HL 33: Optical properties

Time: Tuesday 14:00–16:00 Location: POT 112

HL 33.1 Tue 14:00 POT 112

Influence of edge roughness on the optical properties of ZnSe-based microdisks — •Wilken Seemann[1], Alexander Kothe[1], Gesa Schmidt[2], Alexander Pawlis[2], and Jürgen Gutowski[1] — [1]Institute of Solid State Physics, Semiconductor Optics, University of Bremen, 28359 Bremen, Germany — [2]Peter Grünberg Institute (PGI-9), Forschungszentrum Jülich, 52425 Jülich, Germany

The considerable storage of light in whispering gallery modes (WGM) being favored in microdisk resonators is necessary to achieve low-threshold lasing [1]. It is furthermore an interesting aspect for the use of these resonators in several quantum optical applications where emission centers inside the disk act as single-photon sources or spin-qubits, like quantum memories [2].

We will show micro-photoluminescence (μPL) spectra of WGMs from ZnSe-based quantum well microdisks with diameters in the range of 2.5 to 4 μm and relate their optical properties to structural properties obtained from the analysis of scanning electron microscopy (SEM) images of the disks. We discuss that recutting the disks with a focused ion beam (FIB) can reduce the roughness of their edges and thus lead to better optical quality, i.e. increased light containment.

[1] L. He et al.: Laser & Photonics Reviews 7(1), 2013, 60.
[2] J.I. Cirac et al.: Physical Review Letters 78(16), 1997, 3221.

HL 33.2 Tue 14:15 POT 112

Quantifying Exciton Effects in Graphene Nanoribbons — •Alexander Tries[1,2,3], Paniz Soltani[3], Mischa Bonn[3], Hai I. Wang[3], and Mathias Kläui[1,2] — [1]Institute of Physics, Johannes Gutenberg-University Mainz — [2]Graduate School of Excellence Materials Science in Mainz — [3]Max Planck Institute for Polymer Research, Mainz

Owing to their massless nature, charge carriers in graphene can possess extremely high electron mobility. Yet, its gapless, semi-metallic nature can present a drawback for applications. Recent advances in bottom-up synthesis allows for the atomic control of graphene nanoribbons (GNRs)with well-defined bandgap and optical properties. [1,2]

In these structures, carrier confinement in the lateral dimension induces a bandgap corresponding to visible wavelengths. Owing to the strongly reduced charge screening effect in these atomically flat nanoribbons, strong exciton effects are expected and exciton binding energies in excess of ˜1 eV have been predicted. [3] We will present recent optical ultrafast conductivity studies on atomically precise GNRs using THz spectroscopy, which demonstrates and confirms the strong exciton and charged exciton effects [4]. Time-dependent photoconductivity measurements shed light on the sub- picosecond dynamics of the different quasi-particles.

[1] J. Cai et al., Nature 2010, 466, 470 [2] Z. Chen et al., J. Am.Chem. Soc. 2017, 139, 3635. [3] L. Yang et al., Nano Lett. 2007, 7 (10), 3112 [4] A. Tries et al.,ArXiv:1911.04431

HL 33.3 Tue 14:30 POT 112

Optical Tuning between the Trivial and Topological Regime of InAs/GaSb Quantum Wells — •Manuel Meyer[1], Sebastian Schmid[1], Gerald Bastard[2], Fabian Hartmann[1], and Sven Höfling[1] — [1]Technische Physik, Physikalisches Institut and Würzburg-Dresden Cluster of Excellence ct.qmat, Universität Würzburg, Am Hubland 97074 Würzburg, Germany — [2]Département de Physique, Ecole Normale Supérieure de Paris, 75005 Paris, France

Topological Insulators (TI) are a state of matter characterized by an insulating bulk and gapless helical edge states which were first demonstrated on HgTe/CdTe heterostructures[1]. The proposed TI based on composite InAs/GaSb heterostructures are especially appealing due their rich phase diagram that can be accessed via controlling external electrical fields[2]. We present another tuning knob of the phase diagram in InAs/GaSb quantum wells via optical excitation. Under constant illumination the majority charge carrier type switches from electrons to holes. At an intermediate value of illumination time both carrier types are present, indicating electron-hole hybridization[3]. Magnetic fields applied parallel to the surface enable us to determine the topological insulating phase. The optical tuning is caused by the negative persistent photoconductivity of antimonides in combination with a persistent charge carrier accumulation. This paves the way to an optical control of the phase diagramm of InAs/GaSb heterostructures.

[1] M. König et al., Science 318, 766 (2007).
[2] F. Qu et al., Phys. Rev. Lett. 115, 036803 (2015).
[3] G. Knebl et al., Phys. Rev. B 98, 041301(R) (2018).

HL 33.4 Tue 14:45 POT 112

Selective emitters for thermophotovoltaics at 1400 °C — •Alexander Petrov[1,2], Manohar Chirumamilla[1], and Manfred Eich[1,3] — [1]Institute of Optical and Electronic Materials, Hamburg University of Technology, Hamburg, Germany — [2]ITMO University, St. Petersburg, Russia — [3]Institute of Materials Research, Helmholtz-Zentrum Geesthacht, Geesthacht, Germany

In order to tailor thermophotovoltaic emitters to match specific photovoltaic receivers we demostrate spectrally selective emitters that have close to black body emission at short wavelengths and substantially reduced emission at long wavelengths. To emit significant power at the wavelengths usable for photovoltaic conversion (below 2 micron) the far-field emitter should be heated to high temperatures. The development of such thermally stable selective emitters requires strong cooperation between material science and optics, which was possible in the frame of the Hamburg based Collaborative Research Center SFB 986 "Tailor-made multiscale Materials Systems". We demonstrate selective band-edge emitters based on a W-HfO2 refractive metamaterial and a yttria stabilized ZrO2 opal monolayer on tungsten both stable up to 1400°C. The metamaterial exhibits almost angle independent selective emission due to a topological transition of its isofrequency surface. The monolayer approach, on the other hand, allows keeping the tungsten unstructured and thus demonstrates exceptional emission suppression at longer wavelengths. The physics behind the selective emission of the demonstrated concepts and an outlook for further improvement and enhanced thermal stability will be presented.

HL 33.5 Tue 15:00 POT 112

Chirooptical activity of surface-functionalized CdS nanorods — •Ilka Vinçon, Aksana Svirydava, Simon Prins, Yiou Wang, Jacek Stolarczyk, and Jochen Feldmann — Chair for Photonics and Optoelectronics, Nano-Institute Munich and Department of Physics, Ludwig-Maximilians-Universität (LMU), Königinstr. 10, 80539 Munich, Germany

Excitonic transition and subsequent charge separation is a key component in photovoltaic studies, as well as in solar water splitting. Introducing chirooptical properties in semiconductor nanocrystals via surface functionalization with chiral molecules has emerged as a promising tool to generate a new class of polarization sensitive materials with potential applications for spintronics, enantioseparation and more. To achieve basic control of chirooptical properties, there is a need to fundamentally understand the mechanism of chirality transfer between a chiral ligand and a nanocrystal's surface. We have chosen CdS nanorods as a suitable material with well-defined excitonic transitions. Circular dichroism (CD) has been induced in the excitonic transitions via surface functionalization with chiral ligands. Since the binding motif seems to play a key role in the chirality transfer, ligands with different anchor groups were attached to the surface of the CdS nanorods. Their influence on optical properties was probed via absorption, photoluminescence and CD spectroscopy.

HL 33.6 Tue 15:15 POT 112

Spectroscopic investigation of the radiative efficiency of ordered GaAs/(In,Ga)As core/shell nanowire arrays — •Michał Góra, Miriam Oliva, Jesús Herranz, Manfred Ramsteiner, Lutz Geelhaar, and Oliver Brandt — Paul-Drude-Institut für Festkörperelektronik, Leibniz-Institut im Forschungsverbund Berlin e. V., Hausvogteiplatz 5-7, 10117 Berlin, Germany

The vapor-liquid solid growth of GaAs nanowires on Si enables the integration of the III-As semiconductors on a Si platform for optoelectronic applications. In addition, GaAs/(In,Ga)As core/shell nanowires allow us to extend the emission wavelength toward the telecommunication range. An important question for actual applications of these structures is their internal quantum efficiency for longer emission wavelengths. In the present study, we utilize temperature- and power-dependent photoluminescence spectroscopy to investigate the radiative efficiency of ordered GaAs/(In,Ga)As core/shell nanowire arrays synthesized by molecular beam epitaxy. The shell consists

of either (In,Ga)As quantum wells with different In content or an InAs/(In,Ga)As dot-in-a-well structure. The absolute efficiency is determined by comparison with GaAs/(Al,Ga)As core/shell nanowires with known internal quantum efficiency. Our results show that the internal quantum efficiency of the (In,Ga)As quantum well shell decreases strongly with increasing In content. However, InAs/(In,Ga)As dot-in-a-well shells are found to enable emission wavelengths in the telecommunication O band at 1.26 μm, while maintaining a comparatively high quantum efficiency up to room temperature.

HL 33.7 Tue 15:30 POT 112

Influence of Amino Acids on the Optical Properties of Cu2O-Amino-Acid Cocrystals — •Mariam Kurashvili[1], Iryna Polishchuk[2], Simone Strohmair[1], Boaz Pokroy[2], and Jochen Feldmann[1] — [1]Chair for Photonics and Optoelectronics, Nano-Institute Munich and Department of Physics, Ludwig-Maximilians-Universität (LMU), Königinstr. 10, 80539 Munich, Germany — [2]Department of Materials Science and Engineering and the Russell Berrie Nanotechnology Institute, Technion - Israel Institute of Technology, 32000 Haifa, Israel

Biomineral systems are composed of organic and inorganic compounds. These materials exhibit highly interesting properties. For example, it was found that hardness of calcite single crystals can be increased via embedding amino acids in its lattice [1]. Also optical properties can be altered by amino acid incorporation, as a recent study of our group showed for zinc oxide [2,3]. Copper oxide is a very versatile direct band gap semiconductor, having promising applications in photovoltaics and water splitting. In this context, we report the optical properties of a model biomineral system consisting of copper oxide-amino acid cocrystals. We use steady state and time resolved photoluminescence spectroscopy, along with scanning electron microscopy to elucidate the changes, which are induced by different concentrations of amino acids in copper oxide. Our study emphasizes the great impact of amino acids on the optical and thus intrinsic structural properties of copper oxide.

[1] Y. Kim. et al., Nature Mat. 15, 903 (2016)
[2] A. Madathumpady et al., J. Phys. Chem. C 122, 6348 (2018)
[3] A. Brif et. al. Adv. Mater., 26, 477–481 (2014)

HL 33.8 Tue 15:45 POT 112

Anomalous Raman Scattering in Lead salts — •Nimrod Benshalom[1], Olle Hellman[2], and Omer Yaffe[1] — [1]Weizmann Institute of Science, Rehovot, Israel — [2]Linköping University, Linköping, Sweden

I present experimental evidence for the violation of symmetry constraints in the Raman spectra of rock-salt Lead-Chalcogenides.

The theoretical framework describing Raman scattering relies almost entirely on the harmonic approximation. In the standard (harmonic) Raman picture an incident photon inelastically scatters by either absorbing or emitting a quantum of energy into a vibrational normal mode excitation, or phonon. The phonon itself is a construct of the harmonic approximation.

Given well-defined normal modes, group-theory translates symmetry considerations into selection rules for the kind of allowed light-matter scattering events. In some crystal structures, like rock-salt, symmetry forbids any single phonon Raman scattering.

Using polarization dependent measurements, we observe two new low-frequency modes consistent with a reduced effective symmetry. These modes persist across the Lead-Chalcogenides series, following a number of curious spectroscopic trends. I discuss this anomalous Raman activity as the result of anharmonic temperature activated symmetry breaking.