DF 14: Photonic Dielectrics III

Time: Thursday 10:00–13:00 Location: WIL A317

Invited Talk DF 14.1 Thu 10:00 WIL A317

Spatial nonlinear optics in photonic crystals — •Detlef Kip — Institut für Physik und Physikalische Technologien, TU Clausthal

Künstlich strukturierte Materialien, sogenannte Metamaterialien, weisen radikal neue optische Eigenschaften auf. Ein Beispiel sind Halbleiter oder Dielektrika mit einer periodischen Modulation des Brechungsindexes, die analog zu kristallinen Festkörpern eine optische Bandstruktur zeigen: Wellenausbreitung in Form von Floquet-Bloch-Moden ist nur in erlaubten Bändern möglich, welche durch Bandgaps voneinander getrennt sind. Für zukünftige, äußerst kompakte photonische Bauelemente, aber auch für das grundlegende Verständnis nichtlinearer periodischer Systeme, ist die Untersuchung der nichtlinearen Wellenausbreitung in photonischen Kristallen von großem Interesse. Modellhaft lassen sich solche nichtlinearen Eigenschaften eindimensionaler photonischer Kristalle in evaneszent gekoppelten Streifenwellenleiterarrays untersuchen, welche sich in Lithiumniobat realisieren lassen. Optisch induzierte Defekte führen hier auf räumlich lokalisierte Zustände oder diskrete Solitonen mit Ausbreitungskonstanten innerhalb der Bandlücke; die Wechselwirkung solcher "Quasiteilchen" lässt sich für zukünftige rein optische Schalter ausnutzen. Daneben erlauben nichtlineare räumlich periodische Strukturen das Studium einer Vielzahl weiterer Wellenphänomene. Beispiele im Vortrag sind räumliche Rabi-Oszillationen in periodisch modulierten Gittern oder die Bildung von räumlichen Frequenzkämmen und Superkontinuum über nichtlineare Vier-Wellen-Mischung von Floquet-Bloch-Moden.

5 min. break

DF 14.2 Thu 10:40 WIL A317

Theoretical discussion of present and novel optical methods for space-charge wave analysis — •Kay-Michael Voit, Burghard Hilling, and Mirco Imlau — Department of Physics, University of Osnabrück, Osnabrück, Germany

Space-charge waves are commonly generated in semi-insulating materials via exposure to an oscillating sinusoidal light interference pattern under an application of high electric fields. However, both the study of nonlinear mutual interactions of SCWs and the investigations of charge-transport properties by SCW spectroscopy are restricted by the assumptions underlying the theoretical concept for SCW analysis: (1) the oscillation amplidudes should be smaller than unity so that the oscillating fringe pattern can be separated into a static and two counterpropagating running gratings and, (2) the modulation depth of the fringe pattern should be smaller than unity. Furthermore, the analysis does not allow to determine the sign of the involved charge carriers. Hence it was the aim of our theoretical and experimental study to develop a new technique which overcomes these restrictions. In this contribution, the assumptions made for the analysis of the oscillating technique are presented and discussed with respect to the experimental restrictions. The novel approach of SCW generation by simultaneous exposure with a static and a running fringe pattern having the same spatial frequency is developed starting from the Kiev equations. Key aspects of the derivation are presented and the formula are compared to the well-known equations for SCW generation with an oscillating fringe pattern.

DF 14.3 Thu 11:00 WIL A317

Space-charge wave excitation by static and moving interference patterns — •Burkhard Hilling, Kay-Michael Voit, and Mirco Imlau — Department of Physics, University of Osnabrück, Germany

We report on our first experimental results, where SCW excitation was succesfully realized by simultaneous exposure with a static and a running interference pattern having the same spatial frequency. The static and running interference patterns are generated independently from each other using a new designed four-beam interferometer with only one light source. For this study, a single crystal of BGO ($Bi_{12}GeO_{20}$) was applied as an example. The investigations were performed at a wavelength of 514 nm using a total light intensity of 30 mW/cm^2 and spatial frequencies of $(0.5 - 12) \cdot 10^3$ cm^{-1}, while static electric fields of up to 10 kV/cm were applied. For a better evaluation of this method SCW were also excited in the same sample under the same experimental conditions using the established method of an oscillating interference pattern. The comparison of both sets of data shows an improvement in the way of excitation of the new method, particularly the quality factor is increased. This method also enables us to determine the sign of the charge carriers participating in SCW formation. Further advantages and disadvantages are discussed. Financial support from the Deutsche Forschungsgemeinschaft within the Graduate College 695 is gratefully acknowledged.

DF 14.4 Thu 11:20 WIL A317

UV-assisted domain patterning of MgO-doped lithium niobate crystals — •Hendrik Steigerwald, Niklas Waasem, Fabian Luedtke, and Karsten Buse — Institute of Physics, University of Bonn, Wegelerstrasse 8, 53115 Bonn, Germany

Periodically-poled lithium niobate ($LiNbO_3$) with domain structures in the micrometer regime is of great relevance, e.g. for nonlinear optics. Efficient frequency conversion in this material is usually hampered by optical damage, i.e., undesired index and absorption changes. MgO-doping increases the optical damage threshold, but makes the poling process more challenging, especially for small domain structures in bulk crystals. We obtain such patterns in MgO-doped near-stoichiometric $LiNbO_3$ using structured UV-illumination, which reduces the coercive field for electric field locally. Bulk domain gratings with a period length of 10 μm are realized. Another mechanism that lowers the coercive field strength is heating. We show that for combination of UV-illumination and heating of the crystal both effects add up and the coercive field strength is reduced by a factor of four.

*Financial support from the Deutsche Telekom AG is gratefully acknowledged.

DF 14.5 Thu 11:40 WIL A317

Optischer Schaden in Protonenausgetauschten planaren Wellenleitern in Lithiumniobat-Kristallen — •Fabian Luedtke[1], Javier Villarroel[2], Angel García-Cabañes[2], Mercedes Carrascosa[2] und Karsten Buse[1] — [1]Physikalisches Institut, Universität Bonn, Wegelerstraße 8, 53115 Bonn. Deutschland — [2]Departamento de Física de Materiales C-IV, Universidad Autónoma de Madrid, Campus Cantoblanco, E-28049, Madrid, España

Lithiumniobat-Kristalle sind auf Grund ihrer Ferroelektrizität und ihrer optischen Eigenschaften von großer Bedeutung im Bereich der integrierten und der nichtlinearen Optik. Für Anwendungen bei hohen Lichtintensitäten kann der photorefraktive Effekt zum begrenzenden Faktor werden, in diesem Fall spricht man vom „optischem Schaden". Für die quantitative Untersuchung dieser lichtinduzierten Brechungsindexänderungen bieten sich interferometrische Verfahren an. Kürzlich wurde ein Mach-Zehnder-Interferometer für die Charakterisierung des optischen Schadens in planaren Wellenleitern vorgestellt. Durch zusätzliche Messungen der Intensitätsschwelle für signifikante Verzerrung des Strahlprofils konnten Brechungsindexänderungen in der Größenordnung 1×10^{-4} als Schwellenwert für eine drastische Verschlechterung des Strahlprofils identifiziert werden. Untersuchungen von Dunkelzerfällen der Brechungsindexänderungen lassen einen Beitrag der Dunkelleitfähigkeit zum optischen Schaden ausschließen.

*Wir danken der Deutschen Telekom AG für finanzielle Unterstützung.

DF 14.6 Thu 12:00 WIL A317

Optical cleaning of lithium niobate crystals for suppression of optical damage* — •Carsten Becher[1], Michael Kösters[1], Daniel Haertle[1], Boris Sturman[2], and Karsten Buse[1] — [1]Institute of Physics, University of Bonn, Wegelerstr. 8, 53115 Bonn, Germany — [2]Institute of Automation and Electrometry, Novosibirsk 630090, Russia

Lithium niobate ($LiNbO_3$) is a promising material for optical applications, e.g., electro-optic modulation, holography, and frequency conversion. However, the photorefractive effect in its unwanted form, the so-called "optical damage", still inhibits the use of undoped $LiNbO_3$ at high light intensities: Light-induced refractive index changes cause deteriorations of the light beam and, e.g., disturb quasi-phase-matching, thus limiting the efficiency of non-linear optical processes. Optical cleaning as a method for suppression of optical damage in congruent, undoped $LiNbO_3$ crystals is presented: At sufficiently high temperatures, photo-excitable electrons are removed from an area illuminated by visible light due to the bulk-photovoltaic effect. While at room temperature, an arising electric field would quickly block the photovoltaic drift, at elevated temperatures, H^+-ions are mobile and can compensate for this electric field. Optical cleaning is studied by two independent methods: Determination of the threshold-intensities for beam fanning, as well as measurements of birefringence changes.

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

DF 14.7 Thu 12:20 WIL A317

Temperature dependent Urbach tail measurements of CaF_2 single crystals — •Martin Letz[1], Alexander Gottwald[2], Mathias Richter[2], and Lutz Parthier[3] — [1]Schott AG, Research and Development, D-55014 Mainz — [2]Physikalisch-Technische Bundesanstalt, D-10587 Berlin — [3]Schott Lithotec AG, Otto-Schott Str. 13, D-07745 Jena

In the deep ultra-violet spectral range the transmission of high purity CaF_2 was measured using synchrotron radiation. In the vicinity of the band gap below 11.2 eV or for wavelength longer than 90 nm, a scaling behaviour of the absorption as a function of photon energy was observed. Temperature dependent measurements allow to distinguish different absorption mechanism which differ by their ability to couple to phonon excitations. These two types of Urbach tails were analyzed. The origin of the temperature independent tail is due to defects in the lattice whereas the temperature dependent part originates from short time localization of exciton modes coupling to lattice distortion.

DF 14.8 Thu 12:40 WIL A317

Study of vacancies and extended defects in $SrTiO_3$ — •M. Zschornak[1,2], E. Gutmann[2], H. Stöcker[2], I. Shakhverdova[2], T. Weissbach[2], D.C. Meyer[2], and S. Gemming[1] — [1]Institute of Ion Beam Physics and Materials Research, FZ Dresden-Rossendorf, 01328 Dresden, Germany — [2]Institute of Structural Physics, TU-Dresden, 01062 Dresden, Germany

$SrTiO_3$ is an oxide crystallizing with cubic perovskite-type of structure that exhibits a high tunability of dielectric, electric, mechanical and optical properties by means of defects. Apart from dopants, also intrinsic oxygen vacancies or ordered stacking faults, e.g. Ruddlesden-Popper (RP) phases $SrO(SrTiO_3)_n$, may influence these properties. We have investigated the structural stability, electronic properties and surface energies of such RP phases up to $n = 5$ by means of density-functional theory. Further, we have theoretically verified an anisotropic reversible elastic softening along an O-deficient $\langle 100 \rangle$ direction recently found in nano-indentation of $SrTiO_3$ under influence of an electric field.