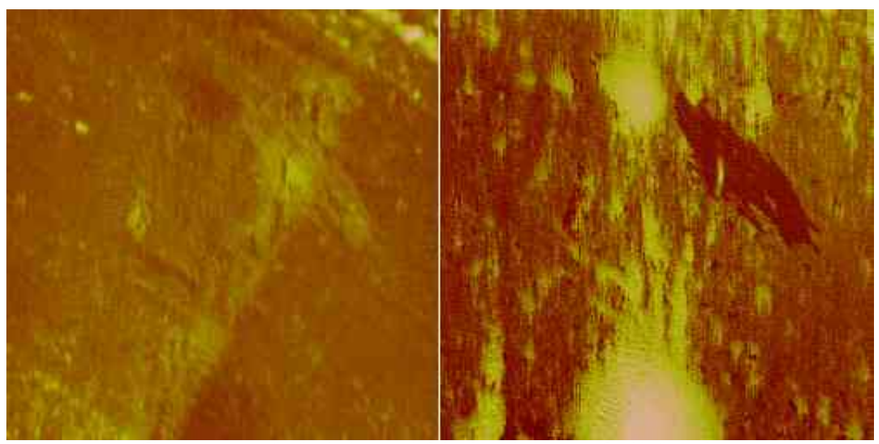
Topographic results can be enhanced by simultaneously using other modes of AFM data capture, such as phase imaging. In the left image (above), we see the many interesting surface features of the coating. When combined with the phase image (right), we can now tell which features are of similar chemical composition. This allows determining whether surface features may be the result of a residue or specific chemical component, or whether the surface is homogeneous.

See what you've been missing

In addition to its superior resolution, the AFM has these key advantages:

- Compared with Scanning Electron Microscopes (SEM), the AFM provides extraordinary topographic contrast, direct height measurements and unobscured views of surface features (no coating is necessary).
- Compared with Transmission Electron Microscopes, 3-dimensional AFM images are obtained without expensive sample preparation and yield far more complete information than the 2-dimensional profiles available from cross-sectioned samples.
- Compared with Optical Interferometric Microscopes (Optical Profilers), the AFM provides unambiguous measurement of step heights, independent of reflectivity differences between materials.

Contaminants on glass



Contact mode height and friction image of oil droplets (fingerprint residue) on glass. Note that in the height image bright colors (yellow and white) are high and dark colors (red) is low. In the friction image dark colors are more sticky and bright colors are less sticky.

Another mode of operation which can be useful when combined with topography is friction imaging. In the height image above (left), there are several areas where the topography appears higher and rougher than the bulk surface. When combined with a friction image (right), we see that there is a contaminant on the surface which appears dark in the image. Therefore the contaminant has a lower coefficient of friction than the underlying surface. This can be helpful in determining the source of the contaminant.