Advanced Scanning Probe Microscopy for Materials Research

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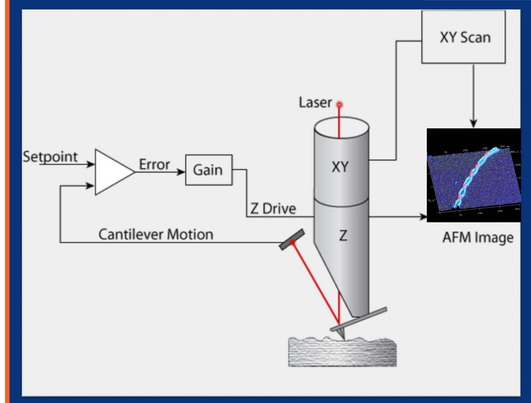
Scanning Probe Microscopy Tools

Atomic Force Microscopes (AFMs)

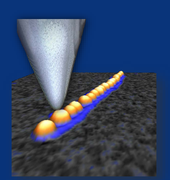
- Bruker Dimension Icon/FastScan Bio & 3100
- Bruker Multimode 8

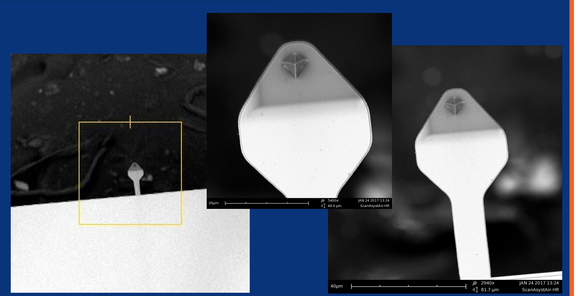
Scanning probe microscopy encompasses a set of advanced imaging techniques for mapping the structure and properties of the surfaces of materials from the atomic to micro scales.



By recording forces between the sample and a sharp tip as the probe rasters across the surface, an image of the surface topography (or other properties of interest) is obtained.[1,2]

AFM Probe

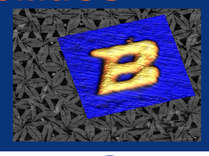


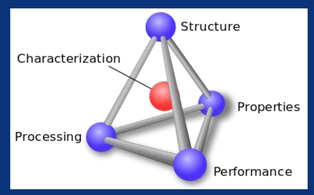


SEM micrographs of an AFM probe. AFM cantilever attached to substrate (bottom left) with yellow boxed area zoomed (right) to show ~2 nm radius of curvature tip (middle).

SPM Capabilities

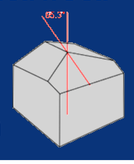
- Sample Topography
  - Surface Roughness
  - Particle Analysis
  - Morphology
- Material Properties
  - Mechanical
  - Magnetic
  - Electrical (Conductivity, Potential, etc.)
- Colocalization with other techniques
  - Scanning Electron Microscopy (SEM)
  - Optical Microscopy

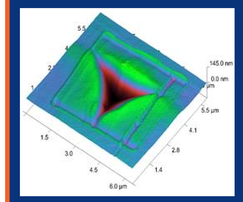




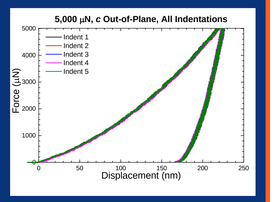
Nanoindentation & Nanomechanical Properties (PF-QNM)

- Elastic (Young's) Modulus
- Adhesion, Deformation, Dissipation

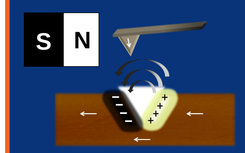




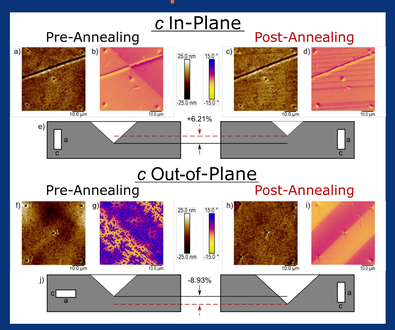
Typical indentation (left) and load-displacement curve (right)[3] obtained with a diamond tip Berkovich probe (above right).



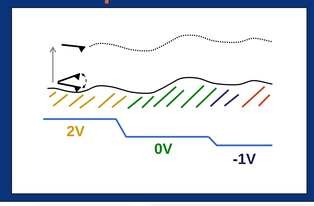
Magnetomechanical Properties Mapping

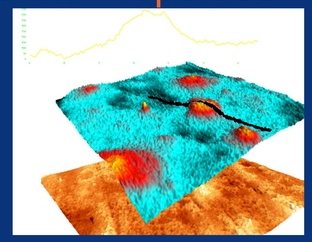


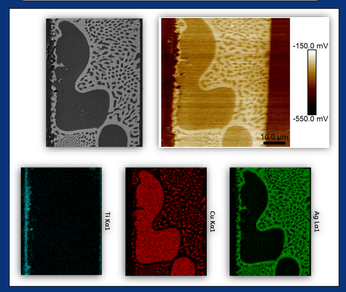
Magnetomechanical coupling in NiMnGa, a magnetic shape memory alloy.[3-4]



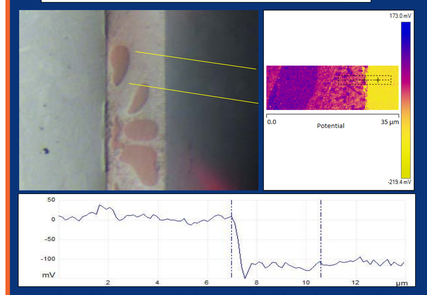
Composition & Electrical Properties



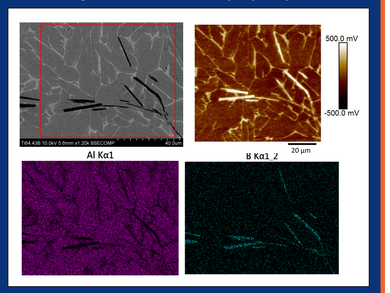




Kelvin Probe Force Microscopy (KPFM) measures surface potential or work function as shown schematically (top left). Surface potential maps of microphases present can be overlaid atop an AFM image (above)[5] or co-localized SEM image or EDS map (left).[6]

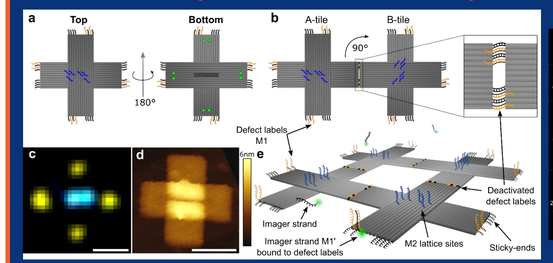


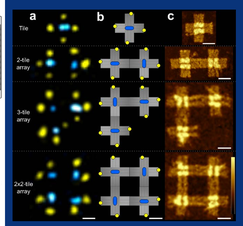
Optical image (above left) of stainless steel coupons joined by a CuSil (Cu/Ag) braze. Phase separation leads to corrosion due to the Volta potential differences (above) seen in the KPFM image (above right).[6]



KPFM Volta potential maps with co-localized SEM and energy dispersive spectroscopy (EDS) maps of a Ti-6Al-4V alloy used in biomedical applications doped with 0.43% boron.[7]

AFM & Super-Resolution Optical Microscopy





AFM can be combined with super-resolution optical microscopy to confirm location and orientation of chromophores on the nanoscale.[8]

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1. AFM schematic adapted from Bruker Dimension Icon/FastScan Bio help files
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