HL 75: Poster IIIB

This poster session includes contributions from the following topics:

- Functional semiconductors for renewable energy solutions - Materials and devices for quantum technology - Optical properties - Thermal properties - Focus Session: Tailored Nonlinear Photonics

Please put up your poster at the beginning of the session and remove the poster immediately after the session. The person peresenting the poster should attend it for at least half of the session duration and indicate the time when to find him/her at the poster.

Time: Thursday 15:00–17:30 Location: P2/3OG

HL 75.1 Thu 15:00 P2/3OG

Classification of Silicon Carbide for Maser Application by Electron Paramagnetic Resonance — •S. Scherbel, A. Gottscholl, C. Kasper, V. Soltamov, V. Dyakonov, and A. Sperlich — Experimental Physics VI, Julius Maximilian University of Würzburg, 97074 Würzburg

Although masers have been known for decades, their application as low noise amplifier is still limited due to their operating conditions, requiring vacuum and cryogenic temperatures. Hence, our aim is to build a room-temperature maser based on spin-carrying defects in the technologically advanced material silicon carbide (SiC). To generate such spin-carrying defects, in our case the negatively charged silicon vacancies (V_{Si}), the SiC crystal was exposed to high-energy particles (electrons or neutrons). To obtain population inversion we optically pumped the ground state spin sublevels of V_{Si}. By applying an external magnetic field we tuned the Zeeman splitting into resonance with an applied microwave frequency of 10 GHz [1]. Using magnetic resonance techniques, we quantified the population inversion within V_{Si} spin sublevels for different SiC polytypes (4H, 6H) and irradiation methods for a wide range of irradiation doses. Finally, we studied the influence of optical pump power, temperature and samples orientation with respect to the external magnetic field on the population inversion. Our systematic study specifies the parameters, necessary for SiC to become a suitable maser system with a wide-ranging applicability.
[1] H. Kraus et al., Nat. Phys. **10**, 152 (2014)

HL 75.2 Thu 15:00 P2/3OG

Temperature dependent optical properties of CuI thin film — •Jan Kremkow, Vitaly Zviagin, Evgeny Krüger, Chang Yang, Chris Sturm, and Marius Grundmann — Universität Leipzig, Felix-Bloch-Institut für Festkörperphysik

We present the optical properties of copper iodide (CuI) thin film fabricated by reactive sputtering at 360 °C on c-sapphire substrate. The dielectric function (DF) was determined by the means of spectroscopic ellipsometry in a wide spectral range (0.5 eV - 8.5 eV) and in the temperature range from 10 K to 300 K. The DF line-shape was initially determined numerically and consequently parametrized by a series of model functions. The DF spectra was found to be dominated by electronic transitions involving the Γ- and L- symmetry points of the CuI Brillouin zone.[1] Their evolution with temperature is investigated with respect to the Bose-Einstein model approximation. The results show a general agreement with literature and give insight into the temperature dependence of CuI electronic structure. [1] E. Krüger *et al.*, Appl. Phys. Lett. **113**, 172102 (2018).

HL 75.3 Thu 15:00 P2/3OG

Raman spectroscopy on anisotropic media — •Ron Hildebrandt[1], Chris Sturm[1], Matthias Wieneke[2], Armin Dadgar[2], and Marius Grundmann[1] — [1]Universität Leipzig, Felix Bloch Institute for Solid State Physics, Germany — [2]Otto-von-Guericke Universität Magdeburg, Institute for Physics, Germany

Raman spectroscopy is a widely used technique e.g. for the determination of the phonon modes, alloy composition, crystalline orientation or characterization of crystalline quality. In optically anisotropic materials, the polarization of the incident and scattered light changes along the propagation within the crystal due to birefringence. Thus the "standard" Raman tensor formalism cannot be applied there. Recently we presented a modified Raman tensor formalism which allows to model the Raman intensity in dependence on the polarization configuration for any crystal symmetry [1,2]. For an optically uniaxial crystal with the optical axis in the surface plane, the effective standard Raman formalism is recovered except an additional phase factor needs to be added to the Raman tensor elements. This phase factor depends only on the material's birefringence and the penetration depth.

Here we investigated exemplarily on a-plane GaN the phase factor as a function of the penetration depth by varying the film thickness from 0.7 to 12 μm. The experimentally determined phase factors agree very well with predictions by the modified Raman formalism.

[1] C. Kranert *et al.*, Phys. Rev. Lett., **116**, 127401, 2016.
[2] C. Kranert *et al.*, Sci. Rep., **6**, 35964, 2016.

HL 75.4 Thu 15:00 P2/3OG

On the calculation of the band gap of periodic solids with MGGA functionals using the total energy — •Fabien Tran — Vienna University of Technology, Vienna, Austria

During the last few years, it has become more and more clear that functionals of the meta generalized gradient approximation (MGGA) are more accurate than GGA functionals for the geometry and energetics of electronic systems. However, MGGA functionals are also potentially more interesting for the electronic structure, in particular when the potential is non-multiplicative (i.e., when MGGAs are implemented in the generalized Kohn-Sham framework), which may help to get more accurate band gaps. Here, we show that the calculation of band gap of solids with MGGA functionals can be done very accurately also in a non-self-consistent manner. This scheme uses only the total energy and can, therefore, be very useful when the self-consistent implementation of a particular MGGA functional is not available. Since self-consistent MGGA calculations may be difficult to converge, the non-self-consistent scheme may also help to speed-up the calculations. Furthermore, it can be applied to any other types of functionals, for which the implementation of the corresponding potential is not trivial.

HL 75.5 Thu 15:00 P2/3OG

In-situ Fabrication of Magnetic Topological Insulator Devices — •Max Vassen-Carl[1], Michael Schleenvoigt[1], Tobias W. Schmitt[2], Abdur R. Jalil[1], Stefan Trellenkamp[3], Florian Lentz[3], Gregor Mussler[1], Peter Schüffelgen[1], and Detlev Grützmacher[1] — [1]Peter Grünberg Institute, Forschungszentrum Jülich & JARA Jülich-Aachen Research Alliance, 52425 Jülich, Germany — [2]JARA-FIT Institute Green IT, RWTH Aachen University, 52062 Aachen, Germany — [3]Helmholtz Nano Facility, Forschungszentrum Jülich GmbH, 52425 Jülich, Germany

Magnetic topological insulators (MTIs), which have their Fermi level in the exchange gap exhibit the quantum anomalous Hall (QAH) effect with chiral edge states. The latter are of high interest to spintronic applications. Moreover, by proximity coupling the MTI to a superconductor (SC), chiral Majorana edge modes are expected to arise. To access the QAH regime in MTIs, it is beneficial to avoid ambient conditions or chemicals during device fabrication, which may disturb the sensitive surface states. This makes ultra-high vacuum (UHV) fabrication techniques highly interesting for these materials. I will present a UHV technique that enables molecular beam epitaxy (MBE) growth of MTIs ((Cr)z(Bi,Sb)2-z(Te,Se)3) in selected areas on silicon substrates. In a second step, a normal conductor or SC can be deposited in-situ onto the MTI utilizing an angular arrangement, effectively creating MTI devices in the MBE without breaking the vacuum.

HL 75.6 Thu 15:00 P2/3OG

Raman spectra under hydrostatic pressure: a first principles investigation — •Jan M. Waack[1,2], Marcel Giar[1], and Christian Heiliger[1,2] — [1]Institut für theoretische Physik, Justus-Liebig-Universität Gießen, Gießen — [2]Zentrum für Materialforschung (LaMa), Justus-Liebig-Universität Gießen, Gießen

In a first principles investigations the vibrational properties of Cu_4O_3

(paramelaconite) under hydrostatic pressure were derived from DFT calculations. With increasing hydrostatic pressure on the system, imaginary phonon frequencies occur. These determine the limit of the stability of the tetragonal Cu_4O_3 in respect to hydrostatic pressure. It became recognizable, that the influence on intensities of Raman peaks strongly depends on the laser wavelength. The resulting effects on Raman spectra are discussed. Additionally, a change of the lattice parameters leads to a clear shift of the Raman peak positions. The impact on the calculations of Raman spectra are explained.

HL 75.7 Thu 15:00 P2/3OG

Open-gate junction field effect transistors as cryogenic charge detectors with attoampere leakage — •Tom Risse, Hüseyin Azazoglu, Kornelia Huba, Hermann Nienhaus, and Rolf Möller — Faculty of Physics/Cenide, University of Duisburg-Essen, Germany

Open-gate junction field effect transistors (JFET) at cryogenic temperatures can be employed as almost perfect charge detectors with leakage currents of less than 0.1 aA [1]. The minimum detectable charge is primarily determined by the leakage current between the source and gate terminals. The intrinsic leakage current is due to a generation of charge carriers in the pn-depletion zone and may be well described by the Shockley-Reed-Hall model. The extrinsic leakage current occurs through parasitic resistive current paths outside the JFET, e.g. due to contaminations. Both contributions can be precisely distinguished by measuring the variation of a gate discharge current with time. The study reports on the intrisic leakage current in the JFET BF545B at 220 K and at room temperature. By reducing the parasitic resistances a leakage current of 2.1 aA is achieved and charges of only 14 aC can be determined. The gate contact of the cryogenic device is successfully connected to an external electrode which allows sensitive charge detection in setups at room temperature. Examples of low charge detection due to UV- , alpha- and beta radiation as well as of detection of moving charged droplets by electrostatic induction are demonstrated. [1] A. Kavangary et al. AIP Advances 9, 025104 (2019).

HL 75.8 Thu 15:00 P2/3OG

Simulating the influence of spectral jitter and phonons on four-wave mixing signals of single quantum dots — •Thilo Hahn, Daniel Wigger, and Tilmann Kuhn — Institut für Festkörpertheorie, Universität Münster, Wilhelm-Klemm-Str. 10, 48149 Münster

Four-wave mixing (FWM) micro-spectroscopy is a powerful technique to investigate the dynamics of charge carriers in semiconductor nanostructures. By using a heterodyne interferometry technique one is able to detect coherence as well as occupation dynamics of a single quantum dot [1]. We model the QD exciton as a two-level system, excited by a series of ultrafast pulses. Additionally we take the pure dephasing coupling to a discrete phonon mode into account. By introducing characteristic functions the dynamics of the entire exciton-phonon system can be calculated analytically in the limit of ultrafast optical excitation [2]. We will present photon echo formation as a consequence of a randomization of the transition energy due to for example charge fluctuations [3]. Then we take the coupling to a discrete phonon mode into account and discuss its impact on FWM signals.

[1] W. Langbein, *Rivista Del Nuovo Cimento* **33**, 5 (2010)
[2] A. Vagov, et al., *Phys. Rev. B* **66**, 165312 (2002)
[3] T. Jakubczyk, et al., *ACS Photonics* **3**, 2461-2466 (2016)

HL 75.9 Thu 15:00 P2/3OG

Four-Wave-Mixing Spectroscopy of a Quantum Dot Microcavity System at Large Pulse Areas — •Daniel Groll[1], Daniel Wigger[1], Jacek Kasprzak[2,3], and Tilmann Kuhn[1] — [1]Institut für Festkörpertheorie, Universität Münster, Wilhelm-Klemm-Str. 10, 48149 Münster — [2]Univ. Grenoble Alpes, F-38000 Grenoble, France — [3]CNRS, Institut Néel, "Nanophysique et Semiconducteurs" Group, F-38000 Grenoble, France

We use four-wave-mixing (FWM) spectroscopy to investigate a single quantum dot (QD) strongly coupled to a microcavity, which we model by the usual Jaynes Cummings (JC) Hamiltonian. The corresponding spectrum is called the JC ladder and consists of doublets of dressed states with a splitting that depends nonlinearly on the number of photons present in the cavity. The inevitable coupling between the QD exciton and the phonons of the surrounding medium is treated using a master equation approach. In our study special emphasis is laid on the behavior of the system, when a large number of photons, up to ∼50, is excited inside the cavity. Reaching large pulse areas, where such an amount of photons drives the dynamics, we observe a quasiperiodic behavior of the cavity polarization which gives rise to characteristic features in the measured FWM signals. We find good agreement between experiment and theory for the entire range of considered pulse areas.

HL 75.10 Thu 15:00 P2/3OG

Open optical microcavities for tunable light–matter coupling with 2D semiconductors — •Chirag Palekar, Franziska Wall, Oliver Mey, Lorenz Maximilian Schneider, and Arash Rahimi-Iman — Faculty of Physics and Materials Sciences Center, Philipps-Universität Marburg, Marburg, 35032, Germany

Light–matter coupling experiments with 2D semiconductors such as transition-metal dichalcogenides in optical microcavities are very attractive due to the strong excitonic binding energies, spin–valley locking and the overall prospect of polariton Bose condensation at elevated temperatures. In this context, microcavities with tunable length, low mode volume and open resonator configuration can be very useful for the systematic variation of the system's parameters [1]. Moreover, tuning between the weak and strong coupling regime becomes feasible, as discussed here based on our simulations. We use the transfer-matrix method to show how to tailor and alter the coupling strength actively by varying the relative field strength at the excitons' position. Therefore, a transparent PMMA spacer layer and angle-dependencies of optical resonances are exploited [2]. The adjustable polariton energy levels could be interesting for polariton chemistry or optical sensing. In addition, cavities that allow working at the exceptional point promise the exploration of topological properties of that point. [1] P. Qing et al., *APL* 114, 021106 (2019). [2] F. Wall et al., *arXiv* (2019).

HL 75.11 Thu 15:00 P2/3OG

Transient four-wave-mixing in semiconductors with half-gap pulses — •Alexander Trautmann[1], Wolf-Rüdiger Hannes[1], Markus Stein[2], Felix Schäfer[2], Martin Koch[2], and Torsten Meier[1] — [1]Department of Physics and CeOPP, University of Paderborn, Warburger Straße 100, D-33098 Paderborn, Germany — [2]Department of Physics and Materials Science Center, Philipps-Universität Marburg, Renthof 5, D-35032 Marburg, Germany

Transient four-wave-mixing (FWM) is demonstrated to occur in bulk semiconductors when excited by two spatiotemporally overlapping strongly off-resonant pulses. This $\chi^{(3)}$-process can be analyzed theoretically by means of the semiconductor Bloch equations including inter- and intraband excitations [1]. As a result of the interference of different excitation pathways, characteristic multi-peak structures may appear in the FWM spectra. The spectra are also significantly broadened compared to the width of the incident pulses. These theoretical findings are qualitatively confirmed by spectrally-resolved FWM experiments on bulk CdTe and bulk GaAs samples with excitation wavelengths near half the band gap.

[1] W.-R. Hannes and T. Meier, Phys. Rev. B **99**, 125301 (2019).

HL 75.12 Thu 15:00 P2/3OG

Cesium-Vapor-Based Delay of Single Photons Emitted by Deterministically Fabricated Quantum Dot Microlenses — •Lucas Bremer[1], Sarah Fischbach[1], Suk-In Park[2], Sven Rodt[1], Jin-Dong Song[2], Tobias Heindel[1], and Stephan Reitzenstein[1] — [1]Institut für Festkörperphysik, Technische Universität Berlin, 10623 Berlin, Germany — [2]Center for Opto-Electronic Materials and Devices, Korea Institute of Science and Technology, Seoul 02792, Republic of Korea

Controlling the propagation of single photons is highly relevant for the implementation of large-scale quantum networks. We report on the realization of a hybrid interconnection of a high-performance quantum dot (QD) microlens with hot cesium (Cs) vapor, allowing to control the time delay of the emitted photons [1]. The QD microlens with excellent optical properties was realized by a deterministic 3D in-situ electron beam lithography process [2]. By numerical simulations of the light-matter interaction in realistic QD-Cs vapor configurations, the influence of the Cs vapor temperature and the spectral QD-atom detuning is investigated in detail in order to maximize the achievable delay in experimental studies. Thus, our hybrid quantum system enables us to delay the emission pulses by up to (15.71 ± 0.01) ns for an effective Cs cell length of 150 mm.

[1] L. Bremer et al., Adv. Quantum Technol., 1900071 (2019).
[2] M. Gschrey et al., Appl. Phys. Lett. 102, 251113 (2013).

HL 75.13 Thu 15:00 P2/3OG

Optical properties of TiN based superlattices: applicability of the effective medium approximation — •Felix-Florian Delatowski, Chris Sturm, Oliver Herrfurth, Florian Jung, and Marius Grundmann — Felix-Bloch-Institut für Festkörperphysik, Universität Leipzig, Linnéstraße 5, 04103Leipzig

Superlattices based on MgO and TiN are promising for the realization of optical hyperbolic metamaterials [1]. In order to show such hyperbolic behavior, it is possible to describe a superlattice by an uniaxial anisotropic effective medium [2]. The effective medium approximation (EMA) allows a simplified description of the optical properties of the entire superlattice.

In this study, we discuss the applicability of the EMA for TiN/MgO superlattices as a function of the number of layer pairs and thickness of each individual layer. The obtained results are compared to experimental TiN/MgO superlattices grown by pulsed laser deposition and investigated by spectroscopic ellipsometry.

[1] G. Naik *et al.*, PNAS **111**, 7546 (2014).
[2] S. Rytov, Soviet Physics JETP **2**, 466 (1956).

HL 75.14 Thu 15:00 P2/3OG

Applying infrared thermography for thermal interface analysis — •Steven Becker and Manfred Bayer — TU Dortmund University, Dortmund, Germany

Combining μLEDs to array-structures enables the manufacturing of high-resolution light sources in a small form factor. Thermal interface analyses are crucial to improve these devices, but chip-level electronics limit the pixel-wise accessibility of the required junction temperature. Here we present an approach to overcome this limitation by using thermal images as data for the JEDEC 51-14 standard's calculation. Thermal imaging cameras are promising candidates due to their spatially resolved and contactless measurement of the μLED array temperature.

HL 75.15 Thu 15:00 P2/3OG

Novel Concepts for Angle-Resolved Photoemission Spectroscopy and Transport Characterization of 1-Dimensional Topological Insulator/Superconductor Heterostructures — •Kevin Janssen[1,2,4], Abdur Rehman Jalil[2,4], Tristan Heider[1,4], Michael Schleenvoigt[2,4], Tobias Schmitt[3,4], Gregor Mussler[2,4], Peter Schüffelgen[2,4], Claus-Michael Schneider[1,4], Detlef Grützmacher[2,4], Lukasz Plucinski[1,4], and Thomas Schäpers[2,4] — [1]Peter Grünberg Institute (PGI-6), Forschungszentrum Jülich GmbH, 52425 Jülich, Germany — [2]Peter Grünberg Institute (PGI-9), Forschungszentrum Jülich GmbH, 52425 Jülich, Germany — [3]Peter Grünberg Institute (PGI-10), Forschungszentrum Jülich GmbH, 52425 Jülich, Germany — [4]JARA-FIT, RWTH Aachen University and FZ-Jülich GmbH

Heterostructures formed by topological insulators (TI's) and superconductors are the main basis for topological quantum computing. Quantum processors employing Majorana fermions demand high purity and one dimensionality of these structures. With our integrated approach we aim to characterize these heterostructures of TI nanoribbons and superconductors by comparing angle-resolved photoemission spectroscopy (ARPES) and transport measurements. Here, we present a novel in-situ fabrication scheme to realize one dimensional heterostructures of TI and superconductor for transport characterization by combining selective area growth and a newly developed shadow technique. Additionally, we show indications of the Dirac cone by ARPES from an array of TI nanoribbons.

HL 75.16 Thu 15:00 P2/3OG

Multi-probe electrical characterization of pn-GaAs-based nanowires under illumination — •Juliane Koch, Andreas Nägelein, Matthias Steidl, Peter Kleinschmidt, and Thomas Hannappel — TU Ilmenau, Institute for Physics, Fundamentals of Energy Materials, Ilmenau, Germany

Semiconducting nanowires (NW) are known as promising candidates for a large variety of future optoelectronic devices, such as for solar energy conversion devices. For their beneficial use it is essential to control doping profiles along the NW with abrupt charge-separating contacts and to assess their optoelectronic performance. This can be achieved by appropriate electronic and optoelectronic characterization. In this work, a multi-tip scanning tunneling microscope (MT-STM), which is equipped with a scanning electron microscope (SEM), enables the independent control of four tungsten-tips, which are employed to perform 2- and 4-point I-V-measurements on individual, freestanding NWs with high spatial resolution. We were able to to record measurements on NW comprising pn-junctions, both with and without illumination. The resulting resistance profiles without illumination provide direct access to the doping profiles, so that the doping concentration of the p- and the n-doped region can be determined as well as the position of the charge-separating contact. Measurements under illumination yields the photocurrent as well as the fill factor associated with the I-V characteristic of the illuminated NW. In addition, the charge-separating contact can be visualized in the SEM by detection of the electron beam induced current.

HL 75.17 Thu 15:00 P2/3OG

Ab initio study on structural and electronic properties of carbon defects in SiC(0001)/SiO$_2$ systems — •Takuma Kobayashi[1,2] and Yu-ichiro Matsushita[1] — [1]Tokyo Institute of Technology, Yokohama, Japan — [2]Friedrich-Alexander-Universität Erlangen-Nürnberg, Erlangen, Germany

Silicon Carbide (SiC) has been regarded as a promising material for power devices owing to its superior physical properties, such as wide bandgap and high critical field strength. SiC metal-oxide-semiconductor field effect transistors (MOSFETs) have, however, suffered from their unexpectedly low channel mobility due to the high interface state density of SiC/SiO$_2$ systems. So far, carbon byproducts created during the oxidation of SiC were pointed out as a strong candidate for the interface states. In the present study, we report the stable atomic structures of carbon defects in SiC, silicon dioxide (SiO$_2$), and those at their interface, depending on the oxidation environment. We also discuss their impact on the device performance based on the calculated defect levels.

HL 75.18 Thu 15:00 P2/3OG

Development of ab initio equations describing optical properties in solids — •Nicolas Schüler, Tobias Zier, and Martin Garcia — Theoretische Physik, Universität Kassel, Heinrich-Plett-Str. 40, 34132 Kassel, Germany

Optical properties of materials are crucial to describe femtosecond-laser pulse excitations properly, since they determine the absorbed energy by the system. However, in regular density functional theory these properties are not included. In order to extend our density functional theory code CHIVES, we seek to develop an analytical theory that describes optical properties in solids and is compatible to our code. In CHIVES the valence electrons are described by atom-centered Gaussian basis sets, which needs a different description than available theories using plane waves, e.g., implemented in WIEN2k. In order to develop such theory, we start from textbook description using Maxwell's equations. This path enables us to understand the nature of optical properties and allow us to derive first equations for metals, which then will be extended to semiconductors. Parallel to this path we consider a different approach, which uses the Berry phase to obtain optical properties of systems. Besides the more precise description of femtosecond-laser excitations in general, this important extension of our code will allow us to directly compare our simulations to optical measurements like time-resolved reflectivity measurements.

HL 75.19 Thu 15:00 P2/3OG

Towards a fully electrically tunable entangled photon source — •Zheng Zeng[1], Arne Ludwig[2], Marcel Schmidt[2], Beata Kardynał[1], and Feng Liu[3] — [1]Peter Grünberg Institute (PGI-9), Forschungszentrum Jülich, 52425 Jülich, Germany — [2]Lehrstuhl für Angewandte Festkörperphysik, Ruhr-Universität Bochum, 44780 Bochum, Germany — [3]JARA-Institute for Quantum Information, RWTH Aachen University, 52074 Aachen, Germany

An entangled photon source (EPS) is one of the key components for optical quantum computing and quantum network. Bright sources of entangled photon pairs have already demonstrated using In(Ga)As self-assembled quantum dots (QDs). However, their scalability and entanglement fidelity are limited by the broad energy distribution and energy splitting between bright exciton states (fine structure splitting (FSS)). In this work, we aim to develop a fully electrical tunable on-demand EPS based on InAs QDs. Simultaneous tuning of the QD transition energy and FSS is essential to achieve this goal. To this end, we fabricated devices with a full back gate and split front gates. We measured the tuning of the QD transition energy by electric field along the QD growth direction via the quantum Stark effect and the tuning of the FSS by the in-plane electric field. Our results strongly indicate that our device can be potentially used as a fully electrically tunable EPS.

HL 75.20 Thu 15:00 P2/3OG

Exceptional Points in optical anisotropic semiconductors — •Sebastian Henn[1], Evgeny Krüger[1], Chris Sturm[1], Armin Dadgar[2], Matthias Wieneke[2], Rüdiger Schmidt-Grund[1,3], and Marius Grundmann[1] — [1]Universität Leipzig, Felix-Bloch-Institut für Festkörperphysik, Linnéstr. 5, Leipzig — [2]Otto-von-Guericke-Universität Magdeburg, Institut für Physik — [3]now at: Technische Universität Ilmenau, Institut für Physik, Weimarerstr. 25, Ilmenau

We investigate exceptional points (EP) in optically anisotropic transparent thin films both experimentally and theoretically. EP represent degeneracies in k-space and were already observed in absorptive biaxial crystals [1] and microcavities [2,3]. At the degeneracy the eigenvalues and eigenstates of the system, i.e. the complex energy and polarization, *coalesce*. This is reflected by a complex square root topology around the EP [2]. Promising systems for the realization of EP are optically anisotropic thin films, providing symmetry breaking and dissipation through losses at the interfaces. We demonstrate the presence of EP in GaN and ZnO thin films using spectroscopic Müller Matrix ellipsometry and presenting rigorous Maxwell-based calculations. We discuss ways to control the occurrence and direction of the EP by altering the design of the system. [1] W. Voigt*et al.*, Ann. Phys **314**, 367 (1902) [2] S. Richter*et al.*, Phys. Rev. Lett. **123**, 227401 (2019) [3] J. Wiersig, Phys. Rev. Lett. **112**, 203901 (2014)

HL 75.21 Thu 15:00 P2/3OG

Confocal microscopy of irradiation induced defects in silicon carbide — •Yuan Gao[2], Michael Hollenbach[1,2], Yonder Berencen[1], Gregor Hlawacek[1], Manfred Helm[1,2], and Georgy Astakhov[1] — [1]Institute of Ion Beam Physics and Material Research, Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany — [2]Technische Universität Dresden, Dresden, Germany

Photons, as the information carrier in quantum technology, can be generated from point defects in crystal structures. Silicon carbide is a promising host material for such defects that can be created by ion implantation of different types [1]. Compared to other ions, helium ions can create defects with less crystal damages and high coherence. For further applications, defects need to be integrated with nanostructures. This can be done by focused ion beam technology [2]. However, the achieved resolution using protons is not sufficient for nanometer range. Here, we present an approach to create defects locally. In this approach, silicon vacancies are fabricated with a Helium Ion Microscope using different fluences at an energy of 25keV. Upon irradiation, defects are systematically characterized by confocal spectroscopy. It is shown that the defects can be created near the surface by this approach. Moreover, the fluence dependence of the count rate and the lateral resolution are investigated. We demonstrate that this approach holds promises for fabricating silicon carbide based quantum nanostructures.

[1] J. F. Wang, et. al, ACS Photonics 6(7),1736-1743(2019). [2] H. Kraus, et. al, Nano Lett. 17(5),2865-2870(2017).

HL 75.22 Thu 15:00 P2/3OG

Identification of defect properties by positron annihilation in heavily doped n-type GaAs — •juanmei duan[1,2], maciej oskar liedke[1], manfred helm[1,2], shengqiang zhou[1], and slawomir prucnal[1] — [1]Helmholtz-Zentrum Dresden-Rossendorf, Institute of Ion Beam Physics and Materials Research, Bautzner Landstrasse 400, D-01328 Dresden, Germany — [2]Technische Universität Dresden, D-01062 Dresden, Germany

The electron concentration limits for GaAs are a universal feature existing in group VI donors and Si doping, which limits the carrier concentration to 1e19 cm-3. In our work, we can use ion implantation method beyond the equilibrium solid solubility limits to achieve heavy doped GaAs with Zn, S and Te. We can use millisecond-range flash lamp annealing (FLA) or nanosecond-range pulsed laser annealing (PLA) to reactive and recrystallize the as-implanted samples. The carrier concentration for n-type GaAs can reach up to 5 e19 cm-3. , which is much above the solid solubility of S in GaAs (~1019 cm-3) prepared by MBE. From Positron annihilation spectroscopy (PAS) results, It shows the positron lifetime from heavily n-type doped GaAs has a longer lifetime (above 500ps) and lower intensity I2 than virgin GaAs, which indicates open-volume defects become bigger, defect evolving from monovacancy to multi-vacancy with decreasing the intensity after doping and annealing process.

HL 75.23 Thu 15:00 P2/3OG

Auger Electron Detected Magnetic Resonance — •David Vogl, Paul Steinacker, and Martin S. Brandt — Walter Schottky Institut and Physik-Department, Technische Universität München, Am Coulombwall 4, 85478 Garching, Germany

For plausible quantum storage applications, long coherence times are required. As Silicon is one of the purest and best-understood materials in the world, it is a natural candidate for such implementations. We investigate and set up a measurement technique for the initialization, manipulation, and readout of electron and nuclear spins of shallow Phosphorus donors in highly isotopically purified ^{28}Si utilizing the spin-dependent and resonant excitation of donor-bound excitons and their successive Auger decay. This method was first implemented by the Thewalt group, who were able to demonstrate coherence times in the order of tens of minutes for the ionized donors at room temperature. In our work, we explore this spin system in detail, applying typical pulsed microwave sequences to measure Rabi oscillations, Ramsey fringes, and Hahn echo decays. We observe beatings in the electron spin Rabi oscillation and are able to selectively generate spin hyperpolarization of the ^{31}P nuclei via a cross relaxation. This technique is also applicable to donors with nuclear spin higher than 1/2, which opens up the possibility of examining the quadrupolar spin interaction in more detail.

HL 75.24 Thu 15:00 P2/3OG

Time-resolved micro-photoluminescence of CuI microwires — •A. Müller[1], E. Krüger[1], G. Benndorf[1], S. Blaurock[2], V. Gottschalch[2], H. Krautscheid[2], C. Sturm[1], and M. Grundmann[1] — [1]Universität Leipzig, Felix-Bloch-Institut für Festkörperphysik — [2]Universität Leipzig, Institut für Anorganische Chemie

The intrinsically p-type conducting copper iodide (CuI) with a direct band gap of 2.95 eV @ 300 K [1] and high exciton binding energy is a promising material for a variety of applications like in transparent semiconductor devices. In particular, CuI micro and nanostructures with high optical quality are well suited candidates for building blocks in integrated optoelectronic circuits. Although photoluminescence emission properties of such CuI crystals have been recently reported [2], the dynamical aspects remain almost unexplored. We report on spectral and dynamical properties of the near band gap emission of CuI microwires, grown by vapor-phase transport method [2]. At low temperatures (10 K) several excitonic emission lines are observed, proving high optical quality of the investigated microwires. The decay of the observed transitions can be modeled by biexponential decay indicating different recombination channels. Here, we focus on the dependence of the decay characteristics on the excitation conditions at low temperature (10 K) as well as their temperature dependence in the range between 10 K and 300 K.

[1] M. Grundmann *et al.*, Phys. Status Solidi A **210**, 1671 (2013)
[2] M. Wille *et al.*, Appl. Phys. Lett. **111**, 031105 (2017)

HL 75.25 Thu 15:00 P2/3OG

Surface modification and charge carrier dynamics of materials and structures for semiconductor-based solar water splitting applications under operation conditions — •Elena Vedel[1], Dani Olfa[1], Mario Kurniawan[2], Theo Pflug[3], Sascha Kürth[1], Noah Hill[1], Shirly Espinoza[4], Mateusz Rebarz[4], Markus Olbrich[3], Oliver Herrfurth[5], Stefan Krischok[1], Alexander Horn[3], Jakob Andreasson[4], Rüdiger Schmidt-Grund[1], Andreas Bund[2], and Thomas Hannappel[1] — [1]Institut für Physik, TU Ilmenau, Weimarer Straße 25, 98693 Ilmenau, Germany — [2]Institut für Werkstofftechnik, TU Ilmenau, Weimarer Straße 25, 98693 Ilmenau, Germany — [3]Laserinstitut Hochschule Mittweida, Technikumplatz 17, 09648 Mittweida, Germany — [4]ELI Beamlines/Fyzikální ústav AV CR, v.v.i., Za Radnicí 835, 25241 Dolní Břežany, Czech Republic — [5]Felix-Bloch-Institut für Festkörperphysik, Uni Leipzig, Linnéstr. 5, 04103 Leipzig, Germany

We present investigations on InP-based materials and heterostructures for applications in photo-chemical water splitting by (fs-time resolved) spectroscopic ellipsometry and real-structure methods. i) We sensitively monitored the modification/corrosion of the semiconductor surfaces under operation in aqueous environment in dependence on the strength and duration of the photo-current flow. ii) The dynamics of the dielectric functions provides access on the dynamics of both, photoexcited electrons and holes in dependence on the carriers' excess energy [1,2] as well as on their transport to the active interface.

[1] APL **115**, 212103 (2019). [2] arXiv:org/abs/1902.05832v2 (2019).

HL 75.26 Thu 15:00 P2/3OG

Dielectric function tensor of ZnO microwires determined by spatially resolved spectroscopic ellipsometry — •Noha Hill[1], Matthias Duwe[2], Sebastian Funke[2], Chris Sturm[3], Lukas Trefflich[3], Marius Grundmann[3], Stefan Krischok[1], and Rüdiger Schmidt-Grund[1] — [1]Institut für Physik, Technische Universität Ilmenau, Weimarer Straße 25, 98693 Ilmenau, Germany — [2]Accurion GmbH, Stresemannstr. 30, 37079 Göttingen, Germany — [3]Felix-Bloch-Institut für Festkörperphysik, Universität Leipzig, Linnéstr. 5, 04103 Leipzig, Germany

ZnO-based nano- and microwire microcavities are very promising systems for room-temperature lasing and quantum-optical applications [1]. But up to know, the optical dispersion functions are not known exactly, there is much evidence that they differ from that of single crystalline bulk material. We have obtained the dielectric function tensor from a single microwire by imaging ellipsometry. The measurements and geometrical conditions provide us with data from three different experimental configurations simultaneously: i) signals from reflection at the top facet of the wire, ii) the same but superimposed with reflections from the wires backside, iii) signals where the light is normally transmitted through the wire and reflected at the substrate. All those were measured for two types of substrates which are SiO_2/Si as well as gold. Especially the transmitted signal, in configuration perpendicular to the wires axis and thus to the crystals *c*- or optic axis, gives us a very sensitive access to the materials birefringence.

[1] R. Schmidt-Grund *et al.*, phys stat sol b, **256**, 1800462 (2019).

HL 75.27 Thu 15:00 P2/3OG

Electrical readout of NV- centers — •Lina Todenhagen and Martin S. Brandt — Walter Schottky Institut and Physik-Department, Technische Universität München, Garching, Germany

The charged nitrogen-vacancy center (NV- center) in diamond is a remarkable option for various quantum technologies. The recently demonstrated, electrical readout dramatically reduces the complexity of NV-based sensing setups compared to the currently more widely used optical readout. Here, we report on the optimization of the electrical readout, in particular by improving the laser pulse sequences used for excitation, photoionization and reset of the NV- center, maximizing the electrically detected contrast.

HL 75.28 Thu 15:00 P2/3OG

Investigation of charge carrier dynamics in Z-scheme water splitting systems — •Nathalie Schmid, Yiou Wang, Jochen Feldmann, and Jacek Stolarczyk — Chair for Photonics and Optoelectronics, Nano-Institute Munich and Department of Physics, Ludwig-Maximilians-Universität (LMU), Königinstr. 10, 80539 Munich, Germany

The so-called "Z-scheme", mimicking the photosystem II - photosystem I in natural photosynthesis, has emerged as a cutting-edge system for efficient photocatalytic water splitting. It consists of two narrow-bandgap semiconductors and is therefore capable of absorbing light in the visible range. One semiconductor acts as oxygen evolution photocatalyst and the other as hydrogen evolution photocatalyst, connected by recycled redox pairs[1,2]. Although the trial-and-error development of materials has boosted the performance over the last two decades, the efficiencies are still far from economically satisfactory. This is mainly due to the lack of fundamental physical knowledge of a Z-scheme photosystem. Therefore, we apply transient absorption spectroscopy to investigate the charge carrier dynamics in an organic/inorganic Z-scheme system, Pt-CN/I-/IO3-/PtOx-WO3 and Pt-CN/Fe2+/Fe3+/BiVO4.

[1] Y. Wang et al., Mimicking Natural Photosynthesis: Solar to Renewable H2 Fuel Synthesis by Z-Scheme Water Splitting Systems. Chem. Rev. 118, 5201 (2018)

[2] J. Stolarczyk et al., Challenges and Prospects in Solar Water Splitting and CO2 Reduction with Inorganic and Hybrid Nanostructures, ACS Catal. 8, 3602 (2018)

HL 75.29 Thu 15:00 P2/3OG

Energieabhängigkeit der Schwellen von Polaritonen-Bistabilität — •Fabian Herbst[1], Daniel Schmidt[1], Manfred Bayer[1,2] und Marc Assmann[1] — [1]Experimentelle Physik 2, Technische Universität Dortmund, Dortmund, Germany — [2]Ioffe Institute, St. Petersburg, 194021 Russia

Auf Exziton-Polariton basierende Optikexperimente finden in den letzten Jahren Aufmerksamkeit, unter anderem durch die Entdeckung der Bistabilität von Polaritonen in Mikrokavitäts-Quantentrögen. Diese Bistabilität wird durch eine Blauverschiebung der Polaritonenmode bei höherer Population hervorgerufen. Wir untersuchen die Energieabhängigkeit ebendieser Bistabilitätsschwellen in einer (In)GaAs-Probe mittels Transmissionsmessung bei resonanter Anregung mit einem CW-Laser.

Bisherige Messungen ließen einen Anstieg der Schwellen mit steigender Laserenergie vermuten. Neue Messungen zeigen jedoch ein anderes Verhalten. Die Bistabilitätsschwelle zeigt, für gewisse Anregungsenergien im Bereich der Polaritonen, Minima der Bistabilitätsschwellen. Dies lässt darauf schließen, dass die Blauverschiebung der Polaritonmode nicht nur abhängig von der Laserleistung ist, sondern auch von der Population eines langlebigen, nicht-radiativ zerfallenden Reservoirs. Bisherige Messungen lassen vermuten, dass es sich hierbei um das Reservoir der Biexzitonen handelt, jedoch muss dies noch hinreichend nachgewiesen werden.