DF 10: Nano- and microstructured dielectrics

Time: Wednesday 10:15–13:00 Location: MÜL Elch

Invited Talk DF 10.1 Wed 10:15 MÜL Elch

Ferroelectric domains: Investigation, fabrication, and applications — •Elisabeth Soergel — Physikalisches Institut, Universität Bonn

Ferroelectric materials posses a permanent spontaneous polarization that can be reversed by the application of an electric field. In this way, ferroelectric domain patterns are fabricated which can be used for various applications ranging from efficient frequency conversion to high-density data storage. Although known since more than half a century, there are still open questions regarding ferroelectrics: For example the physical properties of the domain walls are still under discussion.

I will introduce ferroelectric materials and their applications, the fabrication of domain patterns and their investigation by piezoresponse force microscopy will constitute the principal part in my talk. Finally, as an example for a new application of ferroelectric domains, I will outline how they can be used to fabricate *m-sized single crystal structures suitable for photonic micro-components.

5 min. break

DF 10.2 Wed 11:00 MÜL Elch

Lithiumniobat-Nanokristall-Hybridsysteme für optisch-nichtlineare Prozesse — •Bastian Knabe, David Dung, Matthias Ackermann, Daniel Schütze und Karsten Buse — Physikalisches Institut, Universität Bonn, Wegelerstr. 8, 53115 Bonn

Wir untersuchen die optischen Eigenschaften ferroelektrischer Lithiumniobat-Nanokristalle, insbesondere ihre optische Nichtlinearität, mittels kohärenter Frequenzkonversion. Diese Nanokristalle ermöglichen es optische Nichtlinearität in isotrope und amorphe Trägermaterialen einzubringen, wie z. B. Polymere oder Flüssigkeiten. Dabei sind sie, durch ihre Kristallinität, stabiler als organische Chromophore. Die nichtlineare Antwort einzelner Lithiumniobat-Partikel mit 50 nm Durchmesser wird polarisationsabhängig studiert. Es deutet sich an, dass die nichtlinearen Koeffizienten so groß wie die des Volumenkristalls sind.

*Wir danken der Deutschen Forschungsgemeinschaft (BU 913/21) und der Deutschen Telekom AG für finanzielle Unterstützung.

DF 10.3 Wed 11:20 MÜL Elch

Lithiumniobat-Nanopartikel für optische Anwendungen* — •Matthias Ackermann, Bastian Knabe, Daniel Schütze und Karsten Buse — Physikalisches Institut, Universität Bonn, Wegelerstraße 8, 53115 Bonn

Die Kombination von Lithiumniobat-Nanopartikeln mit Trägermaterialien wie z. B. Flüssigkeiten verspricht, Hybridmaterialien mit variablen ferroelektrischen und optischen Eigenschaften zu erzeugen. Dafür ist es notwendig, die Partikel ausrichten zu können und den Ausrichtungsmechanismus zu verstehen. Wir betrachten die Partikelorientierung in elektrischen Feldern, die durch induzierte und permanente Dipolmomente bestimmt wird. Bei einer Feldstärke von 3 kV/mm richten sich 80 Prozent der Partikel in einem Kegel mit einem Öffnungswinkel von 70° aus. Durch Ausnutzung des pyroelektrischen Effekts, also mittels Temperaturänderungen, wird die Größe der permanenten Dipolmomente beeinflusst und damit das Ausrichtungsverhalten der Partikel manipuliert.

*Wir danken der Deutschen Forschungsgemeinschaft (BU 913/21) und der Deutschen Telekom AG für finanzielle Unterstützung.

DF 10.4 Wed 11:40 MÜL Elch

Nonlinear Optics on Inversion-Domain Nanostructures in $Fe_2O_3(ZnO)_m$ — •Thomas Lottermoser[1], Simon Eichhorn[2], Werner Mader[2], and Manfred Fiebig[1] — [1]HISKP, University of Bonn, Germany — [2]Institute of Inorganic Chemistry, University of Bonn, Germany

We prepared surfaces of ZnO single crystals with thin layers of Fe_2O_3 on top. Diffusion of Fe^{3+} ions generates a layer with the composition $Fe_2O_3(ZnO)_m$ with small $m \approx 15$ at the surface of the ZnO single crystal. Investigation with transmission electron microscopy reveals that in this layers regular patterns of triangular shaped ZnO inversion domains on a nanometer scale are formed by self organization. Additional measurements with electron energy loss spectroscopy show that the Fe^{3+} ions form monolayers at the domain boundaries while the domains itself consist of pure ZnO. The size of the inversion domains can be tuned by controlling the concentration of the Fe^{3+} ions.

These type of nano-structured materials has the potential to exhibit new magneto-optical properties that are tunable in various ways, e.g., by the Fe^{3+} concentration, the structure size and orientation of the iron-'doped' layers. The periodic and spatial inversion symmetry breaking nature of this compounds makes nonlinear optics an obvious characterization tool. Here, we report on our first experiments using optical second-harmonic generation (SHG). We observed an enhancement of the SHG intensity by about one order of magnitude compared to bulk ZnO. Polarization analysis indicates that this enhancement can be attributed to the meta-structure of the doped layers.

DF 10.5 Wed 12:00 MÜL Elch

Computation of dielectric permittivities: comparison of different crystal structures, amorphous systems and nanocomposites — •Andreas Leschhorn and Herbert Kliem — Universität des Saarlandes , Lehrstuhl für Grundgebiete der Elektrotechnik , Campus A5 1 , 66041 Saarbrücken

We investigate the influence of the microscopic structure on the dielectric properties of a dielectric material. To that, effective dielectric permittivities of a system of induced dipoles are simulated numerically on a microscopic scale by calculating the local electric fields. In contrast to macroscopic calculations the method of local fields considers all dipolar fields within the sample taking account of the electrodes by the method of images. In this way all depolarizing fields in inhomogeneous samples are regarded.

Results for amorphous dielectrics and materials with different crystal structures are compared. For example, we found that a fcc structure leads to a higher relative permittivity than a sc lattice at the same parameters. Here the product $n\alpha$ of particle density n and polarizability α has been kept constant. Another example is the calculation of the permittivity of a bcc structure which also exhibits a higher value than a comparable sc structure. Also the permittivity of dielectrics consisting of atoms with different polarizabilities is computed. Furthermore, nanocomposites are investigated, with regions of different structures and species of atoms.

DF 10.6 Wed 12:20 MÜL Elch

Advancement of $Ba_{0.6}Sr_{0.4}TiO_3$ varactors by MgO micro dots — •Stefan Hirsch[1], Yuliang Zheng[2], Shunyi Li[1], Philipp Komissinskiy[1], Andreas Klein[1], Rolf Jakoby[2], and Lambert Alff[1] — [1]TU Darmstadt, Institut für Materialwissenschaft, Darmstadt, Germany — [2]TU Darmstadt, Institut für Elektrotechnik, Darmstadt, Germany

We report on the improvement of high frequency losses of Pt / $Ba_{0.6}Sr_{0.4}TiO_3$ / Pt thin film parallel plate varactors with MgO micro dots produced by pulsed laser deposition. Varactors are measured at frequencies from 1 MHz to 10 GHz. At 1 MHz losses are reduced by 30 % by using MgO micro dots in the BSTO layer. The figure of merit of the varactor is increased by 25 %. The influence of size and geometry of the micro dots on the varactor properties is investigated. The authors thank DFG GK 1035.

DF 10.7 Wed 12:40 MÜL Elch

On the Interpretation of Small Angle Diffraction Experiments on Opaline Photonic Crystals — •Frank Marlow, Mulda Muldarisnur, and Parvin Sharifi — MPI für Kohlenforschung, Kaiser-Wilhelm-Platz 1

Artificial opals are the most important approach to self-assembled photonic crystals. They have been characterized optically and by electron microscopy, but detailed structural information is still missing. Classical methods fail because of the small scattering angles. Recently, interesting structure investigations with neutron reactor sources and synchrotrons have been published. Theses studies reveal a surprisingly high degree of order in the scattering pattern but also some unexpected scattering features.

In this contribution we will add two points to the current interpretation of the diffraction data. First, the exclusion of the allowed (002) diffraction peaks by a small atomic form factor is not fully justified and, second, surfaces scattering has to be included as a possible source for the diffraction peaks. Our neutron diffraction data indicate that surface scattering is the main reason for the lowest detected order in the diffraction patterns.