HL 86: New Materials

Time: Friday 9:30–12:45 Location: POT 112

HL 86.1 Fri 9:30 POT 112

Bulk-boundary correspondence from the inter-cellular zak phase — •Jun Won Rhim, Jan Behrends, and Jens H. Bardarson — Max-Planck-Institut für Physik komplexer Systeme, 01187 Dresden, Germany

The Zak phase γ, the generalization of the Berry phase to Bloch wave functions in solids, is often used to characterize inversion-symmetric 1D topological insulators; however, since its value can depend on the choice of real-space origin and unit cell, only the difference between the Zak phase of two regions is believed to be relevant. Here, we show that one can extract an origin-independent part of γ, the so-called inter-cellular Zak phase γ^{inter}, which can be used as a bulk quantity to predict the number of surface modes as follows: a neutral finite 1D tight-binding system has $n_s = \gamma^{\text{inter}}/\pi \pmod 2$ number of in-gap surface modes below the Fermi level if there exists a commensurate bulk unit cell that respects inversion symmetry. We demonstrate this by first verifying that $\pm e\gamma^{\text{inter}}/2\pi \pmod e$ is equal to the extra charge accumulation in the surface region for a general translationally invariant 1D insulator, while the remnant part of γ, the intra-cellular Zak phase γ^{intra}, corresponds to the electronic part of the dipole moment of the bulk's unit cell. Second, we show that the extra charge accumulation can be related to the number of surface modes when the unit cell is inversion symmetric.

HL 86.2 Fri 9:45 POT 112

Combined Control Mechanisms of the Interatomic Coulombic Electron Capture in Paired Quantum Dots — •Axel Molle[1], Essam Radwan[1], Sascha Bubeck[1], Federico Manuel Pont[2], and Annika Bande[1] — [1]Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Berlin, Germany — [2]Universidad Nacional de Córdoba, and IFEG-CONICET, Córdoba, Argentina

Ultrafast Interatomic Coulomb Electron Capture (ICEC) is a process in which a species A is capturing a free electron. This is mediated by long-range Coulomb-interaction with a bound electron in a neighbouring species B in such a way that the transferred energy releases the bound electron of species B into the continuum.

First predicted for atoms and molecules, ICEC has been established as an important energy-transfer process in paired-quantum-dot systems [1].

It was shown that semiconductor material variations signify one of the important control mechanisms for the ICEC process. Additionally, a related energy transfer-process in quantum dots was found to be controllable by the geometries of both neighbouring quantum dots [2].

In this work, both effects are combined to understand the coupling of those two control mechanisms and predict advantageous experimental setups of the paired-quantum-dot system, underlining that ICEC proves to be a potential candidate for future energy-selective devices.

[1] F. M. Pont *et al.*, J. Phys. Condens. Matter **28**, 075301 (2016).
[2] P. Dolbundalchok *et al.*, J. Comput. Chem. **37**, 2249 (2016).

HL 86.3 Fri 10:00 POT 112

Molecular Self-Assembly of Organic-Inorganic Perovskite Nanocrystals — •Maximilian E. Löw[1,2], Verena A. Hintermayr[1,2], Theobald Lohmüller[1,2], Alexander S. Urban[1,2], and Jochen Feldmann[1,2] — [1]Chair of Photonics and Optoelectronics, Department of Physics and Center for Nanoscience (CeNS), Ludwig-Maximilians-Universität (LMU), Amalienstraße 54, 80799 Munich, Germany — [2]Nanosystems Initiative Munich (NIM), Schellingstraße 4, 80799 Munich, Germany

Having already shown great promise in the bulk form for optoelectronic applications, many researchers are now focusing on the synthesis of nanocrystals of organic-inorganic halide perovskites. Here, we present a straightforward method for producing highly ordered patterns of perovskite nanocrystals based on molecular self-assembly. With this new method, we are able to control structural parameters of the nanocrystal assembly, such as the particle size and interparticle distance over a large surface area. The optical properties of these nanocrystal arrays are investigated by UV-Vis and photoluminescence spectroscopy, while the spatial dimensions and lateral orientation of the nanocrystal assemblies are analyzed by electron microscopy. Overall, our approach represents a new and highly reproducible way of producing perovskite nanopatterns for photonics applications.

HL 86.4 Fri 10:15 POT 112

Characterization of electrochemically deposited MoS_x layers for thin film transistors — •Talha Nisar, Torsten Balster, Jonas Köhling, and Veit Wagner — Department of Physics and Earth Sciences, Jacobs University Bremen gGmbH, Campus Ring 1, 28759 Bremen, Germany

Molybdenum disulfide is a promising material for future electronics. MoS_2 thin layers can be deposited by several deposition methods. The current state of the art for large area deposition of thin layers is chemical vapor deposition.

In our study we used electrochemical deposition to grow large area thin films of MoS_x (x=2-3) onto a Au-substrate. Ammonium tetrathiomolydate (ATTM) has been used as precursor material in the cathodic regime (-0.35V) with respect to Ag/AgCl reference electrode. The obtained layers from aqueous electrolyte are amorphous MoS_3/MoO_3 as could be confirmed from Raman and XPS measurements. It is shown, that the use of organic solvents allow oxygen contamination to be significantly reduced. The characterization of obtained layers by XPS shows an almost ideal Mo:S ratio of 1:2.1. Furthermore, these layer are characterized by Raman, AFM and SEM measurements. Annealed layers are transferred to SiO_2/Si wafers to fabricate thin film transistors in top contact bottom gate geometry.

HL 86.5 Fri 10:30 POT 112

Investigation of dual-tone resists for low-temperature electron-beam lithography of deterministic quantum structures — •Sven Rodt, Arsenty Kaganskiy, Peter Schnauber, Tobias Heuser, Ronny Schmidt, and Stephan Reitzenstein — Institut für Festkörperphysik, Technische Universität Berlin, Hardenbergstrasse 36, D-10623 Berlin

The deterministic integration of light-emitting semiconductor nanostructures like e.g. single quantum dots is of large interest for novel quantum technologies that rely on the emission of single photons. For this we apply an approach that is based on cathodoluminescence spectroscopy in combination with in-situ electron-beam lithography (EBL) [1]. Due to the nature of light emission from quantum dots and its enhancement at low temperatures (LT), such processing is best carried out at liquid-helium temperature. Consequently, EBL resists are needed that perform well in this extreme temperature regime. Here we report on the resists PMMA and CSAR 62 and their applicability in the full range between room temperature and 4 K. They exhibit a dual-tone behavior as they operate in the positive-tone regime for small electron doses and enter the negative-tone regime for larger doses. Besides two-dimensional structuring also three-dimensional EBL is performed and evaluated. CSAR 62 is found to be superior to PMMA as the LT-EBL is more straightforward and results in a higher yield and quality of the processed structures [2].

[1] M. Gschrey et al., Appl. Phys. Lett. 102, 251113 (2013).
[2] A. Kaganskiy et al., J. Vac. Sci. Technol. B 34, 061603 (2016).

HL 86.6 Fri 10:45 POT 112

Transition from Jaynes-Cummings to Autler-Townes ladder in a quantum dot-microcavtity system — C. Hopfmann[1], A. Carmele[2], •A. Musiał[1,3], M. Strauss[4], M. Kamp[4], C. Schneider[4], S. Höfling[4,5], A. Knorr[2], and S. Reitzenstein[1] — [1]IFP, TU Berlin, Germany — [2]ITP, TU Berlin, Germany — [3]LOSN, Politechnika Wrocławska, Poland — [4]TEP, Universität Würzburg, Germany — [5]SUPA, University of St Andrews, UK

We report on experimental and theoretical study of resonantly-driven quantum dot exciton (X) strongly coupled to the microcavity mode (CM). Investigated system exhibits dramatically different character depending on the excitation strength from vacuum Rabi doublet when coupled X-CM is weakly probed to Mollow triplet-like behavior under strong coherent pump. Focus is on the unexplored intermediate regime, where the laser field dresses the polaritons and the coupling of the X to the confined CM and to the laser are equally important, as proven by observing injection pulling of the polariton branches. This regime is of particular interest since it connects the purely quantum mechanical Jaynes-Cummings and the semi-classical Autler-Townes ladder. In or-

der to address underlying physics we excite the coupled system via the matter component of fermionic nature undergoing saturation - in contrast to commonly used cavity-mediated excitation which determines the evolution of the system at high occupations. Exploring the driving strength-dependence we establish robust fingerprint of the transition to be the maximum in the resonance fluorescence signal [1].

[1] C. Hopfmann et al., arXiv:1609.03462 (2016).

Coffee Break

HL 86.7 Fri 11:30 POT 112

Submicron scanning X-Ray diffraction imaging of strain in VO_2 microwires. — •Andreas Johannes[1], Jura Rensberg[2], Carsten Ronning[2], and Manfred Burghammer[1] — [1]ESRF - The European Synchrotron, 38043 Grenoble, France — [2]Institut für Festkörperphysik, Friedrich-Schiller-Universität Jena, Max-Wien-Platz 1, 07743 Jena, Germany

X-Ray diffraction remains the go-to method to identify and characterize the crystal structure of a given material. In general, the small brilliance of lab sources means that large volumes of single crystalline or powdered material have to be investigated, averaging over all localized effects. At the increasing number of synchrotron based, focused X-Ray beam-lines, however, it is becoming possible to perform scanning experiments that yield specially resolved diffraction data. The advantages of this method are highlighted in the scientific case of imaging the strain and multiple-phase-coexistence in VO_2 microwires.

HL 86.8 Fri 11:45 POT 112

EPR and DFT investigation of Fe and Fe-Ti doping in LiNbO3 — •Sara Arceiz Casas[1], Simone Sanna[1], Annamaria Zaltron[2], Giacomo Bettella[2], Gianluca Pozza[2], Cinzia Sada[2], and Siegmund Greulich-Weber[1] — [1]University of Paderborn, Warburger Str. 100, 33098 Paderborn, Germany — [2]University of Padova, Via Marzolo 8, 35131 Padova, Italy

The optical properties of Ti4+ indiffused LiNbO3 waveguides are heavily affected by extended and point defects. In particular, even small percentages of unintentional iron doping increase the photorefractive sensitivity of LiNbO3 considerably.

Ti4+ is known to stabilize Fe2+ impurities against oxidation[1], however, neither the defect complexes formed by Fe and Ti nor the mechanisms leading to the optical degrade are known. As a first step towards the understanding of the photorefractive properties of the waveguides, we investigate isolated Fe and Fe-Ti doped LiNbO3 [2,3] by electron paramagnetic resonance (EPR) and density functional theory (DFT).

Signals originating from different defect centers can be discriminated by EPR in Fe doped and Fe-Ti co-doped samples. Corresponding theoretical models are developed within DFT, showing the structural and electronic properties of the observed defects.

[1] V. Gericke, Appl. Phys. B 44, 155 (1987)
[2] O. F. Schirmer, J. Phys.: Cond. Matt. 21, 123201 (2009)
[3] O. F. Schirmer, Phys. Rev. B 83, 165106 (2011)

HL 86.9 Fri 12:00 POT 112

Hyperdoping silicon with tellurium by ion implantation and ultra-short annealing for optoelectronics — •Mao Wang[1,2], Fang Liu[1,2], Ye Yuan[1,2], Slawomir Prucnal[1], Berencen Yonder[1], Rebohle Lars[1], Wolfgang Skorupa[1], Manfred Helm[1,2], and Shengqiang Zhou[1] — [1]Helmholtz-Zentrum Dresden-Rossendorf, Institute of Ion Beam Physics and Materials Research — [2]Technische Universität Dresden

Hyperdoping silicon with chalcogen atoms is a topic of increasing interest due to the strong sub-band gap absorption exhibited by the resulting materials, which can be exploited to develop infrared photodetectors and intermediate band solar cells [1-3]. In our work, tellurium-hyperdoped silicon layers have been fabricated by ion implantation followed by flash lamp annealing (FLA) or pulsed-laser melting (PLM). The Rutherford backscattering spectrometry / Channeling (RBS/C) results reveal the high-quality recrystallization of tellurium implanted silicon by both FLA and PLM. From the transport measurements, an insulator-to-metal transition is observed with increasing tellurium concentration. Moreover, the ellipsometry measurements show that the band gap narrows with increasing doping concentration. And the Fourier transform infrared (FTIR) spectroscopy show that tellurium hyperdoped Si has strong infrared absorption. All these results give us a signal that hyperdoped silicon with tellurium could enable silicon-based optoelectronics in the infrared band. [1] Kim, T. G., et al., Appl. Phys. Lett. 88, 241902 (2006) [2] Tabbal, M., et al., Appl. Phys. A 98, 589*594 (2010) [3] Umezu, I., et al., J. Appl. Phys. 113, 213501 (2013)

HL 86.10 Fri 12:15 POT 112

Preparation and characterization of self-assembled monolayers on different semiconductive substrates for bio-sensing applications. — •Stefano Gremmo, Johannes Bartl, Martin Stutzmann, and Anna Cattani-Scholz — Walter Schottky Institut, Technische Universität München, München, Germany

Aim of the present work is to realize and characterize bio-interfaces based on self-assembled monolayers of phosphonic acids (SAMPs) stable under physiological conditions, to implement a label-free transduction mechanism for DNA detection. Such process is performed on different semiconductive substrates, such as ZnO and SiN, to investigate their characteristics and performance in detecting the target molecules.

SAMPs of (2-2-[2-hydroxy-ethoxy]-ethoxy-ethyl) phosphonic acid and 11-hydroxy-undecylphosphonic acid are generated on the substrates using a process based on tethering by aggregation and growth (T-BAG). By additional surface functionalization protocols, peptide nucleic acid (PNA) is covalently bound to biocompatible SAMPs interfaces.

Characterization of the electrochemical sensing ability of these new devices is achieved by cyclic voltammetry (CV) and electrochemical impedance spectroscopy (EIS). Structural and morphological properties are investigated by several surface sensitive techniques such as contact angle (CA) measurements, atomic force microscopy (AFM) and X-ray photoelectron spectroscopy (XPS).

HL 86.11 Fri 12:30 POT 112

Photonic crystal fibers with disordered claddings — •Swaathi Upendar[1], Guangrui Li[2], Maxim L. Nesterov[1], Markus Schmidt[2], and Thomas Weiss[1] — [1]4th Physics Institute and Research Center SCoPE, University of Stuttgart, Germany — [2]Leibniz Institute of Photonic Technology, Jena, Germany

Photonic crystal fibers use the photonic band gap effect to confine light in a central defect core with a periodic lattice as its cladding. When such photonic crystal fibers are fabricated, the cladding is never truly perfect as the fabrication process can result in different types of disorder such as diameter, position and shape disorder.

In this contribution, we present numerical investigations of the influence of disorder on the density of cladding states and the dispersion of the fundamental mode of the fiber. In particular, we investigate diameter disorder for an all solid fiber with high index strands in a silica background. We find that the response of the fiber is highly dependent on the range of diameter fluctuations. While fluctuations in the whole cladding region results in a narrowing of the band gap and hamper the light guidance, we observe that disorder in the core surround provides additional means to control the properties of the guided modes and to reduce the confinement loss.