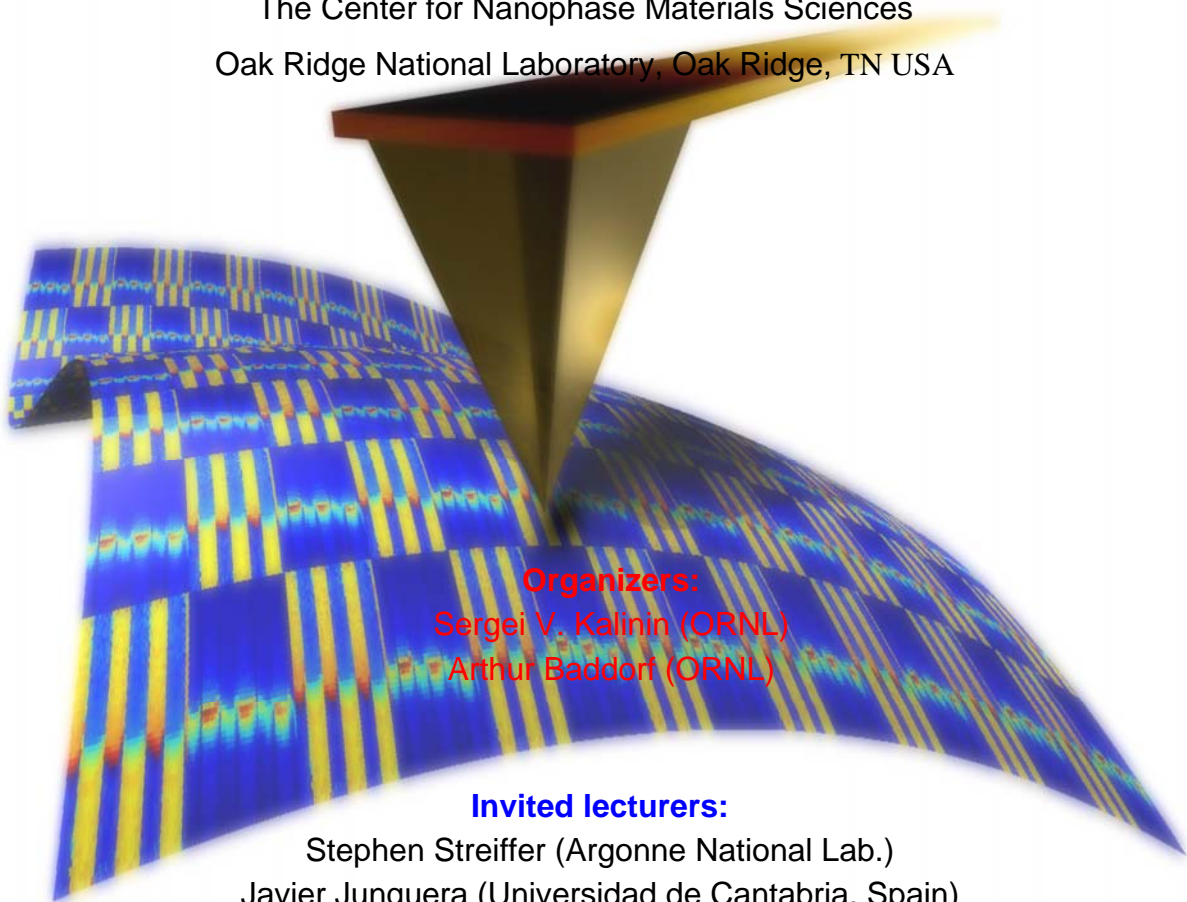


3d International Workshop

**Piezoresponse Force Microscopy and Nanoscale Electromechanics:
Theory, Techniques, and Applications**

September 22-24, 2008

The Center for Nanophase Materials Sciences
Oak Ridge National Laboratory, Oak Ridge, TN USA



Organizers:

Sergei V. Kalinin (ORNL)

Arthur Baddorf (ORNL)

Invited lecturers:

Stephen Streiffer (Argonne National Lab.)

Javier Junquera (Universidad de Cantabria, Spain)

Alexei Gruverman (U. Nebraska-Lincoln)

Andrei Kholkin (U. Aveiro, Portugal)

William Brownell (Baylor College of Medicine)

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3d International Workshop on Piezoresponse Force Microscopy: Theory, Techniques, and Applications

The Center for Nanophase Materials Sciences, Oak Ridge National Laboratory,
Oak Ridge, TN 37831, USA

Sergei V. Kalinin and Art Baddorf

Coupling between electrical and mechanical phenomena is ubiquitous in nature and underpins the functionality of materials and systems as diversified as ferroelectrics and multiferroics to electroactive molecules to biological systems. The series of invited tutorials will cover the basic physics of ferroelectrics that motivate much of the interest in PFM, the complementary method of X-ray scattering for investigating polar materials, underpinning theory, and electromechanical phenomena in biological systems. The workshop aims to provide in-depth description and recent advances in Piezoresponse Force Microscopy. The workshop will introduce basic principles of PFM operation, relevant instrumental aspects, and image interpretation. The theory of cantilever dynamics, PFM contact mechanics, and resolution theory, as well as their implications for qualitative and quantitative data interpretation in PFM, will be presented and illustrated experimentally. The recent technical advances in PFM, including vector PFM, high-frequency PFM, band-excitation and DRFT imaging, switching spectroscopy PFM and imaging and polarization switching in liquids and vacuum, will be presented. For ferroelectric materials, applications of PFM for domain imaging, nucleation center mapping, and probing polarization dynamics in thin films and capacitor structures will be presented. Finally, electromechanical probing of biological, electroactive polymer, and soft-condensed matter systems beyond classical ferroelectric applications will be discussed in detail.

The 2.5 day workshop aimed for intermediate and advanced PFM users will include lectures given by S.V. Kalinin (ORNL) and A. Gruverman (UNL) and experimental tutorials on PFM imaging and SS-PFM studies of polarization dynamics (S. Jesse, M. Nikiforov, K. Seal, ORNL, and K. Jones, Asylum Research). Ultimately, we aim to build a network of advanced PFM practitioners to promote rapid dissemination of theoretical knowledge, experimental protocols, and novel technique development in this rapidly growing area, as well as to establish links to areas such as electrophysiology and physical biology.

The workshop will also feature a series of presentation of practitioners of Piezoresponse Spectroscopy, Switching Spectroscopy PFM and Band Excitation PFM, demonstrating recent advances in application of this technique to ferroelectric and ferroelastic domain walls, capacitors, and ferroelectric multilayers.

The workshop is supported by the Center for Nanophase Materials Sciences and Joint Institute for Advanced Materials.

Piezoresponse Force Microscopy: Theory, Techniques, and Applications

Monday, September 22

- 8.00 a.m – 8.20 a.m. Introduction: Electromechanical Coupling on the Nanoscale: Bonds, Cells, and Molecules (S. Kalinin, ORNL)
- 8.20 a.m. – 10 a.m. **Invited tutorial** "Phase transitions, domain structure & dynamics, and surface chemistry in ferroelectrics studied by x-rays" (S. Streiffer, Argonne National Lab.)
- 10.00 a.m. – 10.30 a.m.** **Coffee break**
- 10.30 a.m. – 12.00 p.m. Principles and Instrumental aspects of Piezoresponse Force Microscopy (A. Gruverman, UNL)
- 12.00 p.m – 1.00 p.m.** **Lunch**
- 1.00 p.m. – 2.30 p.m. PFM of piezoelectric materials: contact mechanics, cantilever dynamics, and resolution theory (S.V. Kalinin, ORNL)
- 2.30 p.m. – 3.00 p.m.** **Coffee break**
- 3.00 p.m. – 4.30 p.m. **Invited tutorial:** "Nanoscale imaging and polarization dynamics in relaxor ferroelectrics" (A. Kholkin, U. Aveiro, Portugal)
- 4.30 p.m. – 6.00 p.m. PFM studies of polarization dynamics in ferroelectric films and capacitors (A. Gruverman, UNL)

Tuesday, September 23

- 8.30 a.m. – 10.30 a.m. **Invited tutorial** "First-principles modeling of ferroelectric surfaces and nanostructures" (Javier Junquera, University of Cantabria, Spain)
- 10.30 a.m. – 11.00 a.m.** **Coffee break**
- 11.00 a.m. – 12.30 p.m. Local polarization switching and PFM spectroscopy (S. Kalinin, ORNL)
- 12.30 p.m – 1.30 p.m.** **Lunch**
- 1.30 p.m. – 3.00 p.m. **Invited tutorial** "Nanoscale electromechanics in biological systems" (W. Brownell, Baylor College of Medicine)
- 3.00 p.m. – 3.30 p.m.** **Coffee break**
- 3.30 p.m. – 5.00 p.m. Advanced topics in PFM: Macromolecular and biological systems and imaging in liquids (S.V. Kalinin, ORNL)
- 5.00 p.m. – 5.45 p.m. Advanced modes in PFM: Band Excitation Method and Energy Dissipation on the nanoscale (S. Jesse and S.V. Kalinin, ORNL)
- 5.45 p.m. – 6.30 p.m. Polarization dynamics and atomic structure on in-situ grown ferroelectric films (A. Baddorf, ORNL)

Wednesday, September 24

- Industry presentations: PFM in action**
Mini-symposium on Switching Spectroscopy PFM

Wednesday Afternoon – Friday: experimental labs and demos (Asylum MFP-3D, Veeco Nanoman V, MultiMode/Nanonis)