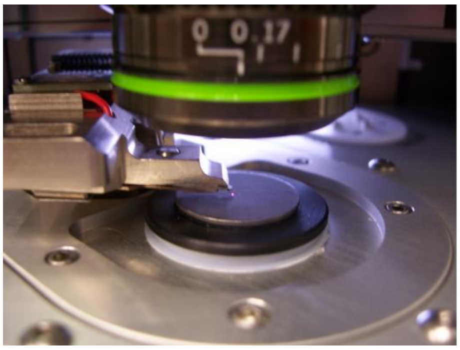
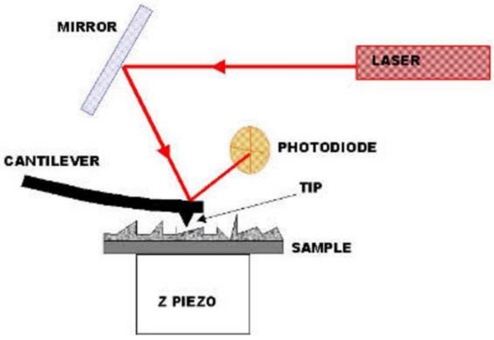
A quick NPL guide to…

Atomic Force Microscopy

What does AFM do?

Atomic force microscopy is a powerful surface analytical technique used in air, liquid or vacuum to generate very high-resolution topographic images of a surface down to molecular/atomic resolution. Depending on the sharpness of the tip it gives spatial resolutions of 1-20 nm. It can record topographic images as well as mapping other information on nanoscale such as mechanical (modulus, stiffness, viscoelastic, frictional, adhesion), chemical, electrical and magnetic properties.





How does AFM work?

In AFM, a sharp microfabricated tip attached to a cantilever is scanned across a sample. The deflection of this cantilever, caused by the forces developed between the tip and the sample, is monitored using a laser and photodiode and is used to generate an image of the surface. The AFM can image in a number of ways using either contact mode or an oscillating technique where the tip taps the surface.

The AFM can also be used for force spectroscopy and mapping. Here it applies forces as a function of height from 5pN to 50 µN to one spot on a surface to analyse mechanical or in some cases chemical properties at surfaces. either pushes into the surface to measure nanomechanical properties of a surface such as modulus, stiffness and adhesion or pulls away from the surface to investigate bond rupture and adhesion.

What is AFM used for?

- Polymers, coatings, inorganics, biological samples and other commercial products
- Healthcare, personal care products – e.g. measuring the change in nanoscale mechanical properties (modulus and friction) of hair, teeth and skin as a function of time or actives
- The topography and nanomechanical properties of nanoparticles, particles, graphene, 2D materials and coatings

What are the measurement challenges?

- Imaging soft samples at high resolution whilst minimising damage
- Calibration, quantification and understanding of AFM modes (including force spectroscopy, multi-frequency modes, frequency modulation mode, lateral force and amplitude modulation mode)
- Obtaining valid additional information from AFM (mechanical, chemical, electrical) as a function of time

See our **AFM research** page to find out more.

Key Publications

"Summary of ISO/TC 201 Standard: ISO 11775: 2015-Surface Chemical Analysis Scanning Probe Microscopy - Determination of Cantilever Normal Spring Constants", C. A. Clifford, *Surface and Interface Analysis*, 2017, 49, 171-172

"Towards easy and reliable AFM tip shape determination using blind tip reconstruction", EE Flater, GE Zacharakis-Jutz, BG Dumba, IA White, CA Clifford. *Ultramicroscopy*, 2014, 146, 130-143

"Modelling of surface nanoparticle inclusions for nanomechanical measurements by an AFM or nanoindenter: spatial issues", C A Clifford, M P Seah. *Nanotechnology*, 23, 165704 (2012)

"Nanomechanical measurements of hair as an example of micro-fibre analysis using atomic force microscopy nanoindentation", C A Clifford, N Sano, P Doyle, M P Seah. *Ultramicroscopy*, 114, 38-45 (2012)

"Quantification issues in the identification of nanoscale regions of homopolymers using modulus measurement via AFM nanoindentation", CA Clifford, MP Seah. *Applied surface science*, 2005, 252 (5), 1915-1933

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