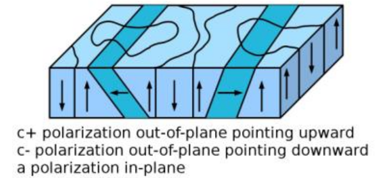
AIST-NT
Integration, Automation and Performance at the Nano scale

Investigation of materials using the SmartSPM™ scanning probe microscope in Piezo response Force Microscopy (PFM) mode

The Piezo response Force Microscopy (PFM) is a technique used to investigate the mechanical response of a piezoelectric material under the influence of electric voltage. The probe is scanned over the sample surface in contact. An AC voltage is applied between the probe tip and sample surface. Due to the piezoelectric effect some features on the sample surface (i.e. grains or domains) change their dimensions under the applied voltage and therefore make the probe oscillate. In the SmartSPM amplitude and phase of such oscillations can be detected by two lock-in amplifiers. One detects normal cantilever oscillations and another detects lateral ones. The oscillation amplitude signal gives the information about a value of piezo response while the oscillation phase signal about a direction of polarization.

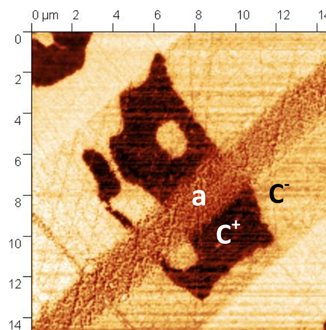
types of domains in ferroelectric substrates



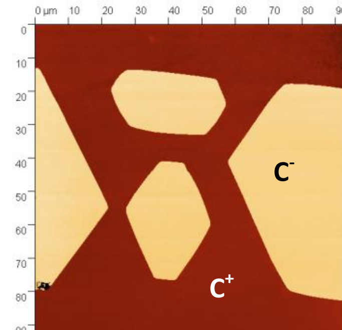
c+ polarization out-of-plane pointing upward
c- polarization out-of-plane pointing downward
a polarization in-plane

Main features:

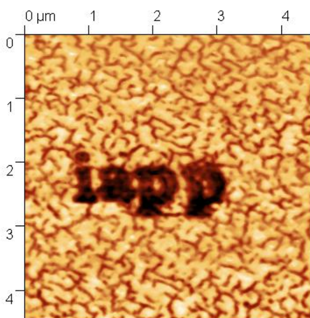
- ✓ **Simultaneous measurement of normal and lateral cantilever deflection. For each signal non-feedback signals such as amplitude, phase (from 0 to 360 degrees) and corresponding signal projections (*sinwt*, *coswt*) can be passed on to the display system to form an image.**
- ✓ **The extended driving voltage range (up to 50V) makes it possible to investigate materials with very low piezo response.**
- ✓ **The bias voltage in the range of +/-50V allows domain repolarization (lithography).**



Barium titanate crystall $BaTiO_3$ (BTO), PFM voltage: 9V, 3 types of domains c^+, c^- and a.



Congruent lihitum niobate crystal LiNbO3 (LNO), doped with magnesium, PFM voltage: 9V, hexagonal domains, 2 types of domains c+ and c-.



Bismuth ferrite (BFO) BiFeO3 thin film (150nm) on (001) Strontium titanate SrTiO3 (STO), with written logo of the institute (iapp) using the lithography tool, PFM voltage 2V

**** All images are kindly provided by Prof. Lukas Eng (eng@iapp.de) from Institut für Angewandte Photophysik, Technische Universität Dresden (http://www.iapp.de)***

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