ASYLUM RESEARCH
Atomic Force Microscopes

Piezo Force Module

DATA SHEET 27

The Piezo Force Module for Electromechanical Measurements

Electromechanical coupling is one of the fundamental mechanisms underlying the functionality of many materials. These include inorganic, macro-molecular materials and many biological systems. The new Piezo Force Module from Asylum Research enables very high sensitivity, high bias, and crosstalk-free measurements on piezoelectrics (including biological systems in fluid), ferroelectrics and multiferroics. These capabilities are exclusively available on the MFP-3D™ AFM.

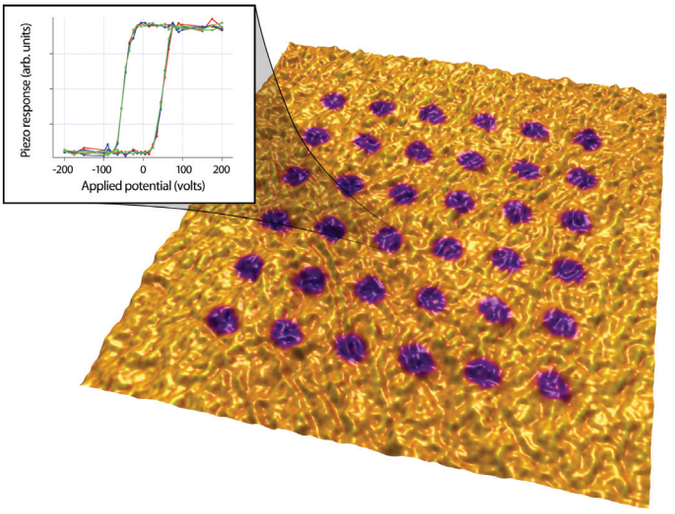
Piezoresponse Force Microscopy

In the last decade, piezoresponse force microscopy (PFM) has emerged as the preeminent tool for nanoscale imaging, spectroscopy, and manipulation of ferroelectric materials. More recently, these same techniques are finding applications for a wider range of materials including soft polymer and biological materials. In response to these advances, Asylum Research has recently developed the new Piezo Force Module which combines new patent-pending measurement techniques and a unique high voltage capability that significantly expands the range and sensitivity of measurements.

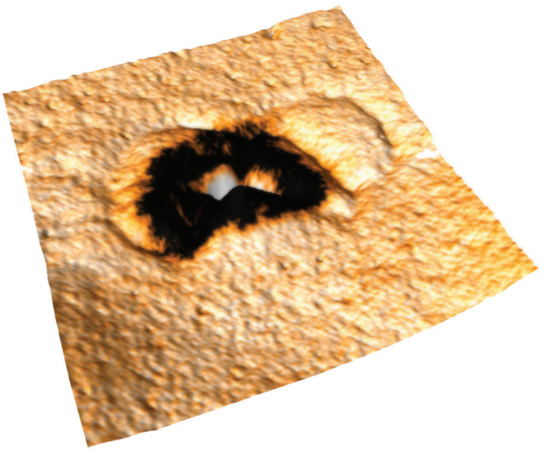
Resonant-Enhanced Imaging Modes

Many measurement techniques have made use of cantilever resonances to enhance the sensitivity of the measurements dating back to the invention of the AFM. Because of crosstalk between the resonant frequency and the topography, resonant operation was not possible with PFM. However, two new patent-pending measurement modes developed by researchers at Asylum Research and their collaborators nearly eliminate crosstalk issues. These modes utilize cantilever resonances which inherently allow higher senstitivity measurements:

- Dual frequency resonance tracking (DFRT)
- Band excitation (optional)



Rendered topography of a $LiNbO_3$ sample with the PFM signal painted on top. Image was taken after switching spectroscopy mapping. Inset shows the hysteresis loops measured at an individual point, 4µm scan.



Zoom of the top surface of a red blood cell. The surface shape was rendered to show the topography while the phase channel is painted on top to show piezo response. A small (sub-micron) region on top (brown) of the cell exhibited a much different piezo response than the surronding cell surface. 2µm scan. Image courtesy of B. Rodriguez and S. Kalinin, ORNL.

These modes avoid the limitations of conventional sinusoidal cantilever excitation while using resonance enhancement to provide new information on local response and energy dissipation which cannot be obtained by standard AFM scanning modes. The large frequency range (1kHz - 2MHz) of the MFP-3D allows imaging both at the static condition, and effective use of several cantilever resonances, and use of the inertial stiffening of the cantilever.

High Voltage Characterizes Even the Weakest Piezoelectric Materials

The MFP-3D Piezo Force Module accessory enables high voltage PFM measurements and advanced imaging modes for characterizing piezoelectric materials. With the Piezo Force Module, a programmable bias of up to ±220 volts is applied to the AFM tip using a proprietary high voltage amplifier, cantilever and sample holder. The amplitude of the response measures the local electromechanical activity of the surface while the phase yields information on the polarization direction. High probing voltages can characterize even the weakest piezoelectric sample and insure that you have the ability to switch the polarization of even high-coercivity materials.

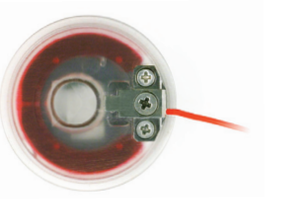
Spectroscopy Modes for Polarization Applications

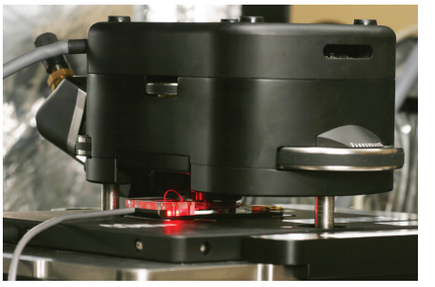
Polarization dynamics can also be studied with these spectroscopy modes:

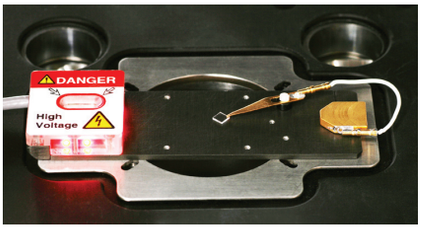
- Single-point hysteresis loop measurements (point and click)
- Switching Spectroscopy Mapping

These modes provide local measure of such parameters as coercive and nucleation biases, imprint, remanent response, and work of switching (area within the hysteresis loop), for correlation with local microstructure. Combined with the high-voltage module, these allow local polarization switching to be probed even in high-coercivity materials such as electro-optical single crystals.

For additional information on PFM, see the R&D magazine Oct.'07 article titled *"A Biased View of the Nanoworld: Electromechanical Imaging by SPM."*







The Piezo Force Module consists of the HVA220 High Voltage Amplifier (top left), the HV sample holder (left) and cantilever holder (above).

Specifications

Model PFM

The Piezo Force Module comes with the following items:

- HVA 220 High Voltage Amplifier
- HV cantilever holder
- HV sample holder
- 70 Electri-Lever probes
- Periodically Poled Lithium Niobate (PPLN) sample

Hardware

- HVA220 High Voltage Amplifier
  - ± 220V at 75ma output to the tip
  - 30V/microsecond slew rate
- Safe loading, HV sample holder
- HV cantilever holder

Software

Imaging

- Single frequency PFM
- Bit mapped voltage
- Dual Frequency Resonance Tracking (DFRT)
- Band excitation (optional)

Spectroscopy

- Single point hysteresis loop measurements (point and click)
- Switching Spectroscopy Mapping

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