DF 13: Poster II

Time: Wednesday 15:00–17:30 Location: Poster E

DF 13.1 Wed 15:00 Poster E

Impedance spectroscopy of printable electrolytes: calculation of frequency dependent effective capacitance — •Anna Stoesser, Robert Kruk, Nina Schweikert, Subho Dasgupta, and Horst Hahn — Institute of Nanotechnology, Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany

In this work firstly presented an ink-jet printed and electrochemically-gated inorganic oxide based FET where indium tin oxide(ITO) nanoparticles compose the active channel of the device. Due to extremely effective gating possible by the polymer electrolytes which closely follows the roughness of the nanoparticulate channel, we obtain a large value of field-effect mobility. However, a generally expressed concern is that the electrolyte-gated device speed is limited by the ionic mobility of the electrolyte. Therefore, we have investigated the conductivity and frequency dependent polarizability of the printable grade of solid polymer electrolyte using electrical impedance spectroscopy. The frequency-dependent effective capacitance of ITO electrodes is calculated. It is shown that if cut-off frequency is defined as $1/2\pi$RC then the value of cut-off frequency for our electrolyte can be as high as 40 kHz when the thickness of the printed electrolyte is about 100 nm. Electrolyte conductivity can be foreseen with regular optimization, therefore, it may be concluded that finally electrolytes would not limit the attainable max. speed for the device-type presented here. Thus, an improvement of resolution and positional accuracy in the printing process is believed to be the key in this case to increase the speed of such transistors from kHz to MHz regime.

DF 13.2 Wed 15:00 Poster E

Complex Impedance Model for Metal/Amorphous Semiconductor/Semiconductor (MASS) heterostructures — •Julian Alexander Amani, Tristan Koppe, Marc Brötzmann, Hans Hofsäss, and Ulrich Vetter — Georg-August-Universität Göttingen, II. Physikalisches Institut, Friedrich-Hund-Platz 1, 37077 Göttingen, Germany

A complex impedance model for MASS heterostructures is developed and compared with voltage dependent impedance spectroscopy measurements of the metal/ta-C/Si system.

The dominant dc conduction process of ta-C is hopping of carriers and the ac conductivity follows the "universal power law" $\sigma \propto \omega^s$ with $s \approx 0.8$. Hence, ta-C is an exemplary disordered material enabling us to investigate the dielectric properties of this material class.

An equivalent circuit considering the dielectric properties and voltage dependence of an disordered material is presented and compared with complex impedance measurements of ta-C.

Metal/ta-C/Si systems with weakly doped silicon substrates show a rectifying behaviour. Adding a depletion layer equivalent circuit to the model gives a good agreement with the data obtained for measurements of those samples.

DF 13.3 Wed 15:00 Poster E

Frequency dependency of the complex elastic stiffnesses of some ferroelectric ceramics — •Ulrich Straube and Horst Beige — Institute of Physics, University Halle, Germany

Ferroelectric ceramic materials exhibit pronounced temperature dependencies of their dielectric properties. The dielectric spectroscopy is used in a broad frequency region with standard equipment to analyze the dielectric material properties. The elastic spectroscopy allows the determination of the elastic stiffness frequency dispersion, but rather different measurement techniques have to be applied for this purpose.

Examples of stiffness determinations with pulse ultrasound at 5 MHz and dynamical mechanical analysis in a frequency range of 0.01 Hz up to 10 Hz and temperatures from 170 K up to 420 K are presented. The investigation are performed using lead zirconium titanate and barium titanate stannate ceramics.

DF 13.4 Wed 15:00 Poster E

Electrical and Structural properties of thermally transformed high-k dielectric $Ba_{0.7}Sr_{0.3}O$ thin films on p-Si(100) — •Shariful Islam[1], Dirk Müller-Sajak[1], Alexandr Cosceev[2], Herbert Pfnür[1], and Karl R. Hofmann[2] — [1]Leibniz-Universität Hannover, Inst. f. Festkörperphysik — [2]Leibniz-Universität Hannover, Bauelemente der Mikro- und Nanoelektronik

Crystalline thin films of $Ba_{0.7}Sr_{0.3}O$ were tested as a high-k dielectric material deposited on p-Si(100) substrate. The valence band offset and conduction band offset between p-Si(100) and $Ba_{0.7}Sr_{0.3}O$ was ∼2.3eV and ∼1.0eV respectively.

It was observed that $Ba_{0.7}Sr_{0.3}O$ was stable up to 400^0C. At higher temperature silicon from the substrate diffuses into the oxide and forms a silicate, as found by XPS. SPA-LEED measurements showed that the silicate phase is amorphous once the reaction is completed (550^0C). Electron Energy Loss Spectroscopy (EELS) of this silicate phase revealed a higher band gap (∼6eV) compared to crystalline $Ba_{0.7}Sr_{0.3}O$ (∼4.3eV). XPS measurements prove that the silicate phase is more stable in ambient conditions than $Ba_{0.7}Sr_{0.3}O$. Extrapolations of dielectric constants at various conditions predict that also this silicate may be usable as a high-k dielectric.

DF 13.5 Wed 15:00 Poster E

Oxygen Related Defects and the Reliability of High-κ Dielectric Films in Field Effect Transistors: An Investigation beyond Density Functional Theory — •Ebrahim Nadimi[1,2], Rolf Öttking[2], Philipp Plänitz[2], Martin Trentzsch[3], Torben Kelwing[3], Rick Carter[3], Christian Radehaus[2], and Michael Schreiber[1] — [1]Institut für Physik, Technische Universität Chemnitz, D-09107, Chemnitz Deutschland — [2]GWT-TUD GmbH Geschäftsstelle Chemnitz, Annaberger Str. 240, 09125 Chemnitz, Deutschland — [3]Global Foundries, D-01109, Dresden Deutschland

The introduction of high-κ (HK) gate dielectrics and metal gate in silicon field effect transistors has created many challenges amongst others the reliability of the gate dielectric. Bias temperature instability (BTI) and stress induced leakage current (SILC) are the key degradation characteristics. The community agrees about the important role of oxygen related defects in the degradation process of HK dielectrics. In this work, ab initio methods are applied to investigate oxygen vacancies as the most important defects in Hf-based dielectrics. Atomic structure, formation energy and electronic structure of these defects are investigated at the level beyond density functional theory using the exact-exchange hybrid functional. We also propose a defect generation mechanism, which could explain the relatively low defect activation energies obtained experimentally. The passivation of the oxygen vacancies by means of different dopants is also investigated and the results are compared. This work was supported by the Sächsische AufbauBank under HEIKO project Grant No. 1000648806/626.

DF 13.6 Wed 15:00 Poster E

Restoring the k value in carbon depleted ultra low k surfaces by the silylation of hydroxyl groups with N-trimethylsilylimidazole and dimethyldiacetoxysilane. — Oliver Böhm[1,2], Roman Leitsmann[2], Philipp Plänitz[2], •Christian Radehaus[2], Matthias Schaller[3], and Michael Schreiber[1] — [1]Institut für Physik, Technische Universität Chemnitz, 09107 Chemnitz — [2]GWT-TUD GmbH, Material Calculation, Annaberger Str. 240, 09125 Chemnitz, Germany — [3]GLOBALFOUNDRIES Dresden Module Two GmbH & Co. KG, Germany

To reduce the resistance capacitance delay of integrated circuits, materials with a small k-value - so called ultra low k materials (ULK) - are used as interlayer dielectrics. An important fabrication step in the semiconductor industry is the etching of the trenches, which leads to a carbon depletion and a formation of hydroxyl groups in the ULK material. This results in a moisture uptake and hence an increased k value. To restore the k value, a silylation of the hydroxyl groups can be done. We investigate the silylation of hydroxyl groups by the chemicals N-trimethylsilylimidazole (TMSIM) and dimethyldiacetoxysilane (DMDAS). In particular we use density functional theory to study the different reaction mechanisms. To determine the minimum energy reaction paths as well as transition states, we use the nudged elastic band method. We found significant differences in the activation barriers, reaction energies and the formation of pre and post reaction complexes of TMSIM and DMDAS.

DF 13.7 Wed 15:00 Poster E

Verzögerte Kristallisation ultradünner Gd2O3 Schichten auf Si(111) beobachtet mittels in-situ Röntgenbeugung —

•Michael Hanke, Vladimir Kaganer, Oliver Bierwagen, Michael Niehle und Achim Trampert — Paul-Drude-Institut Für Festkörperelektronik, Hausvogteiplatz 5-7, D-10117 Berlin

We studied the early stages of Gd2O3 epitaxy on Si(111) in real time by synchrotron-based in-situ high resolution x-ray diffraction and by reflection high-energy electron diffraction. A comparison between model calculations and the measured x-ray scattering, and the change of reflection high-energy electron diffraction patterns both indicate that the growth begins without forming a threedimensional crystalline film since the very first monolayers are not in perfect registry among each other. A cubic bixbyite structure of Gd2O3 appears only after a few monolayers of deposition.

DF 13.8 Wed 15:00 Poster E

Effect of high-frequency on etching of SiCOH films in CHF3 dual-frequency capacitively coupled plasmas — •Yijun Xu — II. Physikalisches Institut, Universität Göttingen, Friedrich- Hund-Platz 1, 37077 Göttingen, Germany — School of Physics Science and Technology, Jiangsu Key Laboratory of Thin Films, Soochow University, Suzhou 215006, People's Republic of China

The effect of high-frequency (HF) frequency on etching characteristics of SiCOH films in a CHF3 dualfrequency capacitively couple plasma driven by 13.56 MHz/2 MHz, 27.12 MHz/2 MHz or 60 MHz/2 MHz sources was investigated in this work. The surface structure of the films after etching and the CHF3 discharge plasma were characterized. The increase of HF frequency reduced the critical HF power for the etching, suppressed the C:F deposition at the surface of etched films, and improved the etching of SiCOH films. The improvement of etching was attributed to the increase of ions energy and F concentration at high HF frequency.

DF 13.9 Wed 15:00 Poster E

Ionic-Liquid Promoted Crystalline β Phase in Polyvinylidene Fluoride Nanofilms — •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

Up to now it is immensely difficult to obtain sub-micrometer thin films of polyvinylidene fluoride (PVDF) in the ferroelectric β phase. We present a novel way to achieve β-phase PVDF sub-micrometer thin films that were obtained by spin coating from a solution containing a small portion of the ionic liquid 1-ethyl-3-methylimidazolium nitrate [EMIM][NO_3]. After drying and annealing at temperatures above 100 °C the films showed strong ferroelectric hysteresis with a remanent polarization of maximum 76 mC/m^2 and a coercive field of 200 MV/m. The pyroelectric coefficient was measured to 17 μC/(m^{2}K) at 30 °C. The impact of [EMIM][NO_3] on the crystallization behavior of PVDF, with particular attention to the occurrence and ratio of the ferroelectric β phase, was confirmed using infrared spectroscopy and X-ray diffraction. The surface morphology was determined using atomic force microscopy and scanning electron microscopy. They show that under the influence of ionic liquids no α-phase spherulitic crystallites are visible and the size of the crystalline regions decreases from about 10 to 2 μm. The ferroelectric β phase is assumed to be promoted by Coulomb interaction between NO_3^- anions and the molecular dipoles of PVDF.

DF 13.10 Wed 15:00 Poster E

Correlation between structural and ferroelectric properties of $BaTiO_3$ thin films — •Anja Herpers[1], Regina Dittmann[1], Daesung Park[2], Joachim Mayer[2], and Rainer Waser[1] — [1]Peter Grünberg Institut 7, Electronic Materials, Forschungszentrum Jülich GmbH, 52428 Jülich — [2]Gemeinschaftslabor für Elektronenmikroskopie, RWTH Aachen University, Ahornstraße 55, 52074 Aachen

Point as well as extended defects in ferroelectric thin films are expected to have a strong influence on their ferroelectric properties. We investigated in detail the influence of growth conditions on the crystal structure of $BaTiO_3$ (BTO) thin films and its influence on the ferroelectric hysteresis loops and the leakage currents.

We performed detailed experiments to distinguish between the different types of defects by varying the pulsed laser deposition (PLD) parameters and the post annealing conditions. Furthermore, systematic studies of the influence of the growth kinetics on the oxygenation state of the thin films were performed and related to defect chemistry models. These investigations were complemented by high resolution transmission electron microscopy analysis of the atomic structure of the thin films and different types of electrode interfaces.

We succeeded to obtain closed hysteresis loops with a remanent polarization of 30μC/cm^2 for a 30nm thick BTO thin films stacked between $SrRuO_3$ and Pt electrodes.

DF 13.11 Wed 15:00 Poster E

Identification of electronic defect states in perovskite oxides — •Elke Beyreuther, Jana Becherer, Stefan Grafström, and Lukas M. Eng — Institut für Angewandte Photophysik, Technische Universität Dresden, D-01062 Dresden, Germany

Perovskite oxide heterojunctions such as the $LaAlO_3/SrTiO_3$ interface have attracted enormous scientific interest due to their unexpected and tunable physical properties but equally because of their technological promises with respect to all-oxide integrated nanodevices. Among other unresolved issues, the detailed physical understanding of the electronic defect structure at these interfaces is indispensable.

We adopt here the surface photovoltage (SPV) method to inspect the surfaces and interfaces of $SrTiO_3$ (STO), which serves as our model perovskite. SPV has already substantially contributed to the analysis of III-V and II-VI semiconductor interfaces, both through spectrally and temporally resolved investigations. Here, we investigated the STO system by acquiring static and transient SPV data over a wide wavelength range and for various light intensities. This allowed us to identify and quantify defect states across the STO band gap, and to derive parameters of distinct states such as optical cross sections and time constants. The feasibility and general possibilities of applying SPV for the analysis of perovskite heterostructures will be discussed.

DF 13.12 Wed 15:00 Poster E

Raman spectroscopic investigations of $CoFe_2O_4$ and $NiFe_2O_4$ epitaxial sub-micron structures — •Cameliu Himcinschi[1], Ionela Vrejoiu[2], and Andreas Talkenberger[1] — [1]TU Bergakademie Freiberg, Institute of Theoretical Physics, D-09596 Freiberg — [2]Max Planck Institute of Microstructure Physics, Weinberg 2, D-06120 Halle

$CoFe_2O_4$(CFO) and $NiFe_2O_4$(NFO) are insulating ferrimagnetic spinel oxides that are attractive for application in magneto-electric oxide heterostrucuture devices. CFO and NFO epitaxial thin films were grown on Nb-doped $SrTiO_3$(100) substrates by pulsed-laser deposition. For the fabrication of ordered arrays of sub-micron structured CFO and NFO a SiN stencil mask was used. In this work we present an investigation of the CFO and NFO thin films and structures by Raman spectroscopy. The Raman spectra of CFO and NFO thin films indicate the formation of a spinel structure with symmetry lower than the cubic inverse spinel one. The assignment of the Raman modes was done by employing different polarization scattering configurations. Similar spectra were measured also for the structured arrays suggesting the preservation of the structure observed in the epitaxial thin films. The degree of disorder in the cation distribution in the octahedral sites is discussed based on the broadening of the Raman peaks.
This work is supported by the German Research Foundation DFG HI 1534/1-1.

DF 13.13 Wed 15:00 Poster E

Production of sub-μm to cm structures on fused silica by laser-induced front side etching using self-regenerating adsorber layer (SAL-LIFE) — •Pierre Lorenz, Martin Ehrhardt, and Klaus Zimmer — Leibniz-Institut of Surface Modification, Permoserstr. 15, 04318 Leipzig, Germany

Laser-induced front side etching (LIFE) is a method for production of 3D structures in dielectric materials over a wide lateral and vertical size range. Within this study the continuous laser-induced front side etching of fused silica with self-regenerating adsorber layers (SAL-LIFE) is presented using nanosecond KrF excimer laser radiation (λ = 248 nm, Δt_p = 25 ns). The sample was positioned in a vacuum chamber which was loaded by toluene gas and the gas phase induced the self-regenerating adsorber layer on the sample surface. For the etching process, the laser beam was focused onto the sample surface through the gas. The SAL-LIFE method allows the production of well-defined nm-precision etched surface structures over a large etching depth range from nm to a few hundred μm as well as a large lateral etching region from sub-μm to a few cm. A surface roughness down to 1 nm can be achieved. The treated fused silica was analysed with microscopic (white light interferometry, scanning electron microscopy (SEM)) and spectroscopic methods (X-ray photoelectron spectroscopy (XPS)).

DF 13.14 Wed 15:00 Poster E

Correlation between size evolution and optical properties of ion beam synthesized silver nanoclusters in lithium niobate — •Jura Rensberg, Steffen Milz, Carsten Ronning, and Werner Wesch — Institut für Festkörperphysik, Friedrich-Schiller-Universität Jena, Max-Wien-Platz 1, 07743 Jena, Germany

Metal nanoclusters embedded in various dielectrics gained a lot of interest for plasmonic applications like optical filters or plasmonic waveguides in the last two decades. Because of its unique electro-optical and nonlinear optical properties, lithium niobate ($LiNbO_3$) is one of the most important materials for integrated optics. Noble metals like silver are of particular relevance for cluster formation in $LiNbO_3$, because of its distinctive surface plasmon resonance (SPR) located in the visible spectral range. We have implanted 380 keV Ag^+ ions up to an ion fluence of $1x10^{17}$ cm^{-2} into $LiNbO_3$ at room temperature and 673 K. Isochronal rapid thermal annealing as well as isothermal annealing were performed in the temperature range of 573 K to 1173 K, resulting in the formation of silver nanoclusters with different size distributions and a reduction of irradiation damage. The samples were analyzed by means of RBS-channeling, and STEM as well as optical spectroscopy. The correlation between structural and optical properties will be discussed in detail in this study.

DF 13.15 Wed 15:00 Poster E

Coupling nanoscale solid state systems to optical fiber microcavities — •Hanno Kaupp[1,2], David Hunger[1,2], Matthias Mader[1,2], Christian Deutsch[1,3], Jakob Reichel[3], and Theodor W. Hänsch[1,2] — [1]Ludwig-Maximilians-Universität München, Deutschland — [2]Max-Planck-Institut für Quantenoptik, Garching, Deutschland — [3]Laboratoire Kastler Brossel, E.N.S., Paris, Frankreich

Optical fibers with machined and coated endfacets can serve as high reflectivity mirrors to build low loss microcavities [1]. Featuring a small mode volume on the order of a few tens of cubic wavelengths, optical quality factors exceeding 10^6, and free space accessability to the cavity modes, they are well suited to study nanoscale systems with high sensitivity. We will present first steps towards coupling a nitrogen-vacancy centers in nanodiamonds to the fiber cavity. First experimental results on absorption spectroscopy with gold nanoparticles will be discussed.

[1] Hunger, Reichel et al., NJP 12, 065038 (2010)

DF 13.16 Wed 15:00 Poster E

First principles study of the magneto-optical Kerr effect in $TbAl_3(BO_3)_4$ — •Udo Schwingenschlögl, Yasir Saeed, and Nirpendra Singh — KAUST, PSE Division, 23955-6900 Thuwal, Kingdom of Saudi Arabia

The electronic and optical properties of $TbAl_3(BO_3)_4$ are determined using density functional theory. The calculated total magnetic moment of 5.96 μ_B is close to the expected moment of Tb^{3+}. The frequency dependent dielectric function, refractive index, extinction coefficient, absorption, optical reflectivity, and energy loss function are explained in terms of the transitions between the valence and conduction bands. We find very high Kerr angles for ultraviolet light and potential for extension, even into the visible range by band structure design.

Reference: J. Appl. Phys., in press, doi:10.1063/1.3662176

DF 13.17 Wed 15:00 Poster E

Heat relaxation and transport in dielectrics: the density dependent two temperature model — •Anika Scholtes[1], Orkhan Osmani[1,2], and Bärbel Rethfeld[1] — [1]TU Kaiserslautern, 67663 Kaiserslautern, Germany — [2]Universität Duisburg-Essen, 47048 Duisburg, Germany

During the irradiation of dielectrics and semiconductors with a laser pulse or a swift heavy ion, electrons are excited from the valence band into the conduction band, thus creating electron-hole-pairs. The excited electronic system interacts with the phononic system by electron-phonon-coupling. For laser-irradiated metals, the two temperature model (TTM) introduced in [1] describes the temporal and spatial evolution of electronic and phononic temperature. Considering dielectrics and semiconductors with an initially negligible free electron density, it is also important to account for the transient electronic density in the conduction band. A first approach to obtain the evolution of the phononic as well as the electronic temperature, which also accounts for the change in the density, was given in [2]. Here, we modified this approach to fully account for the energy conservation and present the influence of the impact ionization and Auger recombination on the electronic density and temperature dynamics for the case of laser-irridiation of Silicon.

[1] S.I. Anisimov, B.L. Kapeliovich, and T.L. Perel'man. *Sov. Phys. JETP* **39**, 375 (1974).

[2] H.M. van Driel. *Phys. Rev. B* **35**, 8166 (1987).

DF 13.18 Wed 15:00 Poster E

Transient absorption in $Sn_2P_2S_6$ induced by sub-100-fs light pulses — •Volker Dieckmann[1], Holger Badorreck[1], Mirco Imlau[1], and Alexandr Shumelyuk[2] — [1]Department of Physics, University of Osnabrück, Germany — [2]Institute of Physics, National Academy of Science, Kyiv, Ukraine

The interaction of sub-100-fs light pulses with single crystals of nominally undoped $Sn_2P_2S_6$ is studied in the NIR spectral range ($590 - 1630$ nm) [1]. A predominant contribution of the two-photon absorption (TPA) is verified. The TPA coefficient β increases in a superlinear way for photon energies $\hbar\omega$ exceeding $E_g/2$; for any photon energy it is nearly independent of propagation direction and polarization of the incident beam. The TPA coefficient saturates at a maximum value of $\beta \approx 8\,\mathrm{cm\,GW^{-1}}$ at $\hbar\omega \approx 1.8$ eV. It drops when reaching the bandgap E_g. The TPA coefficients are higher by a factor of two than the values reported for other wide bandgap ferroelectrics, such as $LiNbO_3$, while being lower in comparison to semiconductor crystals. Using pump-probe measurements at 626 nm, a transient absorption is observed that persists for probe pulse delays much longer than the pump pulse duration, up to 2.5 ns. Such transients are typical for a variety of wide bandgap ferroelectrics, where they are described by optically generated polaronic states. We discuss our results in the framework of the microscopic structure of $Sn_2P_2S_6$ with emphasis on the optical generation of S^- small hole polarons. Financial support by the DFG (IM 37/9-1, INST 190/137-1) is gratefully acknowledged.

[1] M. Imlau et al. Opt. Mater. Express 1, 953 (2011)

DF 13.19 Wed 15:00 Poster E

Transient absorption and nonlinear refractive index changes in nominally pure, thermally reduced $LiNbO_3$ induced by sub-100-fs light pulses — •Holger Badorreck, Volker Dieckmann, Pia Baeune, and Mirco Imlau — Department of Physics, University of Osnabrück, Germany

Nominally undoped lithium niobate—as grown and thermally reduced—is of great interest for ultrafast optical devices due to its polaronic features. With formation times in the sub-ps-range short-lived small polarons can be generated in reduced samples by optical gating of bipolarons due to single photon absorption. Simultaneously, formation of small hole polarons by two-photon-absorption is observed. In this work nonlinear absorption and refractive index changes due to exposure to sub-100-fs light pulses of 488 nm are presented in presence of a considerable number density of bipolarons. It is found that the two-photon absorption coefficient is not affected by the thermal reduction procedure, whereas the nonlinear refractive index change is considerably smaller in the reduced sample compared to the unreduced one. We further present our results on the study of the transient absorption in the blue and NIR spectral range by means of fs-pump-probe technique. The influence of the thermal reduction procedure on lifetime and densities of electron and hole polarons is discussed.

Financial support by the DFG (IM 37/5, INST 190/137-1) is gratefully acknowledged.

DF 13.20 Wed 15:00 Poster E

Light-induced absorption spectroscopy in niobate, titanate and borate crystals — •Andreas Buescher[1], Hauke Bruening[1], Bettina Schoke[1], Christoph Merschjann[2], Stefan Torbruegge[1], Gabor Corradi[3], Susanne Hoffmann-Eifert[4], and Mirco Imlau[1] — [1]Department of Physics, University of Osnabrück, Germany — [2]Helmholtz-Zentrum für Materialien und Energie, Berlin, Germany — [3]Research Institute for Solid State Physics and Optics, Budapest, Hungary — [4]Institut für elektronische Materialien, Forschungszentrum Jülich, Germany

Light-induced absorption spectroscopy (LIAS) is a powerful tool for investigation of wide bandgap oxide materials. In this contribution, we will review the results in the niobates $LiNbO_3$ and $KNbO_3$ as well as in $SrTiO_3$ and β-BaB_2O_4. In $LiNbO_3$, we study the complex interplay of two-photon excitation of small hole and bound polarons and the optical gating of bipolarons into free and bound polarons. In $KNbO_3$, we deal with one electron and one hole polaron allowing for the development of a new model for thermally activated polaron hopping giving

access to new microscopic parameters. $SrTiO_3$, widely discussed as a memristor material, is studied using LIAS to get insight into the charge transport properties of this material taking into account the model of extended defects. In β-BaB_2O_4 polarons are discussed as the origin of laser damage. We face the problem as a result of the high photon-flux showing the limitations of this measurement technique.

Financial support by the DFG (IM37/5 and INST190/137-1) and DAAD (50445542) is gratefully acknowledged.

DF 13.21 Wed 15:00 Poster E

Light-induced linkage isomerization by ultrafast mid-infrared spectroscopy in sodium nitroprusside on the 100 fs time domain — •Felix Freytag, Kristin Springfeld, Volker Dieckmann, and Mirco Imlau — Department of Physics, University of Osnabrück, Germany

Today's information storage and telecommunication industry strongly demands for novel devices to increase storage densities and transmission speed in optical networks. A promising approach is the control of light by light using molecular compounds offering ultrafast photochromism and -refraction on the sub-ps time scale. Nitroprusside compounds have been shown to allow for these features based on a light-induced linkage isomerization [1]. Recently, its time constant has been reported to be less than 200 fs by means of VIS-pump-probe technique [2]. However, such structural alterations have not been proven in the compound by direct measurements on the sub-ps time scale. For studying selected vibrational modes at $\nu \approx 1950\,\mathrm{cm}^{-1}$ of sodium nitroprusside, we use frequency-resolved infrared spectroscopy. The transmission of mid-infrared $\tau \approx 150$ fs pulses is detected by a multichannel MCT detector as a function of time delay to an intense VIS pump pulse of $\tau \approx 100$ fs duration. We will present first results on our studies of the light-induced changes of such vibrational modes on the 100 fs time scale. Financial support by the DFG (IM 37/5, INST 190/137-1) and the DAAD (50445542) is gratefully acknowledged.

[1] Imlau et al., Appl. Phys. B, 68, 877 (1999)

[2] Schaniel et al., Phys. Chem. Chem. Phys., 12, 9029 (2010)

DF 13.22 Wed 15:00 Poster E

Hydrophones based on photonic crystals — Timm Schaer[1,2], •Juliane Tschentscher[2], and Mirco Imlau[2] — [1]ATLAS ELEKTRONIK GmbH, Sebaldsbrücker Heerstr. 235, D-28309 Bremen — [2]Department of Physics, University of Osnabrück

Hydroacoustic sensors commonly consist of piezoelectric ceramics that convert acoustical pressure to electric signals. However, their application in the deep sea (>1800 m depth) with remotely-operated undersea vehicles (ROV) is limited because of large signal losses in copper based connecting wires. In this context, fiber-based photonic networks that include optical hydrophones represent a promising solution. Here, we focus on the application of photonic crystals as highly sensitive sensor elements in hydroacoustic devices. Photonic crystals are artificial structured materials on the scale of light wavelength. Because of their unique sensitivity to alterations in the periodic structure, they are particularly suited for the detection of mechanical pressure and, hence, for the detection of acoustic waves. We have selected polymethymethacrylat (PMMA) as base material because of its Young's modulus, transparency and chemical stability. We present our results on the recording of quasi-periodic structures by means of exposure to ns- and fs-laser pulses. The structures that allow the control of light at the telecommunication wavelength (1.55 μm) are analyzed by photo spectroscopy and light diffraction. The response of the device to dynamic changes of mechanical pressure under seawater conditions is discussed.

Financial support by the DFG (IM37/5, INST 190/137-1) is gratefully acknowledged.

DF 13.23 Wed 15:00 Poster E

Size-dependent optical properties of polar oxide $BaTiO_3$ nanocrystals applied for cell imaging — •Pia Bäune[1], Mirco Imlau[1], Karsten Kömpe[2], and Jacob Piehler[2] — [1]Fachbereich Physik, Universität Osnabrück — [2]Fachbereich Biologie/Chemie, Universität Osnabrück, Germany

Polar oxide nanocrystals have been introduced as novel class of optical markers for cell imaging in biophotonics. Based on frequency conversion they obey interesting, outstanding properties in comparison with imaging techniques via fluorescence and resonance spectroscopy. For instance, pump- and probe-photon energies are spectrally separated, the crystals show no photobleaching and/or photoblinking, and coherent light is generated with anisotropic radiation characteristics. Thus, polar oxide nanocrystals are promising candidates for continuous three-dimensional detection of both position and orientation of markers in biological cells. In this contribution we present our studies on the size-dependent optical properties of $BaTiO_3$ nanocrystals by means of frequency conversion techniques. $BaTiO_3$ nanocrystals have been synthezised with colloidchemical methods taking hydrothermal and solvothermal methods for bulk crystal growth into account. We focus on photodegradation phenomena that relate to the nanocrystal surfaces as a function of nanoparticle size. Our results are compared with $BaTiO_3$ bulk crystals with respect to SHG efficiency and the processes of laser-induced surface damages. Surface modification by SiO_2 or polymers (PEG, PVB) is proposed and discussed taken the physiological environment in cells into account.

DF 13.24 Wed 15:00 Poster E

Adaptive Amplitude Filters for Smaller Feature Sizes in Direct Laser Writing — Erik Waller and •Georg von Freymann — Department of Physics and Research Center OPTIMAS, University of Kaiserslautern

Direct-Laser-Writing is an established technique for the fabrication of almost arbitrary three-dimensional structures in photo resists. These are locally polymerized via two-photon polymerization. The fundamental building block - the so called voxel (volume pixel) - is a volume defined by the iso-intensity surfaces in the focal spot. This voxel is an ellipsoid, defined by the numerical aperture of the microscope objective and the refractive index of the photo resist. The resulting axial elongation is disadvantageous for isotropic features. To overcome this problem, so called shaded-ring filters have been reported. Recently, stimulated-emission-depletion inspired lithography has been demonstrated to yield aspect ratios of one. Corresponding setups require phase masks and an additional laser source. Here, we show that spatial light modulators can be employed to implement shaded-ring filters to decrease the aspect ratio. However, so far shaded-ring filter have to not been able to generate aspect ratios close to one with acceptable side lobe levels. We therefore suggest an adaptive amplitude filter allowing for voxels with an aspect ratio of one, regardless of the scanning direction. This adaptive filter consists of a variable slit with unity transmission imaged onto the entrance pupil of a high numerical aperture objective. We show numerical calculations and experimental data demonstrating the effectiveness of this approach.

DF 13.25 Wed 15:00 Poster E

Strukturierte Materialmodifikationen in optischen Kristallen mittels eines Hochenergie Helium-Microbeams — •Niels L. Räth, Johannes Goetze, Konrad Peithmann und Karl Maier — Helmholtz-Institut für Strahlen- und Kernphysik, Universität Bonn

Optische Kristalle wie Lithiumniobat oder Lithiumtantalat sind äußerst interessant für eine Vielzahl optischer Anwendungen.

Hochenergetische, leichte Ionen, die derartige Kristalle durchstrahlen, verursachen langzeitstabile Modifikationen des Brechungsindexes und reduzieren die Koerzitivfeldstärke E_C.

Um die Materialen im Mikrometerbereich derart strukturieren zu können, wird der Ansatz eines Hochenergie Helium-Microbeams verfolgt. Am Isochron-Zyklotron des Helmholtz-Instituts für Strahlen- und Kernphysik wird dazu mittels ionenoptischer Abbildung ein maskierter Ionenstrahl stark verkleinert auf die Probe abgebildet.

Es werden Berechnungen, Aufbau und erste Resultate vorgestellt.

DF 13.26 Wed 15:00 Poster E

Impulsive stimulated Raman scattering on phonon-polaritons in oxides — •Jewgeni Goldshteyn[1], Daniel Schick[2], Andreas Paulke[2], Peter Gaal[2], and Matias Bargheer[1,2] — [1]Helmholtz Zentrum Berlin, Albert Einstein Str. 15, 12489 Berlin, Germany — [2]Institut für Physik und Astronomie, Universität Potsdam, Karl-Liebknecht-Str. 24-25, 14476 Potsdam, Germany

This contribution presents a time-resolved study of phonon-polariton dynamics in various materials like tetragonal $LiNbO_3$ and quasi-cubic $SrTiO_3$. We excite discrete modes by Impulsive Stimulated Raman Scattering (ISRS) using a k-selective transient grating technique. The excitation is probed by means of a second Raman scattering event, by detection of the four-wave-mixing signal in a box-car geometry. One virtue of our setup is the frequency-resolved detection of the scattered probe pulse, which allows for a measurement of stokes- and anti-stokes shifts of the probe light. The excitation process is presented thoroughly. In particular the transient atomic displacement and the sample symmetry are discussed. Further, we discuss implications on future ultrafast x-ray diffraction experiments to probe Raman excited modes.

DF 13.27 Wed 15:00 Poster E

Linear and non-linear optical properties of Lithium niobate — •Arthur Riefer[1], Simone Sanna[1], André V. Gavrilenko[2], and Wolf Gero Schmidt[1] — [1]Theoretische Physik, Universität Paderborn, 33095 Paderborn, Germany — [2]Norfolk State University, Center for Materials Research, VA 23504 Norfolk, USA

Lithium niobate (LN) is one of the most important ferroelectric materials and the most important optic material. Given the vast range of LN applications, our knowledge about its electronic and optical properties is surprisingly limited. Besides many experiments focusing on the onset of the absorption, we are aware of only two studies that address the absorption in the vacuum ultraviolet (VUV) domain [1,2]. Furthermore, theoretical works investigating the electronic and optical properties beyond the single-particle picture are rare[3,4]. Concerning the non-linear optical properties, only a single theoretical work exists [5]. Thus, in this work we use a quasiparticle band structure based on parameter-free GW calculations for setting up the excitonic Hamiltonian, determine the (linear) optical spectra, and compare to the experimental available spectra [1]. We also present a second-harmonic generation (SHG) spectrum for LN.

[1] A. M. Mamedov *et al.*, Appl. Phys. A **34**, 189 (1984)
[2] E. Wiesendanger *et al.*, Sol. State Commun. **14**, 303 (1974)
[3] W. G. Schmidt *et al.*, Phys. Rev. B **77**, 035106 (2008)
[4] C. Thierfelder *et al.*, phys. stat. sol. (c) **7**, 362 (2010)
[5] H. Akkus *et al.*,Int. J. Nanoelectronics and Materials **3**, 53 (2010)

DF 13.28 Wed 15:00 Poster E

Lithium tantalate electronic and optical properties calculated from first principles — •Arthur Riefer, Simone Sanna, and Wolf Gero Schmidt — Theoretische Physik, Universität Paderborn, 33095 Paderborn, Germany

Ferroelectric materials like Lithium tantalate (LT) are very important for the fabrication of non-linear optical and electro-optical devices. Despite its huge range of applications first principles studies including many-body interactions in the electronic structure and optical spectra of ferroelectrics are rare[2,3]. In particular for LT we are not aware of calculations going beyond density functional theory (DFT). In order to contribute to a better understanding of the LT electronic and optical properties we calculate its quasiparticle band structure within the GW approximation for the electronic self-energy. The optical response is calculated from a Bethe-Salpeter-type approach, thus including excitonic and local-field effects from first principles. The results are compared to similar calculations for other ferroelectric materials like Lithium niobate (LN). Also we present spectra for composite materials consisting of both LN and LT.

[1] Y. Xu, *Ferroelectric materials and their applications*, North-Holland, 1991
[2] W. G. Schmidt *et al.*, Phys. Rev. B **77**, 035106 (2008)
[3] C. Thierfelder *et al.*, phys. stat. sol. (c) **7**, 362 (2010)