DF 17: Nano- and microstructured dielectrics

Time: Thursday 15:30–17:30 Location: H11

DF 17.1 Thu 15:30 H11

Low-Voltage Nano-Domain Writing in He-Implanted Lithium Niobate Crystals — •Martin Lilienblum[1], Avishai Ofan[2], Ákos Hoffmann[1], Ophir Gaathon[2], Lakshmanan Vanamurthy[3], Sasha Bakhru[3], Hassaram Bakhru[3], Richard Osgood Jr.[2], and Elisabeth Soergel[1] — [1]Institute of Physics, University of Bonn, 53115 Bonn, Germany — [2]Center for Integrated Science and Technology, Columbia University, New York NY 10027, USA — [3]College of Nanoscale Science and Engineering, State University of New York at Albany, Albany NY 12222, USA

A scanning force microscope tip is used to write ferroelectric domains in He-implanted single-crystal lithium niobate and subsequently probe them by piezoresponse force microscopy. Investigation of cross-sections of the samples showed that the buried implanted layer, $\sim 1\,\mu$m below the surface, is non-ferroelectric and can thus act as a barrier to domain growth. This barrier enabled stable surface domains of $< 1\,\mu$m size to be written in $500\,\mu$m-thick crystal substrates with voltage pulses of only 10V applied to the tip.

DF 17.2 Thu 15:50 H11

Surface-charge effects of nanocrystalline lithium niobate* — •Daniel Schütze, Bastian Knabe, and Karsten Buse — Universität Bonn, Wegelerstr. 8, 53115 Bonn

As a ferroelectric material, lithium niobate exhibits a spontaneous polarization, which leads to charged c-faces. In the most simple picture, these charges can be fully compensated by various compensation mechanisms. Yet, investigations of surface charges show that this compensation is incomplete. Remaining surface charges lead to a finite dipole moment of lithium niobate nanoparticles. We analyze this dipole moment and its dependence on dopants and dopant concentration by measuring the orientation of nanoparticles in liquids upon application of electric fields.

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DF 17.3 Thu 16:10 H11

The novel polarization patterns in $BaTiO_3$ nanowires from first principles — •Jiawang Hong[1,2], Gustau Catalan[1,3], Daining Fang[2,4], Emilio Artacho[1,5], and James F. Scott[1,6] — [1]Department of Earth Sciences, University of Cambridge, Downing Street, Cambridge CB2 3EQ, UK — [2]AML,Department of Engineering Mechanics, Tsinghua University, Beijing, 100084, P. R. China — [3]ICREA and Centre d'Investigacio en Nanociencia i Nanotecnologia (CIN2), Campus UAB, Bellaterra, Spain — [4]LTCS, College of Engineering, Peking University, Beijing 100084, P.R.China — [5]Donostia International Physics Centre, Universidad del Pais Vasco, 20080 San Sebastian, Spain — [6]Cavendish Laboratory, University of Cambridge, JJ Thomson Ave, Cambridge CB3 0HE, UK

Based on first principles calculations, the behaviour of the cross-sectional polarization field is explored for thin $BaTiO_3$ nanowires with different surface terminations. The unusual and interesting polarization patterns are discovered in these wires, beyond the known patterns in ferroelectric nanostructures. It is found that these new patterns result from the competition of surface effects and edge effects. The critical size of nanowires with different surface terminations is also investigated.

DF 17.4 Thu 16:30 H11

Size Effects in Fine Barium Titanate Particles — •Pavel Sedykh[1], Dieter Michel[1], Elena V. Charnaya[2], and Jürgen Haase[1] — [1]University of Leipzig, Faculty of Physics and Earth Sciences, Linnéstraße 5, 04103 Leipzig, Germany — [2]St.Petersburg State University, Faculty of Physics, Ul'yanovskaya street 1, 198504 St.Petersburg, Russia

^{137}Ba NMR spectroscopy is very suitable to study size effects in very fine particles of barium titanate where particle sizes varied between 155 and 15 nm. The NMR measurements were carried out within the temperature range of the ferroelectric tetragonal phase and allowed us to deduce information about the spontaneous electric polarization. The fine particles are composed of an "ordered" part showing a tetragonal structure and a so called "disordered" part. The "ordered" part reveals a first order phase transition and a temperature dependence of the spontaneous polarization which may be described by a power law similar as predicted by the Landau theory but the phase transition temperature becomes slightly lower with decreasing particle diameter and the exponent changes from 1/2 to about 1/3. The applicability of the core-shell model is discussed and the thickness of the shell is estimated. The shell thickness was shown to strongly decrease with decreasing particle size below 50 nm. Therefore, the applicability of other structural models is also discussed.

DF 17.5 Thu 16:50 H11

Conductivity of $BaTiO_3$ metallic composites below the percolation threshold due to finite size effects — •Hans Lustfeld[1] and Martin Reissel[2] — [1]IFF-1, Forschungszentrum Jülich, D52425 Jülich — [2]Fachhochschule Aachen, Abteilung Jülich, D52428 Jülich

The high dielectric permittivity ϵ of $BaTiO_3$ can be enhanced further by adding metallic nanoparticles, e.g. $Ni[1,2]$ or $Ag[3]$(,size of particles $\approx 10 \cdot 10^{-9}m$). This enhancement becomes arbitrarily high at the concentration c_p of the percolation threshold[4]. Therefore it can be the aim to get very close to c_p. $BaTiO_3$ is an insulator, and if finite size effects can be neglected, the d.c. conductivity remains zero below c_p. However, modern **M**ulti **L**ayer **C**eramic **C**apacitors (MLCC's) have a layer thickness of about $1-5 \cdot 10^{-6}m$ only[5], finite size effects become important and lead to increasing finite conductivities when approaching c_p from below. Here we present calculations for the conductivity in the brick layer model[6] and for a modification of the brick-layer model. A main result obtained for both these models is an exponentially strong increase of the d.c. conductivity, as soon as the concentration increases beyond c_{crit}. The concentration c_{crit} depends sensitively on the size of the nanoparticles and is about 10% smaller than c_p for typical sizes.

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DF 17.6 Thu 17:10 H11

Dielectric analysis of dispersed particles in composites of unknown microstructure — •Béatrice Hallouet, Carsten Volz, and Rolf Pelster — Universität des Saarlandes, FR 7.2 Experimentalphysik, D–66123 Saarbrücken, Germany

In general, the details of the microstructure in nanocomposites is unknown. Nevertheless there is a need to determine the intrinsic properties of the dispersed phase from the measured effective properties of the system. We present a method to extract at least a partial information using basic physical considerations, among other things energy conservation. The procedure is tested for composites consisting of a solid polymer filled with semi-conductive particles (Ga As in a epoxy resin) using broadband dielectric spectroscopy. From the measured dielectric spectra, which show polarisation peaks (MWS polarisation), we obtain boundaries for the permittivity and the conductivity of the particles.