Nanoelectromechanics of Ferroelectric Materials: Piezoresponse Force Microscopy in 3 Dimensions

Junsoo Shin,[1,2] Sergei V. Kalinin,[2] Pradyumna Gupta,[3] and Arthur P. Baddorf,[2]

[1]University of Tennessee, Knoxville, TN 37996
[2]ORNL, Oak Ridge, TN 37831
[3]Lehigh University, Bethlehem, PA 18015

Nanoscale ferroelectrics have great potential for oxide electronic application, non-volatile memories, and microelectromechanical systems. Progress requires quantitative characterization, including polarization imaging and hysteresis loop measurements, at nanometer levels. In Piezoresponse Force Microscopy (PFM), a conductive scanning probe tip is brought into contact with the surface and the electromechanical response of the surface is detected. The task of PFM is to reconstruct the orientation and magnitude of the polarization vector from the measured vertical and torsional component of cantilever displacement. We have investigated the potential of PFM for 3D electromechanical measurements in LaBGeO5 glass-ceramics and several PZT ceramics. To correlate arbitrarily oriented polarization with in-plane domain structure, we have obtained the lateral electromechanical response as a function of sample rotation. A quantitative analysis suggests that the signal strongly depends on the elastic properties of the substrate. To address this, an approach for simultaneous electromechanical and elastic imaging using a combination of PFM and Atomic Force Acoustic Microscopy is demonstrated.

Research was sponsored by the U.S. DOE, under contract DE-AC05-00OR22725 with UT-Battelle, LLC. Research performed as a Eugene P. Wigner Fellow (SVK).