University of Nottingham
Nanoscale and Microscale Research Centre

Atomic force microscopy (AFM)

Atomic force microscopy is a high-resolution scanning probe technique that allows visualisation of material surfaces and their topographical features with nanometre resolution.

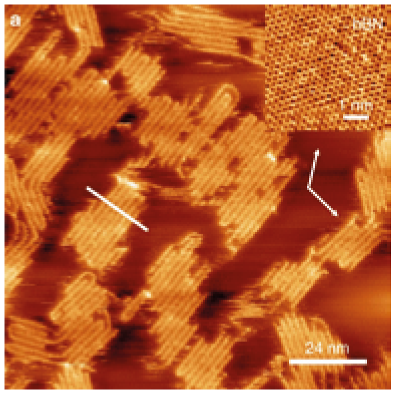
The interaction between a probe tip and the surface is measured via its deflection in response to surface properties. Variations of the technique allow you to calculate surface physicochemical and mechanical properties, measure interaction forces between material surfaces and map the thermal or electrical properties of a sample.

Capabilities

- Micro- and nano-structural visualisation.
- Texture analysis (roughness, topography, morphology).
- Surface forces quantification (adhesion, surface free energy and others).
- Surface mechanical properties assessment (hardness, Young’s Modulus, friction and others).
- Mapping of different surface components and phases.
- Biomolecular interactions.

Typical applications

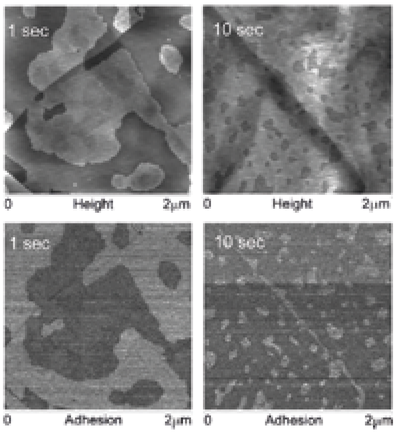
- Identification and localisation of phases in formulations.
- Material coating assessment.
- Visualisation of cell ultrastructure and molecular dynamics.
- Quantification of ligand-receptor interactions.
- Component integrity investigation.



High-resolution AFM images of polythiophene strands adsorbed on the surface of hBN

AFM can image material surfaces with nanometre resolution. In addition to nanostructures (such as peptides, nanoparticles and nanotubes) the technique can resolve molecular/atomic structures. This figure shows individual thiophene units and where a lattice of semicrystalline spin coated films of polythiophenes (PTs) may be resolved using AFM. Real-space images of polymers with sub-molecular resolution could provide valuable insights into the relationship between morphology and functionality of novel polymer based electronic devices.

Vladimir V Korolkov, A Summerfield, A Murphy et al. Ultra-high resolution imaging of thin films and single strands of polythiophene using atomic force microscopy. *Nature Communications* 10 (2019), 1537.



Topography and adhesion characterisation of self-assembled monolayer formation

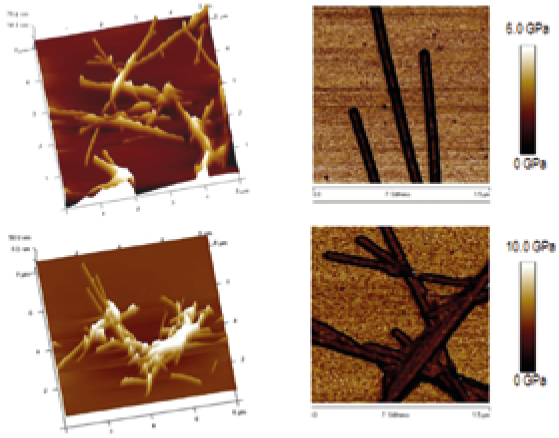
AFM allows the mapping of the adhesive character of a surface or its components. Adhesion forces can be used to calculate the interactivity of a surface and the data can be mapped to complement a topographical assessment. This figure shows height (upper row) and adhesion (lower row) AFM images (2 μm × 2 μm) detailing a real-time surface evolution due to the self-assembly of trimesic acid on a highly ordered pyrolytic graphite (HOPG) surface. The dark regions on the height and adhesion maps correspond to the areas with lower height and adhesion respectively.

Vladimir V Korolkov, Stephanie Allen, Clive J Roberts, and Saul JB Tendler. *Journal of Physical Chemistry C* 116 (2012), 11519–11525.

Mechanical mapping of peptide nanotubes

AFM can provide a mechanical assessment of a surface and its features. Here topography (3D) (left) and mechanical stiffness maps (right) are shown of nanotube structures which form in samples comprising 80% (top) and 60% (bottom) dinapthylalanine (di-Nal) peptides to diphenylalanine peptides (FF). This combination of data channels allows functional, structural, and mechanical analyses where systems with a uniform topography but different material phases can be distinguished.

Victoria L Sedman, Xinyong Chen, Stephanie Allen, Clive J Roberts and Saul JB Tendler. *Journal of Microscopy* 249 (2013), 165–172.



Our facilities

Dimension FastScan Bio™ (Bruker): Capable of scan speeds 100 times faster than traditional AFMs, this AFM offers high-resolution, live-sample observation of interacting molecules, membrane proteins, DNA-protein binding, inter-cellular signalling and other dynamic biological processes. Includes Bruker's PeakForce™ QNM™ (Quantitative Nanomechanical Measurement) capability.

Multimode® 8 Scanning Probe Microscope (Bruker): Nanoscale imaging capabilities supplemented by simultaneous high-resolution force mapping with Bruker's PeakForce™ QNM™.

EnviroScope™ AFM (Bruker): AFM analysis within an environmental chamber capable of precise temperature and humidity control.

Many more… Including Dimension® 3100 and 3000 AFMs (Bruker), ForceRobot® 300 (JPK Instruments), MFP-1D and MFP-3D™ (Asylum Research).

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