KR 1: Various Topics I (with DF)

Nano- and microstructured dielectrics / thin films
Optical and nonlinear optical properties, photonic
High- and low-k-dielectrics
Dielectric surfaces and interfaces

Chair: Martin Diestelhorst

Time: Monday 9:30–12:30 Location: GER 37

KR 1.1 Mon 9:30 GER 37

Octahedral tilt nanostructure in bismuth-based relaxors — •Wolfgang Donner[1], Florian Pforr[1], Marton Major[1], Uwe Stuhr[2], and Bertrand Roessli[2] — [1]Technische Universität Darmstadt, Germany — [2]Paul Scherrer Institut, Switzerland

Among the lead-free ferroelectrics, (1-x)$Na_{1/2}Bi_{1/2}TiO_3$-x $BaTiO_3$ is one of the most promising material systems. The dielectric properties around the morphotropic phase boundary at x = 0.06 are comparable to those of commonly used lead-containing ferroelectrics. However, the atomistic mechanisms leading to the relaxor properties are still unclear.

We performed a diffuse neutron scattering study in order to reveal the nanostructure of the octahedral tilt disorder of the oxygen anions. Our results show the coexistence of multiple tilt systems over a wide temperature range and a strong temperature dependence of the respective domain sizes. On this basis, we propose a model of the nanostructure featuring chemically pinned tetragonal platelets in a rhombohedral matrix. The different tilt domains are separated by a cubic intermediate phase. Furthermore, a strong temperature dependence of the planar defect density was found, which peaks at the depolarization temperature. These features react strongly to the application of an external electric field and their temperature dependence is clearly correlated with the dielectric permittivity.

KR 1.2 Mon 9:50 GER 37

Robust in-plane ferroelectricity over room temperature in atomic-thick SnTe — •Kai Chang[1,2], Junwei Liu[3,2], Haicheng Lin[2], Na Wang[2], Kun Zhao[2], Yong Zhong[2], Xiaopeng Hu[2], Wenhui Duan[2], Liang Fu[3], Qi-Kun Xue[2], Xi Chen[2], Shuai-Hua Ji[2], and Stuart Parkin[1] — [1]NISE, Max-Planck Institute of Microstructure Physics, Weinberg 2, Halle 06120, Germany — [2]State Key Laboratory of Low-Dimensional Quantum Physics, Department of Physics, Tsinghua University, Beijing 100084, China — [3]Department of Physics, Massachusetts Institute of Technology, Cambridge, MA 02139, USA

Stable ferroelectricity with high transition temperature in nanostructures is needed for miniaturizing ferroelectric devices. Here, applying molecular beam epitaxy (MBE) and variant temperature scanning tunneling microscopy (VT-STM), we have studied the stable in-plane spontaneous polarization in atomic-thick SnTe, down to a 1-unit cell (UC) limit. The ferroelectric transition temperature T_c of 1-UC SnTe film is greatly enhanced from the bulk value of 98 K [1] and reaches as high as 270 K. Moreover, 2- to 4-UC SnTe films show robust ferroelectricity at room temperature [2]. Recent high temperature STM experiments show that the ferroelectricity of 2- and 3-UC SnTe films persists even up to 380 K, comparable with the classical perovskite ferroelectric $BaTiO_3$. [1] M. Iizumi et al., J. Phys. Soc. Jpn. 38, 443 (1975). [2] K. Chang et al., Science, 353, 274 (2016).

KR 1.3 Mon 10:10 GER 37

Flexoelectric impact on the polarization switching dynamics in thin ferroelectric films — •Ivan Vorotiahin[1,2], Anna Morozovska[2], Eugene Eliseev[3], and Yuri Genenko[1] — [1]Institut für Materialwissenschaft, Technische Universität Darmstadt, Jovanka-Bontschits-Str. 2, 64287 Darmstadt, Deutschland — [2]Institute of Physics, National Academy of Sciences of Ukraine, 46, pr. Nauky, 03028 Kyiv, Ukraine — [3]Institute for Problems of Materials Science, National Academy of Sciences of Ukraine, Krjijanovskogo 3, 03142 Kyiv, Ukraine

Flexoelectric effect (or flexocoupling) is one of the properties of solid state materials that couples the gradient of electric polarization with the gradient of mechanical strain. It exists virtually in all solids, but has so small magnitude that it cannot be effectively observed in most of them. However, with the reduction of dielectric film thickness, it might obtain a significant influence on the properties of dielectrics.

A process of domainless polarization switching in the tetragonal ferroelectric $BaTiO_3$ has been modelled, using relations of Landau-Ginzburg mean-field theory. Static distributions of electric polarization and other relevant quantities, including electrostatic potential, donor and electron concentrations, as well as dynamics of polarization switching are obtained and analysed. A role of the flexocoupling is estimated for both statics and dynamics. It appeared, that whilst having a negligible influence on the static distributions, flexocoupling can remarkably affect polarization switching times and the values of critical fields under which the switching occurs.

KR 1.4 Mon 10:30 GER 37

Crystalline high-pressure phases in the Bi–Co system — •Leonore Wiehl[1], Shrikant Bhat[1], Iliya Radulov[1], Konstantin Skokov[1], Michael Dürrschnabel[1], Leopoldo Molina-Luna[1], Sabrina Sicolo[1], Leopold Diop[1], Dmitriy Karpenkov[1], Norimasa Nishiyama[2], Hans-Joachim Kleebe[1], Karsten Albe[1], Ralf Riedel[1], and Oliver Gutfleisch[1] — [1]Fachbereich Material- und Geowissenschaften, Technische Universität Darmstadt, Darmstadt 64287, Germany — [2]DESY, Hamburg 22607, Germany

$RECo_5$ (RE = rare-earth) compounds are known as materials with high magnetocrystalline anisotropy [1]. They crystallize in the $CaCu_5$ structure type, space group $P\frac{6}{m}mm$. On searching for RE-free magnetic materials, which could replace the classical NdFeB magnets, MCo_5 type materials were considered as promising candidates. The existence of crystalline MCo_5 and MFe_5 (M = Bi, Ca, Zr) phases and their magnetic properties were explored. Here we report on the Bi-Co system. Samples with starting compositions 5:1 & 1:1 were subjected to high pressure (15.6 GPa) and temperature (900°C) in a multianvil press at DESY, Hamburg. The recovered products were characterized by X-ray diffraction with synchrotron radiation (ALS, Berkeley), SEM/EDX, and magnetic measurements. They proved to be a mixture of several crystalline phases, with the most prominent phase Bi_3Co [2]. The search for new phases was complemented by DFT calculations.

Financial support by the excellence program LOEWE "RESPONSE" is gratefully acknowledged. [1] K. Strnat et al., J. Appl. Phys. 38 (1967) 1001 [2] S. Tencé et al., J.Phys.: Condens. Matter 26 (2014) 395701

20 min. break

KR 1.5 Mon 11:10 GER 37

Tunability of polymeric whispering gallery mode micro-lasers — •Tobias Siegle[1], S. Schierle[1], S. Krämmer[1], A. M. Flatae[1,2], M. Remmel[1], B. Richter[3], S. Nocentini[2], C. Parmeggiani[2], H. Zeng[2], M. Burresi[2], D. Wiersma[2], S. F. Wondimu[4], P. Schuch[4], C. Koos[4], and H. Kalt[1] — [1]Institute of Applied Physics, KIT, Karlsruhe, Germany — [2]European Laboratory for Non-Linear Spectroscopy, Sesto Fiorentino, FI, Italy — [3]Zoological Institute, KIT — [4]Institute of Microstructure Technology, KIT

Realizing tunable micro-optical devices, e.g., filters or lasers is a challenging task. A possibility is to use mechanically flexible structures. However, often lithographic fabrication and the rigidity of conventional materials induce an inflexibility. Here, we demonstrate that the flexibility of polymers can be utilized for widely tunable photonic circuits.

We review the fabrication of polymeric whispering gallery mode (WGM) micro-lasers and show their superiority in post-fabrication configuration tuning. The first example demonstrates resonance tuning by exploiting liquid crystal elastomers (LCE). When integrated into the cavity, a LCE cylinder can function as a micro-actuator modifying the resonator diameter and hence tuning the WGM resonances.

Polymers allow substrate-independent fabrication based on direct laser writing. As a second example we present the flexible coupling of WGM cavities structured on elastomer substrates. Reducing the inital inter-cavity gap through deformation of the substrate leads to the formation of photonic molecules. Tunable coupling is verified by exponential trends in the intensities of arising super-modes.

KR 1.6 Mon 11:30 GER 37

Interface engineering in all-oxide $Ba_xSr_{1-x}TiO_3$ thin-film varactors with highly conducting $SrMoO_3$ electrodes — •Patrick Salg[1], Aldin Radetinac[1], Dominik Walk[2], Holger Maune[2], Rolf Jacoby[2], Philipp Komissinskiy[1], and Lambert Alff[1] — [1]Institute of Materials Science, TU Darmstadt, Germany — [2]Institute for Microwave Engineering and Photonics, TU Darmstadt, Germany

We present epitaxial varactor heterostructures utilizing highly conducting oxide $SrMoO_3$ bottom electrodes with a room-temperature resistivity of 30 $\mu\Omega$cm [1] grown by pulsed laser deposition using $SrMoO_4$ targets. During thin film synthesis, highly reductive conditions are essential to achieve a Mo^{4+} state in the $SrMoO_3$ thin film. In contrast to the growth conditions of $SrMoO_3$, the growth of $Ba_xSr_{1-x}TiO_3$ films requires a high oxygen partial pressure of 1.5 mTorr. In order to prevent oxidation of the underlying $SrMoO_3$ layers during growth of $Ba_xSr_{1-x}TiO_3$, a $SrTiO_3$ layer was grown between $SrMoO_3$ and $Ba_xSr_{1-x}TiO_3$. The effectivity of this $SrTiO_3$ interlayer as an oxygen diffusion barrier was investigated by X-ray diffraction (XRD) and X-ray photoelectron spectroscopy (XPS). The use of a $SrTiO_3$ interlayer allows a successful epitaxial growth of varactor heterostructures with high electric tunability of up to 80 % and low losses at microwave frequencies.

[1] A. Radetinac *et al.*, *Highly conducting $SrMoO_3$ thin films for microwave applications*, Appl. Phys. Lett. **105**, 114108 (2014).

KR 1.7 Mon 11:50 GER 37

The pyroelectric coefficient of free standing GaN grown by HVPE — •Sven Jachalke[1], Patrick Hofmann[2], Gunnar Leibiger[3], Frank S. Habel[4], Erik Mehner[1], Tilmann Leisegang[1,4], Dirk C. Meyer[1], and Thomas Mikolajick[2,5] — [1]Institute for Experimental Physics, TU Bergakademie Freiberg, Leipziger Str. 23, 09599 Freiberg, Germany — [2]NaMLab gGmbH, Nöthnitzer Str. 64, 01187 Dresden, Germany — [3]Freiberger Compound Materials GmbH, Am-Junger-Löwe-Schacht 5, 09599 Freiberg, Germany — [4]Samara National Research University, Moskovskoye Shosse 34, Samara 443086, Russia — [5]Institute for Semiconductors and Microsystems, TU Dresden, Nöthnitzer Str. 64, 01187 Dresden, Germany

Here, we present the first temperature dependent measurements of the pyroelectric coefficient of free standing, and strain free GaN grown by hydride vapour phase epitaxy (HVPE). The Sharp-Garn method is applied to extract the pyroelectric coefficient from the electrical current response of the crystals subjected to a sinusoidal temperature excitation in a range of 0°C to 160°C. To avoid compensation of the pyroelectric response by an internal conductivity, insulating GaN crystals were used by applying carbon, manganese and iron doping during HVPE growth. Different pyroelectric coefficients observed at room temperature due to the doping correlate well with the change of the lattice parameter c. The obtained data is compared to previously published theoretical and experimental values of thin film GaN and discussed in terms of a strained lattice.

KR 1.8 Mon 12:10 GER 37

Confocal Raman analysis of diffusion profiles in ion exchanged waveguides in PPKTP — •Julian Brockmeier, Michael Rüsing, Christof Eigner, Laura Padberg, Gerhard Berth, Christine Silberhorn, and Artur Zrenner — Department Physik, Universität Paderborn, 33098 Paderborn, Germany

KTP presents a promising material system for integrated quantum optical applications. Integrated quantum optical devices require the fabrication of waveguides, which can be achieved in this material via the ion exchange of Potassium by Rubidium. An optimized fabrication of these structures requires a detailed understanding of the induced changes in the material structure, such as the diffusion profile. Here the confocal Raman imaging technique presents one of the foremost methods for a three dimensional spatial analysis of the material properties. Within this work periodically poled KTP (PPKTP) waveguides have been visualized by Raman imaging. For a more detailed analysis of the induced material changes the data processing has been improved and now allows to map the changes of the FWHM shift and intensity of peaks in the Raman spectra. Based on this optimized method, spectral features have been identified, which are sensitive to the concentration of the ion exchanged Rubidium.