

DF 1: Dielectric and ferroelectric thin films 1

Time: Monday 10:15–13:00

Location: MÜL Elch

Invited Talk

DF 1.1 Mon 10:15 MÜL Elch
Design and Fabrication of Quantum-Enhanced Capacitors for CMOS-Applications — ●JOCHEN MANNHART¹, THILO KOPP¹, CHRISTOPH RICHTER¹, LU LI², and ASHOORI RAY² — ¹Center for Electronic Correlations and Magnetism, Institute of Physics, Augsburg University, Augsburg, Germany — ²Department of Physics, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139, USA

As the miniaturization of electronic circuits reaches the quantum scale, new possibilities emerge for the realization of novel, quantum electronic devices which exploit the quantum nature of solids. Here we show that by using quantum effects, the capacitance of electronic devices can be optimized to a great extent, which is a key to the further miniaturization of electronic components.

It is shown that by optimizing the material of the conducting electrodes, the capacitance of capacitors reaching the quantum regime can be substantially enhanced or reduced. Dielectric capacitors with negative total capacitances are suggested and their properties analyzed. Resulting perspectives to enhance the performance of electronic devices are discussed.

5 min. break

DF 1.2 Mon 11:00 MÜL Elch
Observation of ultrafast structural dynamics in perovskite ferroelectrics under optical excitation — ●MICHAEL VATTILANA¹, DAN DARANCIANG², NATHANIEL BRANDT⁴, MATTHEW HIGHLAND³, HAROLD HWANG⁴, HAIDAN WEN², PAUL FUOSS³, JOHN GOODFELLOW², JORGEN LARSSON⁵, KEITH NELSON⁴, ANDREW RAPPE⁶, DAVID REIS², BRIAN STEPHENSON³, KLAUS SOKOLOWSKI-TINTEN¹, and AARON LINDENBERG² — ¹Universität Duisburg-Essen — ²SLAC/Stanford University — ³Advanced Photon Source, Argonne National Lab — ⁴Massachusetts Institute of Technology — ⁵Lunds Universitet — ⁶University of Pennsylvania

We used femtosecond time-resolved x-ray diffraction to investigate the dynamic structural evolution of thin PbTiO₃ films after optical excitation with intense fs laser pulses at 400 nm. The experiments were performed at the XPP pump-probe station of the Linac Coherent Light Source (SLAC) using ultrashort (60 fs) hard X-ray pulses at 9 keV. Our data reveal a complex structural response depending on the temperature (i.e. below and above the ferroelectric Curie-temperature) and the domain structure of the sample. We attribute this behavior to the strong coupling between the ferroelectric polarization, lattice strain and electronic degrees of freedom.

DF 1.3 Mon 11:20 MÜL Elch
Low voltage ferroelectric electron emission from Pb(Zr_{0.4}Ti_{0.6}) thin films — ●JANA BECHERER¹, OLIVER MIETH¹, VINAY SHANKAR VIDYARTHI², GERALD GERLACH², and LUKAS M. ENG¹ — ¹Institut für Angewandte Photophysik, Technische Universität Dresden, D-01062 Dresden — ²Institut für Festkörperelektronik, Technische Universität Dresden, D-01062 Dresden

We report on the electron emission from 600 nm thin ferroelectric Pb(Zr_{0.4}Ti_{0.6}) films. Based on a monolayer of polystyrene beads, structured top electrodes were prepared on the PZT films revealing nanometer-sized and regularly arranged apertures. The application of an ac voltage between top and bottom electrode initiates electron emission from the apertures. The emission current is measured under UHV conditions using a single electron detector for small signals and an amperemeter for larger currents.

The onset of the electron emission process could be accomplished at voltage values as low as 10 V. Emission current densities up to $3 \cdot 10^{-8} \text{ Acm}^{-2}$ for excitation voltages of 60 V were achieved. Using Piezoresponse Force Microscopy (PFM), the polarization state within the apertures was imaged for different voltages applied between top and bottom electrode. An increasing fraction of the free surface area was found to exhibit the reversed polarization orientation for rising voltage amplitudes. Thus, it is shown that the emission process in thin PZT films is strongly correlated to the switching of the ferroelectric polarization.

DF 1.4 Mon 11:40 MÜL Elch

Transient surface charging of insulators — ●BJÖRN MARTIN, ANDREY OSTROSKIY, and HERBERT KLIEM — Saarland University, Germany

The time dependent surface potential of insulators is investigated after charging of the surface with an electrical field. The surface potential is measured contactless using a scanning Kelvin probe or the Kelvin option of an atomic force microscope (AFM).

In a first experiment, a small point on the surface of an one side metallized insulator is charged with the cantilever of the AFM. The surface potential around this point is measured afterwards. On the position of the charged point a potential difference in relation to the uncharged regions is found. A transient decay and spread of the surface potential is observed in the long time range.

In another experiment, regions around evaporated top electrodes are charged by applying linear increasing voltages. Simultaneously the charging current is measured. Peaks are found in the measured current during the charging process. After application of a short circuit the surface potential at the electrode edge is measured. A potential peak near the electrode is found. The width and the temporal decay of this potential peak depend on the electrode material. The peaks during the charging process are correlated to the appearance of the potential peak. It is remarkable and not yet understood that positive surface charges are found near the electrode edge after application of a positive voltage.

DF 1.5 Mon 12:00 MÜL Elch
Comparative study of ferroelectric properties in Langmuir-Blodgett and spin-coated thin films of poly(vinylidene fluoride/trifluoroethylene) copolymers — ●MANFANG MAI, BJOERN MARTIN, and HERBERT KLIEM — Institute of Electrical Engineering Physics, Saarland University, Campus Building A5 1, D-66123, Saarbruecken, Germany

Poly(vinylidene fluoride/trifluoroethylene) copolymer thin films were prepared by Langmuir-Blodgett technique with thickness d ranging from 37 to 139 nm and spin coating method ($d=53\text{-}327\text{nm}$). Their ferroelectric behavior has been investigated and compared by polarization switching measurements. Both kinds of films exhibit almost the same switching behaviour with varying thicknesses. As sample thickness reduces, the hysteresis loops tend to slant and the switching transients become broader. The coercive field increases with decreasing sample thickness, whereas the remanent polarization is nearly independent of sample thickness. The switching time decreases with increasing field and it is independent of thickness down to 69 nm in LB films and 71 nm in spun films. Slower switching is observed for a thickness below 60 nm in both LB films and spun films. This could be due to the depolarization field induced by the surface oxidation layers of Al electrodes which becomes the more pronounced the thinner the sample is. The switching voltage suggests thin films in the range of 60-100 nm are promising candidates for technical applications.

DF 1.6 Mon 12:20 MÜL Elch
Ferroelectric poly(vinylidene fluoride) films crystallized with ionic liquids: Structure-property relations — ●FEIPENG WANG¹, ALEXANDER LACK¹, ZAILAI XIE², PETER FRÜBING¹, WERNER WIRGES¹, and REIMUND GERHARD¹ — ¹Applied Condensed-Matter Physics, University of Potsdam, Karl-Liebknecht-Strasse 24-25, 14476 Potsdam-Golm, Germany — ²Institute of Chemistry, University of Potsdam, Karl-Liebknecht-Strasse 24-25, 14476 Potsdam-Golm, Germany

Ferroelectric polymer films from poly(vinylidene fluoride) (PVDF) and its copolymers are often used in all-organic electronics. However, preparation of thin ferroelectric β -phase PVDF films is a challenging task due to the various crystalline phases of PVDF. In this work, ferroelectric PVDF films were obtained from a solution containing a small portion of the ionic liquid 1-Ethyl-3-methylimidazolium nitrate ([EMIM][NO₃]) and subsequent drying and annealing at elevated temperatures. The films show clear ferroelectric hysteresis behavior, with a remnant polarization of about 60 mC/m² and a relatively high coercive field of about 200 MV/m. The quasi-static pyroelectric coefficient increases from 14 to 18 $\mu\text{C}/(\text{m}^2\text{K})$ at temperatures between -20 and 40 °C. However, the measured pyroelectricity drops rapidly to 5 $\mu\text{C}/(\text{m}^2\text{K})$ when the films are heated up to 70 °C. The

pyroelectric activity remains 60 % after the films were heated to 120 °C for 1 h and cooled back to 20 °C. X-ray diffraction measurements prove that addition of the ionic liquid enhances the films' crystallinity.

DF 1.7 Mon 12:40 MÜL Elch

Ferro- and pyroelectric characterization of thin poly(vinylidene fluoride) films — ●ALEXANDER LACK, FEIPENG WANG, PETER FRÜBING, WERNER WIRGES, and REIMUND GERHARD — Applied Condensed-Matter Physics, Department of Physics and Astronomy, Faculty of Science, University of Potsdam, Karl-Liebknecht-Strasse 24-25, 14476 Potsdam-Golm, Germany

Ferroelectric poly(vinylidene fluoride) (PVDF) films with a thickness of about 430 nm were prepared by spin coating from DMF/acetone

solution with addition of the ionic liquid 1-Ethyl-3-methylimidazolium nitrate ([EMIM][NO₃]). After drying and annealing at elevated temperature, Fourier-transform infrared (FTIR) spectra and X-ray diffraction (XRD) measurements indicate dominance of the ferroelectric β phase. Ferroelectric hysteresis loops were obtained by integrating non-linear current-voltage characteristics from a uni/bipolar electric-field sweep that allows separation of ferroelectric switching from capacitive charging and conduction. The nano-scale films show a relatively high coercive field of 200 MV/m. The remnant polarization is about 60 mC/m², which agrees with the degree of crystallinity. The pyroelectric coefficient is determined by analyzing the short-circuit current response during low-frequency temperature oscillations at different temperatures. From XRD measurements, the crystallinity, and the size and the distribution of the crystallites are determined.