

## DF 6: Optical and nonlinear optical properties, photonic

Time: Tuesday 10:15–13:00

Location: MÜL Elch

## Invited Talk

DF 6.1 Tue 10:15 MÜL Elch  
**Ultrafast X-ray Diffraction and all-optical Pump-Probe Spectroscopy on Oxide Multilayers** — ●MATIAS BARGHEER — Institut für Physik und Astronomie, Universität Potsdam — Helmholtz-Zentrum Berlin

We present experimental results of ultrafast x-ray diffraction and ultrafast optical experiments that simultaneously measure optical reflection and transmission changes on various multilayer systems. The investigated multilayer samples include epitaxially grown oxides (STO, SRO, LSMO, PZT, BTO) with dielectric, metallic, ferromagnetic and ferroelectric character as well as polyelectrolyte multilayers with embedded gold nano-particles.

From the ultrafast x-ray techniques we assess the exact structural properties and structural changes. On the one hand we are able to measure transient relative changes of the lattice constant of STO as small as  $10^{-7}$ . On the other extreme, we can induce changes of the x-ray diffraction efficiency of 2500% on particular superlattice Bragg-reflections by launching strain-waves with an amplitude of 1.8%.

Broadband visible and infrared pump-probe experiments are used to measure the changes in the dielectric function. We show how the information determined from ultrafast structural measurements can help with the interpretation of all-optical spectroscopies.

## 5 min. break

DF 6.2 Tue 11:00 MÜL Elch  
**Temperature dependent absorption and Urbach tail scaling in LuAG single crystals.** — ●MARTIN LETZ<sup>1</sup>, ALEXANDER GOTTWALD<sup>2</sup>, MATTHIAS RICHTER<sup>2</sup>, VLAD LIBERMAN<sup>3</sup>, and LUTZ PARTHIER<sup>1</sup> — <sup>1</sup>Schott AG, Hattenbergstr. 10, 55128 Mainz — <sup>2</sup>Physikalisch-Technische Bundesanstalt (PTB), Abbestr. 2-12, 10587 Berlin — <sup>3</sup>Lincoln Laboratory, MIT, 244 Wood St., Lexington, Massachusetts 02420-9108, USA

In the deep ultraviolet (DUV) spectral range the transmission of high purity  $\text{Lu}_3\text{Al}_5\text{O}_{12}$ , LuAG was measured using monochromatized synchrotron radiation. In the vicinity of the band gap below 7.8 eV, a scaling behavior of the absorption as a function of photon energy was observed. Temperature dependent measurements [1] allow us to distinguish different absorption mechanisms which differ by their ability to couple to phonon excitations. Interpreting the Urbach tails measured at different temperatures, we show that the temperature independent part originates from the short term localization of exciton modes coupling to lattice distortions. These results allow us to extrapolate the maximum transmittance which can be obtained with LuAG crystals at the lithographic wavelength of 193.39 nm. Accurate determination of the maximum transmission limit is critical in deciding whether the material can meet industry's specification for 193-nm-based high index lithography.

[1] M.Letz, A.Gottwald, M.Richter, V.Liberman, L.Parthier, Phys. Rev. B, 81, 155109 (2010)

DF 6.3 Tue 11:20 MÜL Elch  
**A microscopic model for diffusive hopping charge transport in wide-bandgap oxide semiconductors** — ●CHRISTOPH MERSCHJANN<sup>1</sup>, MIRCO IMLAU<sup>2</sup>, and HAUKE BRÜNING<sup>2</sup> — <sup>1</sup>Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Berlin, Germany — <sup>2</sup>Universität Osnabrück, Fachbereich Physik, Osnabrück, Germany

Relaxation and recombination processes of optically excited charge carriers in wide-bandgap oxide semiconductor crystals (e.g. niobates, phosphates, borates) often exhibit non-exponential decay shapes. In recent years, such relaxations have been phenomenologically described by stretched exponential functions after Kohlrausch, Williams and Watts (KWW). Although they describe the shapes fairly good, it is not possible to directly retrieve informations about the nature of the relaxation, i.e. the charge-transport process, from the KWW formalism.

We present a novel microscopic model for the diffusive hopping charge transport via strongly localized states (e.g. small polarons). This random-walk-based model directly incorporates microscopic quantities, such as lifetimes of single hopping events, electron and hole densities, and dimensionality of the system under study. We

compare our numerical, analytical and experimental results. In the common case of equal electron and hole densities, as found in  $\text{KNbO}_3$ , our model yields the above named quantities with high accuracy.

Generalizations of our model, as well as relations to the KWW formalism, are discussed in the presentation.

DF 6.4 Tue 11:40 MÜL Elch  
**Tunability of the photofunctional properties in photochromic polypyridine ruthenium sulfoxide complexes** — ●KRISTIN SPRINGFELD, VOLKER DIECKMANN, SEBASTIAN EICKE, and MIRCO IMLAU — Department of Physics, University of Osnabrück, Barbarastr. 7, D-49069 Osnabrück, Germany

Ruthenium polypyridine sulfoxide compounds feature photo-triggered linkage isomerization into two metastable structural isomers. This isomerization is accompanied by a pronounced photochromism in the UV/VIS spectral range. The absorption changes are combined with a tremendous photosensitivity and a high thermal stability of the structural isomers. In this contribution, we discuss the modification of photochromic properties in the frame of ligand substitution and the replacement of the dielectric environment of the compounds. The complex  $[\text{Ru}(\text{bpy})_2(\text{ROSO})]\text{-PF}_6$  [1] (with OSO: 2-methylsulfinylbenzoate) is modified with the groups  $\text{R} = \text{H}, \text{Bn}, \text{BnCl}$  and  $\text{BnMe}$  [2] and studied in different solvents. The studies are performed by UV/VIS laser-spectroscopy as a function of temperature and exposure. Our results reveal a selective tunability of the thermal stability in the compounds, while the photosensitivity and the characteristic absorption spectra remain unchanged. We discuss the impact of our findings in view of application of sulfoxide compounds in molecular photonic devices.

Financial support by the DFG (GRK 695) is gratefully acknowledged.

[1] Dieckmann et al., Opt. Express, 17, 15052 (2009)

[2] Dieckmann et al., Opt. Express, 18, 23495 (2010)

DF 6.5 Tue 12:00 MÜL Elch  
**Polarization controlled switching of optical nonlinearity in nanocomposite glass** — ●SABITHA MOHAN and GERHARD SEIFERT — Physics Institute, Martin-Luther-Universität Halle-Wittenberg, von-Danckelmann-Platz 3, 06120 Halle (Saale)

Nonlinear optical properties of uniformly oriented anisotropic metal nanoparticles in a glass matrix are studied using the Femtosecond Z-Scan technique. The glass samples (thickness  $200\mu\text{m}$ ) contain spheroidal nanoparticles only in a thin surface layer of 1-2 micrometer thickness. The macroscopic structural anisotropy of the composite system allows to tailor the optical nonlinearities of longitudinal and transverse Plasmon band separately. Ultrafast excitation of the longitudinal plasmon band (peak at 550 nm) in the near-resonant regime with 1030nm excitation wavelength (280fs pulse duration, 1 kHz repetition rate) results in a saturable absorption along with a negative nonlinear refraction. Contrastingly in the non-resonant regime the excitation results in a positive nonlinear refraction with negligible nonlinear absorption, which stems from the pure glass substrate. The contribution from the transverse plasmon band is observed by tuning the excitation wavelength to 800nm (pulse duration  $\tau=80\text{fs}$ , 1 kHz repetition rate) which is in two-photon absorption resonant with the transverse plasmon band (peak at 390 nm). Studying samples with different aspect ratio, we obtained the dispersion of third-order nonlinearity in the near resonant regime, showing a boosting of the nonlinear processes due to the dielectric field enhancement.

DF 6.6 Tue 12:20 MÜL Elch  
**Bestimmung der effektiven Ladungsträgerkonzentration in nominell undotierten Lithiumniobat-Kristallen mittels holographischer Methoden** — ●FABIAN LÜDTKE<sup>1</sup>, DANIEL HAERTLE<sup>1</sup>, BORIS STURMAN<sup>2</sup> und KARSTEN BUSE<sup>1</sup> — <sup>1</sup>Physikalisches Institut, Universität Bonn, Deutschland — <sup>2</sup>Institute of Automation and Electrometry, Novosibirsk, Russia

Lithiumniobat-Kristalle sind auf Grund ihrer nichtlinearen und elektrooptischen Eigenschaften von großer Bedeutung in den Bereichen Photonik und integrierte Optik. Doch selbst nominell hochreine Kristalle weisen Verunreinigungen, beispielsweise durch Eisen oder Chrom, von wenigen ppm oder geringer auf. Diese führen bei hohen Lichtintensitäten zu Erwärmung durch Absorption und zu optischem Schaden

durch photorefraktive Fremdatome. Beide Effekte schränken die Anwendbarkeit der Kristalle stark ein. Um den Einfluss der Verunreinigungen quantitativ abzuschätzen und Verfahren zu deren Beseitigung zu optimieren, ist eine genaue Kenntnis der Konzentration notwendig. Standardmethoden wie Absorptionsspektroskopie versagen hier auf Grund unzureichender Empfindlichkeit. Allerdings ist es unter Ausnutzung von Raumladungsbegrenzung möglich, die effektive Ladungsträgerkonzentration mit holographischen Methoden zu messen. Typische Konzentrationen liegen im Bereich um  $10^{20} \text{ m}^{-3}$ . Die Empfindlichkeit des Verfahrens ist im Vergleich zur optischen Absorptionsspektroskopie etwa 100-mal höher.

DF 6.7 Tue 12:40 MÜL Elch

**Photoakustische Absorptionsmessungen in Lithiumniobat-Kristallen** — •STEPHAN FIEBERG<sup>1</sup>, NIKLAS WAASEM<sup>1</sup>, DANIEL HAERTLE<sup>1</sup>, FRANK KÜHNEMANN<sup>2</sup> und KARSTEN BUSE<sup>1</sup> —  
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Department, German University in Cairo, Egypt

Lithiumniobat ist ein hochtransparenter, elektrooptischer Kristall, der in vielen Bereichen der Photonik verwendet wird. Bei sehr hohen Lichtintensitäten können jedoch schon kleine Absorptionskoeffizienten zu unerwünschten Effekten führen, z.B. thermischen Schäden oder Photorefraktion. Aus diesem Grund ist eine genaue Kenntnis der Absorptionsspektren erforderlich. Zudem können Absorptionsspektren Auskunft über die Bandstruktur, Art und Dichte von Fremdatomen und die Stöchiometrie geben. Sie sind daher nicht nur technisch, sondern auch wissenschaftlich von großem Interesse. Derzeit gängige Messmethoden erreichen entweder nicht die nötige Auflösung von  $< 10^{-4} \text{ cm}^{-1}$  oder sind zu aufwändig und langsam. Eine sowohl schnelle, als auch hochauflösende Alternative bieten Photoakustische Verfahren, die eine durch Absorption des Lichts hervorgerufene Schallwelle zum Nachweis der Absorption nutzen. Der vorliegende Beitrag beschäftigt sich mit der Anwendung dieser Verfahren auf Lithiumniobat.