DF 11 Electric, Electromechanical and Optical Properties II

Time: Friday 10:50–13:10 Room: MÜL Elch

Invited Talk

DF 11.1 Fri 10:50 MÜL Elch

Universal domain wall dynamics in ferroics and relaxors — •Wolfgang Kleemann — Angewandte Physik, Universität Duisburg-Essen, Duisburg, Germany

Domain walls in random ferroic media reveal different dynamic modes. The complete series under external *ac* fields at decreasing frequencies, f, segmental relaxation, creep, slide and switching, is observed in quantum ferroelectric $SrTi^{18}O_3$ [1], superferromagnetic $CoFe/Al_2O_3$ multilayers [2], and ultrathin ferromagnetic trilayers Pt/Co/Pt [3]. Dynamic scaling explains the transition from Cole-Cole-type segmental relaxation to creep with inverse power law dispersion as observed in periodically-poled $KTiOPO_4$ at $f_m = f_{m0}\exp(-\ E/k_BT)$, $f_{m0} = 3\times10^9$ Hz and E = 0.6 eV [4]. Segmental relaxation and creep are also observed in the uniaxial relaxor $Sr_{0.61}Ba_{0.39}Nb_2O_6$ [5], where wall pinning due to charge disorder-induced random electric fields is also responsible for the occurrence of nanopolar regions in the paraelectric regime, $T > T_c \approx 350$ K. Their interfaces with the paraelectric environment reveal similar dynamic modes as pinned ferroic domain walls. [1] J. Dec *et al.*, Ferroelectrics **298** (2004) 163. [2] X. Chen *et al.*, Phys. Rev. Lett. **89** (2002) 137023. [3] O. Petracic *et al.*, unpublished. [4] Th. Braun *et al.*, Phys. Rev. Lett. **94** (2005) 117601. [5] W. Kleemann *et al.*, Phys. Rev. B **65** (2002) 220101.

DF 11.2 Fri 11:30 MÜL Elch

Characterization of Periodically-Poled Lithium Niobate Crystals using External Electric Fields* — •Michael Kösters[1], Ulrich Hartwig[1], Theo Woike[1], Karsten Buse[1], and Boris Sturman[2] — [1]Institute of Physics, University of Bonn, Wegelerstraße 8, D-53115 Bonn, Germany — [2]Institute of Automation and Electrometry, 630090 Novosibirsk, Russia

A nondestructive method for characterizing copper-doped periodically-poled lithium niobate crystals (PPLN) using external electric fields is presented. The samples are irradiated with a laser beam of the wavelength $\lambda = 633$ nm; simultaneously electric fields of up to 6 kV/mm are applied. The resulting refractive index pattern inside the crystal, which is not solely due to the electro-optic effect, but also due to effects at the domain walls, creates a diffraction pattern behind the crystal. The model used to describe this pattern allows to determine important properties of PPLN such as the duty cycle. It also gives information on properties of the domain walls. This is of great importance for applications using quasi phase-matching, e.g. second harmonic generation and optical parametrical oscillation.

*Financial support from the Deutsche Forschungsgemeinschaft (FOR 557) and from the Deutsche Telekom AG is gratefully acknowledged.

DF 11.3 Fri 11:50 MÜL Elch

Trapping and Manipulation of Micro- and Nanoparticles on the Surfaces of Lithium Niobate Crystals utilizing Light-Induced Electric Space Charge Fields* — •F.Y. Kuhnert[1], J. R. Adleman[2], H. A. Eggert[1], D. Psaltis[2], and K. Buse[1] — [1]Institute of Physics, University of Bonn, Wegelerstr. 8, 53115 Bonn — [2]Department of Electrical Engineering, California Institute of Technology, Pasadena, CA 91125

The ability to trap and to manipulate inorganic particles and organic cells of micrometer and submicrometer size plays an important role in the field of Optofluidics. Optical tweezers are well known that use high intensity laser beams to trap particles due to the field gradient of a focused laser beam. Here we try a novel approach: Irradiating a lithium niobate crystal with an inhomogeneous light pattern leads to charge separation along the c-axis which causes electrical fields. As a result strong field gradients are present in proximity of the crystal surface. In contrast to optical tweezers, the strength of the electrical field depends only on the exposure i.e. on the product of intensity and time. With a laser beam we record space-charge and field patterns of circular shape as well as space-charge gratings with period length between 20 micron and 1000 micron into a lithium niobate crystal doped with 0.05 wt% Fe. Chalk particles (˜15 micron diameter) and silicon dioxide particles (80 nm diameter) in air as well as silicon carbide particles (130 nm diameter) in liquid are trapped and moved on the crystal surface. * Financial support by the DAAD, the DFG (BU 913/17), and the Deutsche Telekom AG is gratefully acknowledged.

DF 11.4 Fri 12:10 MÜL Elch

Recording and Readout of Spatial Gratings with Femtosecond Laser Pulses* — •Dominik Maxein[1], Peter Reckenthäler[1], Oliver Beyer[1], Karsten Buse[1], Boris Sturman[2], Hung Te Hsieh[3], and Demetri Psaltis[3] — [1]Physikalisches Institut, Universität Bonn, Wegelerstr. 8, 53115 Bonn — [2]Institute of Automation and Electrometry, Novosibirsk, Russia — [3]Department of Electrical Engineering, California Institute of Technology, Pasadena, USA

Employing the pump-and-probe technique with short laser pulses it is possible to investigate physical processes on very short time scales. With holographic methods, one can detect small absorption and refractive index changes. It is therefore desirable to combine both kinds of measurements for the investigation of light-induced processes in materials. However, while the well-known coupled wave equations are applicable for continuous-wave light and long pulses, new aspects like the short pulse duration and geometry have to be taken into account. We present results of theoretical studies on recording of spatial gratings with two femtosecond laser pulses. Time resolved read out of resulting gratings is performed with a Bragg matched pulse at another wavelength. Instantaneous effects (Kerr effect, two-photon absorption) are taken into consideration as well as longer-lasting changes of the material due to the exposure (excitation of charge carriers). The predictions of our model are compared with results of experiments utilizing lithium niobate and calcium fluoride crystals as the recording material.

* Financial support by the DFG (award BU 913 / 13) and the Deutsche Telekom AG is gratefully acknowledged.

DF 11.5 Fri 12:30 MÜL Elch

Holographic Investigation of Lithium Niobate Crystals with Femtosecond Laser Pulses* — •Peter Reckenthäler[1], Dominik Maxein[1], Oliver Beyer[1], Boris Sturman[2], and Karsten Buse[1] — [1]Physikalisches Institut, Universität Bonn, Wegelerstr. 8, 53115 Bonn — [2]Institute of Automation and Electrometry, Novosibirsk, Russia

Lithium niobate is an important material for nonlinear and photorefractive applications. For short light pulses high intensities occur, and transient nonlinearities like the Kerr-effect and free charge-carriers, become increasingly important. These effects can be serious obstacles for applications. A profound understanding of the processes on the femtosecond-timescale is therefore indispensable. Holography with femtosecond laser pulses allows to investigate charge excitation and transport processes as well as other nonlinear effects with very high temporal resolution. Volume gratings are generated with two interfering pump pulses ($\lambda_\mathrm{p} = 388$ nm, $t_\mathrm{p} \simeq 200$ fs) in lithium niobate crystals, and time-resolved read out is performed using a probe pulse ($\lambda_\mathrm{r} = 776$ nm, $t_\mathrm{r} \simeq 200$ fs). The diffraction efficiency shows mainly two features: A sharp peak with a width of the order of the pump-probe-crosscorrelation, and a plateau which is constant on the picosecond timescale. Matching the Bragg condition for the 2K contribution to the grating allows to separate different transient effects. With further experiments, it is possible to extract information about the build up of photorefractive gratings and to learn about the dynamics of charge separation on the femtosecond time scale.

* Financial support by the DFG (award BU 913 / 13) and the Deutsche Telekom AG is gratefully acknowledged.

DF 11.6 Fri 12:50 MÜL Elch

Suppression of optical damage in lithium niobate crystalsby thermo-electic oxidization* — •Matthias Falk, Theo Woike, and Karsten Buse — Physikalisches Institut, Wegelerstr. 8, 53115 Bonn

Lithium niobate crystals are a promising material for nonlinear optics. For applications, e.g. frequency mixing, undesired refractive index changes caused by intense light are a serious problem (”optical damage”). This effect originates from a light-induced redistribution of electrons between defect centers, a build-up of space-charge electrical fields, and finally the electro-optic effect. A method to suppress the optical damage is to remove all electrons, that occupy impurity sites and crystal defects, i.e. a perfect oxidization of the crystal is needed. We discovered a thermo-electric treatment, that provides an extremely strong oxidization of the crystals. Quantitative measurements of the optical damage are performed. Thermo-electrically oxidized crystals are much more robust than untreated crystals.

*Financial support of the DFG (FOR 557) and the Deutsche Telekom AG is gratefully acknowledged.