HL 25: Poster 1

Topics:
- 2D semiconductors and van der Waals heterostructures
- Acoustic waves and nanomechanics
- Focus Session: Perspectives in Cu(In,Ga)Se2: How to go beyond 23.4 percent
- Focus Session: Quantum Properties at Functional Oxide Interfaces
- Functional semiconductors for renewable energy solutions
- Heterostructures, interfaces and surfaces
- Optical properties
- Organic semiconductors
- Quantum dots and wires
- Quantum transport and quantum Hall effects
- Semiconductor lasers
- Spin phenomena in semiconductors
- Thermal properties
- THz and MIR physics in semiconductors
- Transport properties

Time: Wednesday 18:00–20:00 Location: P2

HL 25.1 Wed 18:00 P2

A versatile transfer printing toolbox for 2D material stacking — •Ioannis Caltzidis, Maja Groll, Julius Bürger, Marc Satison, Jörg K. N. Lindner, and Klaus D. Jöns — Institute for Photonic Quantum Systems, Center for Optoelectronics and Photonics Paderborn, and Department of Physics, Paderborn University, 33098 Paderborn, Germany

2D materials are of great interest to scientists due to the versatile integration with other materials into, for example, Van-der-Waals heterostructures. The resulting nanoscale Moiré superlattices have applications in electronic and photonic quantum technologies. In 2D materials, the electronic band structure is generally determined by the number of layers, species of materials, as well as their angular and relative translational orientation. Transfer printing 2D materials on top of each other or onto different platforms is a frequently used fabrication method for 2D devices in state-of-the-art laboratories worldwide. Here we show how our transfer printing apparatus can be used to deterministically transfer tungsten diselenide (WSe_2) on transmission electron microscope (TEM) grids for high-resolution differential phase contrast measurements, revealing the electronic field distribution. We employ water-assisted and dry transfer methods with WSe_2 on a polyvinylalcohol (PVA) - polymethylmethacrylate (PMMA) or polydimethylsiloxane (PDMS) polymer substrate. The transfer stage's translational, rotational, and azimuthal degrees of freedom enable deterministic positioning and control in the fabrication process.

HL 25.2 Wed 18:00 P2

Enhancement of Raman and Defect Photoluminescence Emission in Hexagonal Boron Nitride (h-BN) — •Felix Schaumburg, Marcel Zöllner, Vasilis Dergainlis, Axel Lorke, Martin Geller, and Günther Prinz — Faculty of Physics and CENIDE, University Duisburg-Essen, Germany

Optical spectroscopy, especially Raman- and photoluminescence (PL)-spectroscopy, is commonly used to study the optical properties of two-dimensional materials. In order to obtain the highest Raman/PL-signals, it is important to reduce the reflection of the excitation laser. We studied a number of exfoliated h-BN flakes with different thicknesses on a Si substrate with a 300 nm SiO_2 top-layer. By changing the h-BN layer-thickness, we found a specific thickness, where all Raman signals showed maximum intensity, whereas the backscattered laser light was almost completely suppressed. To explain the increased intensities, we calculated the reflectivity of the layer system (air, h-BN, SiO_2, Si) for different h-BN layer thicknesses and used the transfer-matrix-algorithm. For our 532 nm excitation laser, the minimum reflectivity was found for a h-BN flake thickness of about 160 nm. Using AFM measurements, we were able to confirm that the thickness of the h-BN flakes having the strongest Raman signals correspond almost exactly to the calculated thickness. Our results suggest, that the PL from defects will also be strongly enhanced for an h-BN thickness of 160 nm and an excitation laser wavelength of 532 nm. This optimal thickness for the defect state PL emission can easily be calculated for other excitation laser wavelengths, as well as for other materials.

HL 25.3 Wed 18:00 P2

Surface acoustic wave modulation of optical and electrical properties in TMDC monolayers — •Clemens Strobl, Benjamin Mayer, Hendrik Lambers, Ursula Wurstbauer, and Hubert Krenner — Institute of Physics, University of Münster, Germany

Two-dimensional transition metal dichalcogenides (TMDCs) such as WSe2 exhibit large exciton binding energies combined with a high sensitivity of their bandgap energy to mechanical stimuli [1]. Excitons in these materials can be generated either optically by above bandgap illumination or via two electrodes. Similarly, excitons in TMDCs can be studied optically via photoluminescence and absorption spectroscopy, electrically by detecting a photocurrent or via the interaction with surface acoustic waves (SAWs).

The aim of this project is to investigate SAW-dependent photoconductance in exfoliated monolayers [2] and to determine the influence of SAWs on the optical and optoelectronic properties in TMDCs. We study the SAW-driven exciton transport in monolayers and thus the change in the exciton decay rate [1]. For all experiments lithium niobite (LiNbO3) substrates and interdigitated electrodes (IDTs) operating at a frequency range from 300MHz up to 1GHz are used.

[1] Datta et al. Nat. Photon. 16, 242-247 (2022). [2] Preciado, E., Schülein, F., Nguyen, A. et al. Nat Commun 6, 8593 (2015).

HL 25.4 Wed 18:00 P2

Raman fingerprint of twisted TMDC bilayers — •Sina Bahmanyar, Nihit Saigal, Hendrik Lambers, Laura Schusser, Clemens Strobl, and Ursula Wurstbauer — Institute of Physics, University of Münster, Münster, Germany

The discovery of superconductivity and other correlated phases in twisted bilayer graphene opened up a new field of research aimed at understanding the many body physics and strong electronic interactions in twisted van der Waals bilayers. [1] Such bilayer systems provide an ideal platform for simulation of Hubbard model physics and its control using the relative twist angle between the layers [2] in order to tune interlayer interaction and electronic correlations. [1,2] We have fabricated twisted WSe2 bilayers with various twist angles between the monolayers and characterized them using low and high energy Raman spectroscopy and photoluminescence spectroscopy. The low-frequency Raman spectra shows the shear modes that are highly sensitive to the twist angle and interlayer coupling between the monolayers. Our measurements establish Raman spectroscopy as a non-destructive way to characterize the interlayer coupling in twisted TMDC bilayers to study electronic and excitonic correlation physics [3]. We acknowledge financial support via WU 637/7-1 and SPP2244. [1] Y. Cao et al., Nature 556, 23 (2018). [2] Y. Tang et al., Nature 579, 353 (2020) [3] L. Sigl. et al. Phys. Rev. Res. 2, 042044(R) (2020)

HL 25.5 Wed 18:00 P2

Nonlinear spectroscopy of valley polarization in transition metal dichalcogenides — •Paul Herrmann[1], Sebastian Klimmer[1], and Giancarlo Soavi[1,2] — [1]Institute of Solid State Physics, Friedrich Schiller University Jena, Jena, Germany — [2]Abbe Center of Photonics, Friedrich Schiller University Jena, Jena, Germany

Valleytronics is the branch of science that aims at controlling the valley (i.e., local maximaminima in the valenceconduction bands) degree of freedom to store, manipulate and read information. Monolayer transition metal dichalcogenides (TMDs) are promising candidates for valleytronic applications their hexagonal symmetry in the real and reciprocal space leads to the appearance of two energetically degenerate but non-equivalent valleys at the K and -K points. In addition, their direct bandgap nature in the monolayer limit enables direct optical excitation into these valleys, which can be achieved in a highly selective fashion by means of circularly polarized light [1]. All-optical control of the valley population would enable information processing at optical frequencies, thus overcoming by three to six orders of magnitude the speed of current electronic devices [2]. Here, we perform non-linear and time-resolved optical spectroscopy to study the purity and temporal evolution of the valley population in TMDs. In particular, we combine 2-photon-photoluminescence and time-resolved second harmonic measurements to investigate the impact of intra-valley relaxation and inter-valley scattering on the degree of valley polarization.

[1] Xu X. *et al.*, NPhys **10**, 5 (2014) 343-350
[2] Mitchell Waldrop M. *et al.* Nature **530**, (2016) 144-147

HL 25.6 Wed 18:00 P2

Charge carrier dependent Raman response in WS2 monolayers — •Hendrik Lambers, Nihit Saigal, and Ursula Wurstbauer — Institute of Physics, University of Münster, Münster, Germany

Semiconducting transition metal dichalcogenides such as WS2 and MoS2 are among the most widely studied 2D materials due to their unique optical and electronic properties. Monolayers of these materials show a large exciton dominated light matter coupling. Exciton-phonon and electron-phonon interaction effects are prone to modification of the charge carrier density and impacts the optical and electronic behavior of the atomically thin semiconductors [1]. Here we report on a detailed Raman study of the charge carrier dependent evolution of the phonon modes in WS2 monolayer embedded in a field effect structure using a solid-state electrolyte [2]. The optimized field effect structure using a polymer electrolyte top gating allows tuning the fermi-energy cross the band gap and hence enables ambipolar doping.

We acknowledge financial support via DFG WU 637/7-1 and SPP2244.

[1] B. Miller et al., Nat Commun 10, 807 (2019).
[2] B. Miller at al., APL 106, 122103 (2015).

HL 25.7 Wed 18:00 P2

Tuning exciton recombination rates in doped transition metal dichalcogenides — •Theresa Kuechle, Sebastian Klimmer, Marco Gruenewald, and Giancarlo Soavi — Institute of Solid State Physics, Friedrich Schiller University Jena, Helmholtzweg 5, 07743 Jena, Germany

Monolayer transition metal dichalcogenides (TMDs) are direct gap semiconductors that hold great promise for advanced applications in photonics and optoelectronics such as integrated, flexible and high-speed light emitting devices [1]. Understanding the interplay between their radiative and non-radiative recombination pathways is thus of crucial importance not only for fundamental studies but also for the design of future nanoscale on-chip devices. Here, we investigate the interplay between doping and exciton-exciton annihilation (EEA) and their impact on the photoluminescence quantum yield in different TMD samples and related heterostructures. We demonstrate that the EEA threshold increases in highly doped samples, where the radiative and non-radiative recombination of trions dominates [2]. The results are interpreted with a rate equation model that takes into account all radiative and non-radiative recombination pathways of excitons and trions in TMDs as a function of doping (*i.e.*, trion concentration) and generation rate (*i.e.*, photoexcited carrier concentration).

[1] Wang *et al.*, *Nanoscale Adv.* **2**, 4323 (2020)
[2] Kuechle *et al.*, *Opt. Mat.: X* **12**, 100097 (2021)

HL 25.8 Wed 18:00 P2

Destructive Photon Echo Formation in Six-Wave Mixing Signals Induced by Local Field Effects — •Thilo Hahn[1], Jacek Kasprzak[2], Tilmann Kuhn[1], and Daniel Wigger[3] — [1]Institute of Solid State Theory, University of Münster, Germany — [2]Université Grenoble Alpes, CNRS, France — [3]School of Physics, Trinity College Dublin, Ireland

The optical properties of transition metal dichalcogenides have emerged as an outstanding topic in nanoscience. In these materials, tightly bound excitons dominate the optical response. Ultrafast nonlinear spectroscopy is an ideal tool to study the excitonic properties and their dynamics. To model the dynamics of excitonic transitions we use a few-level system with an additional local field (LF) effect to describe exciton-exciton interaction [1]. Effectively, the LF shifts the transition energy depending on the exciton occupation, which is directly visible in pump-probe experiments [2]. In this contribution we consider six-wave mixing spectroscopy [3], where we discover a new destructive photon echo effect, that is produced by the LF contribution. In contrast to the traditional echo formed by constructive interference [4], the signal is temporarily suppressed due to destructive quantum interference.

[1] T. Hahn, et al., *New J. Phys.* 23, 023036 (2021), [2] A. Rodek et al., *Nanophotonics* 10, 2717 (2021), [3] T. Hahn, et al., *Adv. Sci.* 9, 2103813 (2021), [4] E. L. Hahn, *Phys. Rev.* 80, 580 (1950)

HL 25.9 Wed 18:00 P2

Signature of lattice dynamics in twisted 2D homo/hetero-bilayers — •Yang Pan[1,2], Shutong Li[3], Mahfujur Rahaman[1,2], Ilya Milekhin[1,2], and Dietrich R. T. Zahn[1,2] — [1]Semiconductor Physics, Institute of Physics, Chemnitz University of Technology, Chemnitz, Germany — [2]Center for Materials, Architectures, and Integration of Nanomembranes (MAIN), Chemnitz, Germany — [3]Department of Chemical Engineering and Materials Science, University of Minnesota, Minneapolis, Minnesota, USA

Twisted 2D bilayer materials are created by artificial stacking of two monolayer crystal networks of 2D materials with a desired twisting angle θ. The material forms a moiré superlattice due to the periodicity of both top and bottom layer crystal structure. The optical properties are modified by lattice reconstruction and phonon renormalization, which makes optical spectroscopy an ideal characterization tool to study novel physics phenomena. Here, we report a Raman investigation on a full period of the twisted bilayer (tB) WSe_2 moiré superlattice (*i.e.* $0° \leq \theta \leq 60°$). We observe that the intensity ratio of two Raman peaks, B_{2g} and E_{2g}/A_{1g} correlates with the evolution of moiré period. Using a series of temperature-dependent Raman and photoluminescence (PL) measurements as well as *ab initio* calculations, the intensity ratio $I_{B_{2g}}/I_{E_{2g}/A_{1g}}$ is explained as a signature of lattice dynamics in tB WSe_2 moiré superlattices. By further exploring different material combinations of twisted hetero-bilayers, the results are extended for all kinds of Mo- and W-based TMDCs.

HL 25.10 Wed 18:00 P2

Transport Measurements on Twisted Graphene Heterostructures around Magic Angle — •Bei Zheng, Xiao Yue Zhang, Jun Hui Huang, Lina Bockhorn, and Rolf J. Haug — Institut für Festkörperphysik, Leibniz Universität Hannover, 30167 Hannover, Germany

The twisting of graphene layers opens up a whole new field of rich physics [1]. Especially, the electronic properties of twisted (double Bernal-stacked) bilayer graphene layers depend strongly on the twist angle, owing to the energy band modulation from the corresponding Moiré superlattice [2,3]. Furthermore, twisted graphene structures around the magic angle were the first systems that show new many-body phases, as e. g. superconductivity or Mott insulator phases [4].

We fabricated twisted graphene heterostructures around the magic angle encapsulated in hexagonal boron via 'tear and stack' method and investigated their transport characteristics at low temperature down to 1.5 K. The longitudinal resistance was observed to periodically change with charge carrier concentration. The periodicity is relative to the superlattice density n_s and depends on how the degenerated superlattice sub-bands are filled.

[1] H. Schmidt et al., Nat. Commun. 5, 5742 (2014)
[2] J. C. Rode et al., 2D Mater. 3, 035005 (2016)
[3] S. J. Hong et al., 2D Mater. 8, 045009 (2021)
[4] Y. Cao et al., Nat. 556, 43-50 (2018)

HL 25.11 Wed 18:00 P2

Rashba Splitting Modulated by Tuned Intrinsic Dipole Moment in MoSSe/WSSe Heterostructures — •hamid mehdipour and peter kratzer — Faculty of Physics, University of Duisburg-Essen, Lotharstrasse 1, 47057 Duisburg, Germany

First-principles calculations in the framework of the density-functional theory are performed to study the van der Waals heterostructures of two Janus transition metal dichalcogenide (TMDC) monolayers, MoSSe and WSSe. Sixteen possible heterostructures of the two monolayers and their associated stackings (AA, AB) are studied. Thermal stability and electric and optical properties of all possible heterostructure configurations are investigated and compared. Owing to the lack of structural mirror symmetry in this class of TMDCs, a non-zero electric dipole moment exists for each Janus monolayer. The intrinsic dipole moments of the monolayers could build up an inter-monolayer coupling, which varies in magnitude across the possible heterostructure configuration spectrum. The total electric moment modulated by stacking could impact the overall stability of the heterostructures and their electronic and linear optical responses. Most intriguing for this class of material is the Rashba splitting of band structures for each Janus monolayer, which strongly depends on the intrinsic electric field associated with the non-zero electric moment due to the lack of mirror symmetry. By combining the DFT calculation and charge analysis, we quantify the Rashba effect for each heterostructure of MoSSe/WSSe and bring into the spotlight the role the stacking plays in modulating this effect.

HL 25.12 Wed 18:00 P2

Valley dynamics in WSe_2 monolayers and $MoSe_2$-WSe_2 heterobilayers — •Philipp Parzefall, Matthias Brem, and Christian Schüller — Institut für Experimentelle und Angewandte Physik, Universität Regensburg, Deutschland

We have performed an in depth study of the valley coherence and polarization in hBN-encapsulated WSe_2 monolayers, which shall be extended to WSe_2-$MoSe_2$ heterostructures.

Therefore, we investigate first the excitonic properties and possible exciton-phonon coupling in hBN-encapsulated WSe_2 monolayers via micro-photoluminescence and resonant Raman spectroscopy measurements with excitation energies close to the A-exciton's fine-structure. Hereby, the valley polarization and -coherence are of special interest as possible resonant phonon excitation influences the valley dynamics behavior tremendously.

Afterwards, the resulting understanding is used to investigate interlayer excitons and trions on $MoSe_2$-WSe_2 heterobilayers with 0° or 60° relative twist between the layers, similarly, with an excitation energy close to the resonances of the WSe_2's A-exciton.

HL 25.13 Wed 18:00 P2

Electrical control of orbital and vibrational interlayer coupling in bi- and trilayer 2H-MoS_2. — Julian Klein[1,2], Jakob Wierzbowski[1], •Pedro Soubelet[1], Thomas Brumme[3,4], Lorenzo Maschio[5], Agnieszka Kuc[6,7], Kai Müller[1], Andreas V. Stier[1], and Jonathan J. Finley[1] — [1]Walter Schottky Institut, TU München, Germany — [2]Department of Materials Science and Engineering, MIT, USA. — [3]Wilhelm-Ostwald-Institute for Physical and Theoretical Chemistry, Leipzig University, Germany. — [4]Faculty for Chemistry and Food Chemistry, TU Dresden, Germany. — [5]Dipartimento di Chimica and Centre of Excellence NIS, Università di Torino, Italy. — [6]Helmholtz-Zentrum Dresden-Rossendorf, Abteilung Ressourcenökologie, Forschungsstelle Leipzig, Germany — [7]Department of Physics and Earth Sciences, Jacobs University Bremen, Germany.

Manipulating electronic interlayer coupling in layered vdW materials is essential for designing optoelectronic devices. Here, we control vibrational and electronic interlayer coupling in bi- and trilayer 2H-MoS_2 using large external electric fields in a microcapacitor device. The electric field lifts Raman selection rules and activates phonon modes in excellent agreement with ab initio calculations. Through polarizationresolved photoluminescence spectroscopy, we observe a strongly tunable valley dichroism. By modeling our result using rate equations, we have explained the valley dichroism tunability using realistic material parameters.

HL 25.14 Wed 18:00 P2

Assigning excitonic transitions in reconstructed $MoSe_2$-WSe_2 heterostacks — •Christos Paspalides[1], Mirco Troue[1], Lukas Sigl[1], Johannes Figueiredo[1], Manuel Katzer[2], Malte Selig[2], Florian Sigger[1], Roland Gillen[3], Jonas Kiemle[1], Andreas Knorr[2], Ursula Wurstbauer[4], and Alexander Holleitner[1] — [1]TU Munich — [2]Technische Universität Berlin — [3]Friedrich-Alexander-Universität Erlangen-Nürnberg — [4]University of Münster

Transition metal dichalcogenide monolayers exhibit strong light-matter interactions, which promotes them as ideal candidates for novel 2D optoelectronic applications. The vertically stacked Van der Waals heterostacks facilitate the emergence of a type-II band alignment, which leads to the formation of long-lived interlayer excitons. We present g-factors for three distinct interlayer exciton emissions in $MoSe_2$-WSe_2 heterostacks measured up to 9 T. Theoretical considerations including density functional theory lead to the assignment of the characteristic emission lines to optical transitions inside an atomically reconstructed H-type heterostack with a near-zero twist-angle. Here, the H_h^h atomic registry is able to fill sizable commensurate domains within the reconstructed lattice while the corresponding selection rules are found to govern the optical response of the system.

Following the attribution of the interlayer exciton emissions, we provide a deeper insight into the effect of atomic reconstruction in $MoSe_2$-WSe_2 heterostacks and discuss the possibility for a macroscopic occupation of the ground-state leading to unique many-body effects of interlayer excitons in such systems.

HL 25.15 Wed 18:00 P2

Fabrication and Characterization of Twisted TMDC Bilayer — •Laura Nicolette Schusser, Sina Bahmanyar, Nihit Saigal, Hendrik Lambers, Hossein Ostovar, and Ursula Wurstbauer — Institute of Physics, University of Münster, Münster, Germany

Semiconducting 2D materials such as transition metal dichalcogenides (SC-TMDCs) excel due to their strong exciton dominated light matter interaction [1]. Van der Waals (VdW) heterobilayers prepared from SC-TMDCs are ideal systems for the realization and study of dense exciton ensmebles [2,3] and correlated phases phases of matter [4]. We are working to improve the fabrication protocol for high-quality twisted TMDC bilayers. We obtain monolayers by micro-mechanical exfoliation along with a deterministic pick-up and dry transfer using a viscoelastic stamp and to create vdW heterostacks with several layers. The twist angle between the layers is precisely controlled by a using a rotation stage. We use hexagonal boron nitride (hBN) as an encapsulating material. Photoluminescence (PL) spectroscopy combined with Raman spectroscopy is utilized for characterization. While the former technique probes the intralayer and interlayer exciton transitions, the latter one is used for the investigation of the phonon fingerprints of the system. [1] [1] U. Wurstbauer et al. J. Phys. D: Appl. Phys. 50, 173001 (2017). [2] L. Sigl et al. Physical Review Research 2, 042044(R) (2020). [3] J. Kiemle et al. Phys. Rev. B 101, 121404(R) (2020). [4] Y. Tang et al., Nature 579, 353 (2020).

HL 25.16 Wed 18:00 P2

Optical characterization of van der Waals WS2 Monolayer-Pyrenemethylammonium chloride few-layer vertical heterointerfaces — •Mohammed Adel Aly[1,2], Hilary Masenda[1,3], Arslan Usman[1,4], Bettina Wagner[5], Johanna Heine[5], Marina Gerhard[1], and Martin Koch[1] — [1]Department of Physics and Materials Sciences Center, Philipps-Universität, Marburg, 35032 Germany — [2]Department of Physics, Faculty of Science, Ain Shams University, Cairo, 11566 Egypt — [3]School of Physics, University of the Witwatersrand, Johannesburg, 2050 South Africa — [4]Department of Physics, COMSATS University Islamabad - Lahore Campus, Lahore, 54000 Pakistan — [5]Department of Chemistry and Material Sciences Center, Philipps-Universität Marburg, 35043 Marburg, Germany

Van-der-Waals transition metal dichalcogenides(vdW-TMDCs) layered materials have received huge attention due to their strong light-matter interaction. Moreover, combining 2D TMDCs with different organic materials opened a new line in heterostructure(Hs) research, providing unprecedented tunability for heterostructure(Hs) engineering. Few layers Pyrenemethylammonium chloride (PyMACL) is an emerging exfoliable organic material that offers distinct properties and could be attractive for photonic and optoelectronic applications. Here, we present our work on WS2/PyMACL vdW-HS. We have investigated our specimen using micro-photoluminescence and time-resolved photoluminescence shedding light on exciton dynamics in such structures, and possible recombination channels. Moreover, investigating possible charge transfer between the different layers of the Hs.

HL 25.17 Wed 18:00 P2

Modification of charge transport in single layer MoS2 — •Zahra Fekri[1], Phanish Chava[1], Gregor Hlawacek[1], Vivek Koladi[2], Tommaso Venanzi[3], Wajid Awan[1], Antony George[4], Andrey Turchanin[4], Kenji Watanabe[5], Takashi Taniguchi[5], Manfred Helm[1], and Artur Erbe[1] — [1]Helmholtz Zentrum Dresden Rossendorf, Dresden, Germany — [2]Imec, Leuven, Belgium —

[3]Sapienza University of Rome, Rome, Italy — [4]Friedrich Schiller University, Jena, Germany — [5]National Institute for Materials Science, Tsukuba, Japan

Ion beam irradiation is a technique that can be used to alter the electrical and optical properties of two-dimensional (2D) materials through defect creation. In this work, we used 5-7.5 keV helium and neon ions to modify charge transport in monolayer molybdenum disulfide (MoS_2). Electrical characterization was performed in-situ immediately after ion beam irradiation. Raman and photoluminescence spectroscopy were implemented to further characterize the effect of ion irradiation on MoS_2. Our experiments show that the electrical properties of MoS_2-based transistors strongly depend on the nature of the substrate and the specific ion and dose used. Although 10^{12}-10^{13} helium ions/cm^2 contribute to the increase in the current level, a similar dose of neon ions deteriorates the channel. To examine the role of the substrate, few-layer hexagonal boron nitride (h-BN) was used as an intermediate layer between MoS_2 and the Si/SiO_2 substrate. MoS_2 samples on h-BN show different electrical behaviour during ion irradiation as compared to the MoS_2 flakes which were directly placed on SiO_2.

HL 25.18 Wed 18:00 P2

Tunable THz-absorption and gain in transition metal dichalcogenides — •Josefine Neuhaus, Tineke Stroucken, and Stephan W. Koch — Philipps University, Marburg, Germany

Exhibiting linear optical spectra that are dominated by strongly bound excitonic features, transition metal dichalcogenides have attracted considerable interest in the past decade. In a properly pre-excited system, it is possible to study intra-excitonic transitions between optically bright *s*- and dark *p*-type excitons by their THz-absorption. In particular, as *p*-type states lie energetically below *s*-type states of equal main quantum number, not only absorptive but also gain features can be observed. Furthermore, the application of an external magnetic field perpendicular to the sample results in a shift of the various excitonic resonances. As the induced Zeeman shift depends on the angular momentum quantum number, the magnetic field induced shift differs for *s*- and *p*-type excitonic states, enabeling a tunability of the intra-excitonic transitions. Here, we study the tunability of the intra-excitonic absorption and gain spectra upon the interplay of an applied magnetic field, the dielectric environment and the material parameters by means of a combined approach based on DFT and a Semiconductor-Bloch equation approach.

HL 25.19 Wed 18:00 P2

Contact engineering of black phosphorus field-effect transistors — •Yagnika Vekariya[1], Phanish Chava[1], Zahra Fekri[1], Kenji Watanabe[3], Takashi Taniguchi[3], Sibylle Gemming[2], and Artur Erbe[1] — [1]Helmholtz Zentrum Dresden Rossendorf, 01328 Dresden, Germany — [2]Technische Universität Chemnitz, 09126 Chemnitz, Germany — [3]National Institute for Materials Science, Tsukuba 305-0044, Japan

Black phosphorus (BP) has recently emerged as new semiconducting two-dimensional (2D) material because of its unique properties such as tunable direct bandgap, high field-effect mobility, and good on/off ratio. In this work, we fabricated and characterized field-effect transistors (FETs) based on a few layers of black phosphorus, in order to evaluate the performance of devices using different contact materials like Graphene, Nickel (Ni), Titanium (Ti), and Chromium (Cr). We observed that the polarity and mobility value of transistors strongly depend on the contact material.

HL 25.20 Wed 18:00 P2

Single photon emitters study in hBN via low power implantation approach — •Renu Rani[1], Minh Bui[1,2], Bilal Malik[1,2], Manuel Auge[3], Thorsten Brazda[1], Hans Hofsäss[3], Detlev Grützmacher[1,2], and Beata Kardynał[1,2] — [1]Peter Grünberg Institut-9, Forschungszentrum Jülich, Jülich — [2]Department of Physics, RWTH Aachen, Aachen — [3]II. Physikalisches Institut, Georg-August-Universität Göttingen

A discovery of quantum emitters in hexagonal boron nitride (hBN) has recently incited immense interest in the field of quantum technologies. It offers not only a platform for fundamental science but is of interest for applications in quantum photonics owing to its robust single photon emission at room temperature. Recent studies have suggested that these SPEs are associated with intrinsic defects, which led to efforts to engineer the SPE in hBN by various such as plasma treatment, annealing, laser, e-beam and ion irradiation methods. Despite these efforts, the origin of single photon emission and the correlation of emission with particular defects still need to be scrutinized. Here we propose to use low-energy ion implantation to introduce the different defects in hBN. We will show results of optical characterization of hBN implanted with various noble gas ions with different energies, which depending on their atomic mass generate different vacancies and at different depths. We will discuss the viability of creating localized emitters throughout the surface, not only edges or grain boundaries. We will use Raman spectra to show that implanted material is free of contamination and damage associated with energetic particle beams.

HL 25.21 Wed 18:00 P2

Twist angle dependent proximity induced spin-orbit coupling in graphene/WSe$_2$/hBN heterostructures — •Tobias Rockinger[1], Antony George[2], Andrey Turchanin[2], Ziyang Gan[2], Kenji Watanabe[3], Takashi Taniguchi[3], Dieter Weiss[1], and Jonathan Eroms[1] — [1]University of Regensburg, DE-93040 Regensburg, Germany — [2]Friedrich-Schiller-Universität, DE-07743 Jena , Germany — [3]NIMS, Tsukuba 305-0044, Japan

Recently, theoretical calculations predicted a strong dependence of the proximity-induced SOC on the twist angle between SLG and TMDCs [1]. To prove this, we fabricated SLG/WSe$_2$/hBN heterostructures with well-defined twist angles between the SLG and WSe$_2$ layers in two ways. For the first type, we exfoliated SLG and WSe$_2$ which often break along zigzag or armchair edges [2]. This was used to align and estimate the rotation angles between the flakes (zigzag/armchair edges not distinguishable). For the other type of samples, we used CVD-grown WSe$_2$ on anisotropically etched SLG to align and determine the twist angles exactly (zigzag/armchair edges distinguishable) [3]. Strong SOC causes weak anti-localization, which we used to determine the strength of the Rasbha type SOC (λ_R) and the valley-Zeeman type SOC (λ_{VZ}). We found that samples with an angle around 15° or 22° show a much stronger SOC in both cases, for λ_R as well as for λ_{VZ}, compared to samples, with twist angles around 0°/30° or 11°. This is in qualitative agreement with theoretical predictions [1]. [1]Y. Li and M. Koshino, Phys. Rev. B **99**, (2019) 075438; [2]Y. Guo *et al.*, ACS Nano **10**, (2016) 8980; [3]P. Incze *et al.*, Nano Res **3**, (2010) 110

HL 25.22 Wed 18:00 P2

Nucleation of hBN on HOPG in conventional MBE — •Constantin Hilbrunner, Juli Zhang, Joerg Malindretos, and Angela Rizzi — IV. Physikalisches Institut - Georg-August-Univiersität Göttingen

Due to its large bandgap of around 5.9 eV and due to its high breakdown voltage as well as its natural inertness, hexagonal boron nitride (hBN) is a promising substrate and encapsulation material to study the intrinsic properties of two-dimensional materials. Due to thermodynamics, the growth of hBN requires very high substrate temperatures. At present, the hBN films grown by molecular beam epitaxy (MBE) on non-metallic substrates with highest structural quality were fabricated using substrate temperatures between 1300°C and 1600°C not achievable using conventional systems.

In a different approach, we intend to utilize laser assisted heating during MBE. Here, we report on our preliminary results concerning the nucleation of hBN on HOPG at conventional substrate temperatures for varying B fluxes and the heating characteristic of the substrate surface in response to ns laser pulses.

HL 25.23 Wed 18:00 P2

Ultra-sensitive extinction measurements of optically active defects in monolayer MoS$_2$ — •Ines Amersdorffer[1], Florian Sigger[2], Alexander Hötger[2], Manuel Nutz[1], Alexander Högele[1], David Hunger[3], Thomas Hümmer[1], and Christoph Kastl[2] — [1]Faculty of physics, Ludwig-Maximilians-Universität Munich, Germany — [2]Walter Schottky Institute and Physics Department, Technical University of Munich, Germany — [3]Physikalisches Institut, Karlsruhe Institute of Technology, Germany

Measurements of the marginal absorption of nanomaterials are challenging. One way to address this issue is the use of an optical resonator in which the light passes the sample multiple times and thereby enhances the absorption of nanoscale objects to a measurable amount. Here, we demonstrate how a high-finesse microcavity can be exploited in order to measure the extinction by defects in monolayer MoS$_2$. Such atomistic defects embedded in nanomaterials are a promising candidate for single-photon sources. However, to make them optically accessible, it is beneficial to know their absorption properties. To this end, we performed wavelength-dependent extinction measurements. The absolute values of extinction were recorded with a detection limit of down to 0.01% and agree in the order of magnitude with theoretical predictions. In case of neglectable scattering, the extinction values can be interpreted as absorption. The results show advances towards routine hyperspectral absorption measurements on the nanoscale.

HL 25.24 Wed 18:00 P2

Electrical tuning of excitonic complexes in twisted van-der-Waals heterostructures — •Barbara Rosa, Chirag Palekar, and Stephan Reitzenstein — Institute of Solid State Physics, Technische Universität Berlin, D-10623 Berlin, Germany

Moiré excitons arising from transition metal dichalcogenides (TMDs) bilayers are directly controlled by the twist angle between the monolayers[1]. Noteworthy features of that new class of excitons, such as their ultrafast formation and charger transfer, long population recombination lifetimes, and binding energy of ~150 meV[2,3], turn TMD heterostructures into an attractive device for the study and manipulation of optical and transport properties via electrical fields. Here, we explore the ability to modulate interlayer exciton states in homo- and heterobilayers (HB) throughout electrical tuning. By fabricating TMD heterostructures using CVD and exfoliated monolayers, we study the effects of an out-of-plane applied electrical field in heterostructures with distinct twist angles. Our work aims to achieve control of optical and transport properties of interlayer excitons, which have shown energy tunability that ranges over several hundreds of meV[2,3]. Furthermore, we intend to discuss our first results in exploring light-matter interaction of an HB embedded in a photonic microcavity by electrically manipulating the Moiré excitonic response.

[1] K. L. Seyler et al., Nature 567, 66-70 (2019)
[2] A. Ciarrocchi et al. Nature Photon. 13, 131 (2019)
[3] H. Baek et al. Science Advances 6, 37 (2020)

HL 25.25 Wed 18:00 P2

Optical excitations in 2D material heterostructures under pressure — •Devika Sivankutty, Paul Steeger, Johann Preuss, Robert Schmidt, Steffen Michaelis de Vasconcellos, and Rudolf Bratschitsch — University of Münster, Institute of Physics and Center for Nanotechnology, Wilhelm-Klemm Str. 10, 48149 Münster

Heterostructures of transition metal dichalcogenides (TMDCs) have attracted a lot of attention due to their unique optical and electronic properties and easy fabrication by stacking distinct TMDC monolayers on top of each other. Depending on the material choice, the heterostructures can also exhibit interlayer excitons, where the hole resides in one layer and the electron in the other. The coupling between the layers, and thereby the optical and electronic properties of the heterostructure, are expected to be strongly dependent on the interlayer distance, which can be tuned by applying pressure to the heterostructure. Here, we investigate the optical properties of TMDC heterostructures under high pressure in a diamond anvil cell. We use a home-built stamping setup to fabricate the heterostructures and perform optical spectroscopy at various pressure values to investigate the excitonic resonances.

HL 25.26 Wed 18:00 P2

Optical properties of multilayer MoS_2 under high pressure — •Paul Steeger[1], Robert Schmidt[1], Ilya Kupenko[2], Carmen Sanchez-Valle[2], Steffen Michaelis de Vasconcellos[1], and Rudolf Bratschitsch[1] — [1]University of Münster, Institute of Physics and Center for Nanotechnology, Wilhelm-Klemm-Str. 10, 48149 Münster, Germany — [2]University of Münster, Institute for Mineralogy, Corrensstr. 24, 48149 Münster, Germany

Vertically stacked homo- and heterostructures of 2D semiconductors have recently attracted a lot of attention. One of the most critical parameters affecting their optical and electronic properties is the interlayer coupling. Controlling the distance between the layers by applying pressure to the sample allows to tune the interlayer interaction in-situ and opens up new ways to investigate its influence on the physical properties of multi-layered 2D materials. Here, we use a diamond anvil cell to measure how absorption and emission properties of multilayer MoS_2 crystals change under pressure, highlighting the differences between inter- and intralayer excitons.

HL 25.27 Wed 18:00 P2

Deterministic creation of strain gradients in 2D materials — •Robert Schmidt, Johannes Kern, Jannis Bensmann, Paul Steeger, Robert Schneider, Helge Gehring, Wolfram H. P. Pernice, Steffen Michaelis de Vasconcellos, and Rudolf Bratschitsch — University of Münster, Institute of Physics and Center for Nanotechnology, Wilhelm-Klemm-Str. 10, 48149 Münster, Germany

Strain is a powerful tool to modify the optical and electrical properties of 2D materials. While the controlled application of homogeneous strain to 2D materials is feasible, the creation of deterministic strain gradients over distances of several micrometers is still challenging. Commonly, monolayers or few-layers are manually transferred onto a pre-patterned substrate, which often results in strain gradients differing from sample to sample.

In this work, we imprint structures into 2D materials. Using a home-built nanoimprint setup and SiO_2 stamps produced by reactive ion etching, we print into 2D materials with lateral precision below one micrometer. The strain fields induced by this deformation are analyzed using optical absorption mapping.

HL 25.28 Wed 18:00 P2

"Ghupft und Gschobm": An ab initio multi-scale approach to bands and electron-phonon coupling in twisted WSe_2 bilayers — •Michael Winter and Tim Wehling — I. Institute of Theoretical Physics, Universität Hamburg

Transition metal dichalcogenide bilayers host electron correlation effects like superconductivity, exciton condensation, and Mott insulation. These phenomena are tuneable via charge doping, optical excitation, dielectric environment, and twist angle. The complex interplay of Coulomb and electron-phonon interactions with multi-orbital and multi-valley physics behind the aforementioned correlation effects remains to be understood.

We study the twisted homo-bilayer of tungsten diselenide by construction of many-body quantum lattice models describing the electronic and phonon degrees of freedom as well as their coupling. From ab initio DFT and DFPT calculations with subsequent Wannier constructions on untwisted snapshots of commensurate structures corresponding lattice models are compiled. With an automated interpolation we are able to address twisted systems.

HL 25.29 Wed 18:00 P2

Ultrafast dynamics of dark states in photocurrent of TMD heterostructures — •Denis Yagodkin, Elias Ankerhold, Abhijeet Kumar, Johanna Richter, Firas Ben Moussa, Cornelius Gahl, and Kirill Bolotin — Freie Universitat Berlin

We study the photocurrent response of TMD heterostructures $MoS_2/MoSe_2$ with 150 femtosecond time resolution. In order to study the dynamics of transport at the interface of the heterostructure, we tune one pulse to MoS_2 excitation resonance and the second, time-delayed pulse, to that of $MoSe_2$. We find stark asymmetry between negative and positive delays. We attribute this asymmetry to the formation of interlayer excitons. Using a simple model of charge carriers decaying in optically dark states we successfully describe both time-resolved reflectivity and photocurrent response of heterostructures. Extracted formation time of interlayer excitons is similar to that observed in ARPES and TR-THz at room temperature. Strong response to interlayer excitons shows the potential of our technique in detecting other dark states promising for information storing and processing.

HL 25.30 Wed 18:00 P2

Charge carrier localization in nanobubbles of atomically thin TMD semiconductors — Christian Carmesin[1], Michael Lorke[1,2], Matthias Florian[1], •Daniel Erben[1], and Frank Jahnke[1] — [1]Institute for Theoretical Physics, University of Bremen — [2]Bremen Center for Computational Materials Science, University of Bremen

Atomically thin transition metal dichalcogenides on nanostructured substrate like nanopillar arrays have gained attention as they show single photon emission. In contrast to a prestructured substrates, we investigate TMD nanobubbles that form naturally during stacking processes. Upon optical excitation these bubbles also exhibit quantum light emission, which indicates strong charge carrier confinement.

Starting from atomistic modelling of the strain field and electronic confinement potential of the nanobubble structure, we calculate the excitation spectrum for different bubble geometries. The microscopic origin of this carrier confinement lies in the bending rigidity of these materials leading to wrinkling of the surface. The resulting strain field facilitates nanoscale carrier localization due to its pronounced influence on the band gap. This localization mechanism is supported by local changes of the dielectric environment. As a result, strongly localized states are formed that lead to emission sites around the periphery of the nanobubble. A specific localization signature allows for experimental identification of this mechanism, which has also been demonstrated in spatially resolved photoluminescence experiments.

HL 25.31 Wed 18:00 P2

Tunable 2D phononic crystals — •Yuefeng Yu, Jan Kirchhof, Bianca Hofer, Oguzhan Yucel, and Kirill Bolotin — Department of Physics, Freie Universität Berlin, 14195 Berlin, Germany

In the field of phononics, periodic patterning controls vibration and thereby flow of heat and sounds based on its phononic band structure. This kind of structures name as phononic crystals (PnCs). Bandgaps of PnCs arise their potentials in low-dissipation mechanical states towards efficient waveguide and stable mechanical qubit. By combining highly flexible suspended two-dimension (2D) materials and PnCs into 2D-capacitor framework, applying pressure through voltage and thereby changing the unit size of periodic pattern to tune the phononic bandgap is accomplishable. For now, we are playing the PnCs in graphene and 2D MoS2 with hexagonal lattice and microscale cavity. From cavity interferometric measurement, the periodic pattern can effectively block a frequency-range of vibration modes and establish the 1.5MHz-wide phononic bandgap of 2D-MoS2 PnCs. By varying the incident-laser power and gating voltage, position of bandgap moves in MHz-frequency-range. With the supporting of simulation, graphene shows a much higher tunability of the width and position in frequency of phononic bandgap than MoS2. All of these suggests a potential playground for quantum information and phase transition in mechanical.

HL 25.32 Wed 18:00 P2

Effect of gallium content on the grain boundary properties of polycrystalline Cu(In,Ga)Se2 absorber layers in thin-film solar cells — •Sinju Thomas[1], Wolfram Witte[2], Dimitrios Hariskos[2], Stefan Paetel[2], Chang-Yun Song[3], Heiko Kempa[3], Nora El-Ganainy[4], and Daniel Abou-Ras[1] — [1]Helmholtz Zentrum Berlin für Materialien und Energie (HZB) — [2]Helmholtz Zentrum Berlin für Materialien und Energie GmbH, Hahn-Meitner-Platz 1, 14109 Berlin, Germany — [3]Martin-Luther-Universität Halle-Wittenberg, Institut für Physik, Fachgruppe Photovoltaik — [4]Competence Centre Photovoltaics Berlin (PVcomB)/(HZB)

In the present work, we apply several scanning electron microscopy techniques in a correlative manner on five solar cells with different ([Ga]/([Ga]+[In]) GGIs (0.13, 0.34, 0.51, 0.67, and 0.83) in the Cu(In,Ga)Se2 photoabsorbers, in addition to time-resolved photoluminescence and quantum-efficiency measurements. Grain sizes, electron lifetimes, grain-boundary (GB) recombination velocities, elemental distributions within the absorber layer, as well as luminescence emission distributions were assessed for all five samples. Owing to much reduced grain size at a GGI of 0.83,there is a high density of GBs that serve as active recombination centers. At this GGI, Voc losses via non-radiative recombination deteriorates the device efficiency However, the effective GB recombination velocity does not vary linearly with the increasing GGI. Distribution of the recombination velocities at individual GBs suggests that upward and downward band bending at GBs is independent of the Ga concentration

HL 25.33 Wed 18:00 P2

Phonon Transport in Thin Homoepitaxial β-Ga_2O_3 Films — •Robin Ahrling[1], Olivio Chiatti[1], Rüdiger Mitdank[1], Zbigniew Galazka[2], Andreas Popp[2], and Saskia F. Fischer[1] — [1]Novel Materials Group, Humboldt-Universität zu Berlin, 10099 Berlin, Germany — [2]Leibniz Institute for Crystal Growth, 12489 Berlin, Germany

As a wide-band gap semiconductor with a high breakthrough field, gallium oxide (Ga_2O_3) has shown to be a promising material for applications in high power electronics. However, due to the materials low thermal conductivity [1,2] heat dissipation is a challenge for future device applications. By photolithography, magnetron sputtering and subsequent liftoff we prepare structures for investigating the thermal transport in the bulk Ga_2O_3 substrate and the thin homoepitaxial β-Ga_2O_3 films by applying the 2-ω and 3-ω measurement techniques.

For the substrate, we observe a dominance of phonon-phonon Umklapp scattering for high temperatures (>90 K) and a combination of point defect scattering and boundary effects for low temperatures. The phonon mean free path reaches a limit for low temperatures that can be explained with the crystal thickness. We aim to investigate the thermal transport exclusively in the thin films by producing sub-μm heater widths using electron beam lithography and performing measurements at higher frequencies.

[1] M. Handwerg *et al.*, Semicond. Sci. Technol. **30**, (2015) 024006
[2] M. Handwerg *et al.*, Semicond. Sci. Technol. **31**, (2016) 125006

HL 25.34 Wed 18:00 P2

Towards Heat Transport in Exfoliated β-Ga_2O_3 Flakes — •Sakhir Shibli[1], Robin Ahrling[1], Olivio Chiatti[1], Rüdiger Mitdank[1], Zbigniew Galazka[2], and Saskia F. Fischer[1] — [1]Novel Materials Group, Humboldt-Universität zu Berlin, 10099 Berlin, Germany — [2]Leibniz Institute for Crystal Growth, 12489 Berlin, Germany.

Heat transport is known as a diffusive process that is characterized as a slow process compared to other physical processes. Nevertheless, heat transport can also occur ballistically in the speed of sound within a material over distances comparable to the phonon's mean free path, known as Casimir limit [1]. Therefore, thin-layer materials are of interest for detecting ballistic heat transport [2]. As a model system with large potential of application, e.g. in power electronics, we are investigating exfoliated thin-layer flakes of β-Ga_2O_3 single crystal [3][4]. As a wide-band gap semiconductor with a high-breakthrough field, β-Ga_2O_3 has shown to be a promising material for applications in high power electronics [5]. In this work, we fabricate and pattern micro-heater lines in order to employ the 3ω- and 2ω- methods [3].

[1] Casimir, H.B.G. (1938) Physica, **5**, 495-500.
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[3] M. Handwerg, *Sci. Technol.* **30** (2015) 024006.
[4] Galazka, Zbigniew *et al.* **45** (2010): 1229-1236.
[5] J. Boy *et al.*, APL Mater. **7**, 022526 (2019).

HL 25.35 Wed 18:00 P2

Investigation of pinhole defects in ALD TiO_{2-x} corrosion protection layers on III-V semiconductor photocathodes — •Nicola Taffertshofer, Tim Rieth, and Ian Sharp — Walter Schottky Institute and Physics Department, Technical University of Munich, Am Coulombwall 4, 85748 Garching, Germany

The application of semiconducting photoabsorbers for photoelectrochemistry (PEC) provides a relevant path to solar fuel generation. However, a major challenge is the chemical instability of many potentially suitable semiconductors in PEC applications. Titania (TiO_{2-x}) protection layers with defined properties can be conformally deposited by atomic layer deposition (ALD) and have been shown to improve chemical stability of photoelectrodes in PEC cells. Despite these benefits, TiO_{2-x} ALD protection layers exhibit structural imperfections, including pinholes, that limit the long-term stability of underlying semiconductor photoelectrodes under PEC conditions. In our work, we quantify the pin-hole density in TiO_{2-x} ALD protection layers, synthesized under different growth conditions, by combining controlled etching experiments with inductively coupled plasma mass spectrometry (ICP-MS). Using the high sensitivity of ICP-MS, the unprotected substrate area associated with existing and emerging pinholes can be deduced by an increase of the substrate elements concentrations dissolved in liquid. Overall, this method provides crucial information for the development of pinhole mitigation strategies in the TiO_{2-x} ALD growth process and, hence, is an important step towards an increased lifetime of photoelectrodes.

HL 25.36 Wed 18:00 P2

Investigation of Electrically-Active Dopants in Sulfur-Hyperdoped Silicon Using Resistance Measurements — •Skrollan Detzler, Christoph Flathmann, and Michael Seibt — 4th Institute of Physics - Solids and Nanostructures, University of Goettingen, Friedrich-Hund-Platz 1, 37077 Göttingen, Germany

Due to its abundance and particularly adjustable electric properties, silicon has become the dominating material in solar cell fabrication as of today. One approach to further increase the efficiency of silicon solar cells is to introduce an intermediate band into the band gap, allowing for broader absorption of the sunlight spectrum. This could be realized by doping the material with deep-level impurities far beyond its equilibrium solubility limit. In this study, we analyze sulfur-hyperdoped silicon, produced by femtosecond pulsed laser annealing, resulting in inhomogeneous regions reaching from the surface into the bulk material. To gain information on electrically-active dopants across different regions, resistance measurements using micromanipulators and scanning electron microscopy imaging were performed.

HL 25.37 Wed 18:00 P2

Automation of band structure simulations to determine Si-dopant efficiency in AlGaAs — •Maximilian Kristo, Nico Brosda, Andreas D. Wieck, and Arne Ludwig — Lehrstuhl für Angewandte Festkörperphysik, Ruhr-Universität Bochum, D-44801 Bochum, Germany

The potential landscape for electrons in semiconductor heterostructures is represented by its band structure.Their simulations can significantly help in the design of devices with new functionality. In order to systematically evaluate the doping efficiency in heterostructure samples, we automatized band structure calculations in a feedback loop with experimentally determined Hall parameters. These were determined by Van der Pauw measurements at 4.2 K.

The effective dopant concentration in the simulations was adapted to fit the experimental results and thus allowed to determine the effective dopant efficiency of Si doped AlGaAs HEMT structures to be compared with the dopant efficiency in Si doped GaAs samples. A majority of the dopant atoms are present in AlGaAs (with an aluminium concentration above 20 %) as deep impurities (Donor CompleX (DX) centers), which do not contribute to the electrical conductivity at 4.2 K if cooled in dark without bias. Therefore, these DX centers in Si doped AlGaAs lower the doping efficiency compared to Si doped GaAs. For AlGaAs with an aluminium concentration of 34 %, an average dopant efficiency of 14 ± 3 % and a negative correlation of -0.83 with the thickness of the doped layer could be found this way.

HL 25.38 Wed 18:00 P2

Electrochemical epitaxial (200) PbSe submicron plates on single layer graphene for ultrafast infrared response — •Chan Yang, Shuanglong Feng, Yinye Yu, Jun Shen, Xingzhan Wei, and Haofei Shi — Chongqing Institute of Green and Intelligent Technology, Chinese Academy of Sciences

Highly efficient near and medium-wave infrared detection at room temperature is considered one of the most intensive studies due to their robust detection in foggy weather or other low visibility conditions. 2D atomic layer graphene has an unconventional broad optical spectrum and high carrier mobility properties for the next generation electronics and optoelectronics device. The single-layer graphene has a lower quantum efficiency, and the PbSe has a direct narrow bandgap with a highly sensitive infrared response. Here, we examine the growth mechanism of high quality-oriented (200) PbSe crystals on a single atomic layer graphene using the electrochemical atomic layer epitaxy growth method in an aqueous electrolyte. The crystalline phase and density of nucleating seeds controlled by changing electrodeposition parameters are crucial for determining the submicron-crystal geometry. It is revealed that the controllable growth orientation and nucleation of PbSe crystals are realized by combining underpotential deposition of Pb and overpotential deposition of Se. The PbSe crystals/graphene hybrid photodetector indicates the benefit of infrared absorption. The extraordinary response speed of 1.8 ms, photo-responsivity in exceeding 36 AW^{-1}, and figure-of-merit detectivity $D^* > 2.7 \times 10^9$ Jones have been demonstrated in 2.7 μm at room temperature.

HL 25.39 Wed 18:00 P2

Reconstructions of the As-terminated GaAs(001) surface exposed to atomic hydrogen — Marsel Karmo[1], Isaac Azahel Ruiz Alvarado[2], Wolf Gero Schmidt[2], and •Erich Runge[1] — [1]Technische Universität Ilmenau — [2]Universität Paderborn

We explore the atomic structures and electronic properties of the As-terminated GaAs(001) surface in the presence of hydrogen based on ab-initio density functional theory. We calculate a phase diagram dependent on the chemical potentials of As and H, showing which surface reconstruction is the most stable for a given set of chemical potentials. The findings are supported by the calculation of energy landscapes of the surfaces, which indicate possible H bonding sites as well as the density of states, which show the effect of hydrogen adsorption on the states near the fundamental band gap [1]. Extension to the $GaAs_xP_{1-x}$(001) surfaces are presented.

[1] M. Karmo et al., ACS Omega 7, 5064-5068 (2022), https://doi.org/10.1021/acsomega.1c06019

HL 25.40 Wed 18:00 P2

Remote Heteroepitaxy of In(x)Ga(1-x)As on Graphene Covered GaAs(001) Substrates — •Tobias Henksmeier[1], Friedemann Schulz[2], Elias Kluth[2], Martin Feneberg[2], Rüdiger Goldhahn[2], and Dirk Reuter[1] — [1]Paderborn University, Warburger Str. 100, 33089 Paderborn, Germany — [2]Otto von Guericke University, Magdeburg, Universitätsplatz 2, 39106 Magdeburg, Germany

Recently, remote epitaxy on monolayer graphene covered substrates has attracted considerable attention as a way to improve lattice mismatched growth. It was reported that placing a monolayer graphene on a substrate offers a relaxation pathway different to the creation of crystal defects. Here, we present a study on solid source molecular beam epitaxy of In(x)Ga(1-x)As-layers (0<x<0.5) on chemical vapor deposition monolayer-graphene covered GaAs-(001) substrates. We show detailed investigations on the low temperature In(x)Ga(1-x)As nucleation and on the strain relaxation of 200 nm thick In(x)Ga(1-x)As-layers on graphene coved GaAs and for comparison on bare GaAs. The samples were analyzed by atomic force microscopy (AFM), scanning electron microscopy (SEM), Raman-spectroscopy and high-resolution X-ray diffraction measurements (HRXRD). We see the same crystal orientation and similar root-mean-square roughness for films grown on graphene and on bare GaAs substrates. Further, the layers grown on graphene show a more symmetric strain relaxation and a larger degree of strain relaxation compared to films grown on bare GaAs where the strain relaxation is larger along [110].

HL 25.41 Wed 18:00 P2

Nonlinear dynamics of Dirac fermions in topological HgTe structures — •Tatiana Aureliia Uaman Svetikova[1], Alexej Pashkin[1], Thales Oliveira[1], Florian Bayer[2], Christian Berger[2], Lena Fürst[2], Hartmut Buhmann[2], Laurens W. Molenkamp[2,3], Manfred Helm[1], Tobias Kiessling[2], Stephan Winnerl[1], Sergey Kovalev[1], and Georgy V. Astakhov[1] — [1]HZDR, Dresden, Germany — [2]Physikalisches Institut (EP3), Universität Würzburg, Würzburg, Germany — [3]Institute for Topological Insulators, Würzburg, Germany

High harmonic generation has applications in various fields, including ultrashort pulse measurements, material characterization and imaging microscopy. Strong THz nonlinearity and efficient third harmonic generation (THG) were demonstrated in graphene [1], therefore it is natural to assume the presence of the same effect in other Dirac materials, such as topological insulators (TI)[2].

We used a series of HgTe samples corresponding to three qualitatively different cases: 2D trivial and topological structures and 3D TIs. By using moderate THz fields, the presence of highly efficient THG was measured at different temperatures and THz powers. This provides insight into physical mechanisms leading to THG in TIs. For in-depth understanding of Dirac fermions dynamics and dominating scattering mechanisms in HgTe TI, we conducted THz pump-probe experiments that reveal several relaxation time scales.

[1] Hafez, H. A. et al., Nature 561, 507 (2018).

[2] Kovalev, S. et al., Quantum Mater. 6, 84 (2021

HL 25.42 Wed 18:00 P2

Graphitic Carbon Nitride/Semiconductor Quantum Dots 2D/0D Heterostructures — •Thuy Linh Nguyen Thi, Oleksandr Selyshchev, and Dietrich R.T. Zahn — Semiconductor Physics, TU Chemnitz, Chemnitz D-09107, Germany

The 2D semiconductor graphitic carbon nitride (g-C3N4) is of great interest due to its photocatalytic properties and potential application in optoelectronic devices. However, a relatively large bandgap of 2.7 eV [1] requires its additional sensibilization to extend the photosensitivity to entire visible range. Here, we investigate heterostructures of n-type g-C3N4 and p-type semiconductor quantum dots (QDs), e.g. AgInS2. The single-layered g-C3N4 flakes exfoliated from bulk material using tetraethylammonium hydroxide (TEA-OH) ligands [1] and AgInS2 QDs with a size of ~3.5 nm [2] were used in aqueous solutions. X-ray Diffraction (XRD) indicates the intercalation of TEA-OH ligands between the flakes of g-C3N4. The thickness of the carbon nitride flakes of 0.3 +/- 0.1 nm, corresponding to a monolayer, and lateral sizes in the range of 35 - 55 nm are confirmed by Atomic Force Microscopy (AFM). Photoluminescence (PL) quenching of both g-C3N4 and QDs indicates an electronic interaction. A model photodetector device based on a thin film of a g-C3N4 and QD mixture, a TiO2 transport layer, indium-tin-oxide and gold electrodes was utilized for investigating the photoconductivity.

[1] O. Stroyuk et al., Phys. Status Solidi B, 2018, 256, 2, 1800279.

[2] A. Raevskaya et al., J. Phys. Chem. C, 2017, 121,16, 9032.

HL 25.43 Wed 18:00 P2

Contactless mapping of the sheet resistance of GaAs samples — •Timo A. Kurschat, Arne Ludwig, and Andreas D. Wieck

— Angewandte Festkörperphysik, Ruhr-Universität Bochum, Universitätsstraße 150, D-44780 Bochum

Measurements of the sheet resistance without the need to break the sample and integrate electrical contacts enable the evaluation of the homogeneity and quality of samples before further processing. Spatially resolved maps can be created without destroying or modifying the wafer.

The sheet resistance is measured by placing the sample on top of two circular electrodes. These couple capacitively with the conducting layer through the substrate. When applying a high frequency alternating voltage at one electrode, a signal can be measured at the other one. The sheet resistance is measured by sweeping the frequency from 1 MHz to 400 MHz and applying a fit. The setup works for sheet resistances between 300 Ω/□ and 50 kΩ/□.

The measured resistance and the coupling capacitances depend on the geometry of the sample and the electrodes. The changes at the edges of a sample are shown with line scans across a quarter 3" wafer and across a 5 mm wide sample. To show the effect of changes in the sheet resistance, the conducting layer was partly removed by etching. This shows artifacts especially if one electrode is completely below an isolating region. The spatial resolution depends strongly on the orientation of the electrodes.

HL 25.44 Wed 18:00 P2

GW benchmarks — •Maryam Azizi, Matteo Giantomassi, and Xavier Gonze — Université Catholique de Louvain, Louvain-la-Neuve, Belgium

GW is presently the best available first-principles methodology for the prediction of electronic structure, including band gaps. However, dealing with GW calculations is always challenging, not simply due to unfavorable scaling with system size, or possible lack of symmetry, but also due to the large number of parameters of such calculations. As a consequence, systematic GW benchmarks for large sets of materials are much more limited than for density-functional theory.

In the present work, we pave the way beyond the study of Van Setten and coworkers, who examined 70 materials, however aiming to a limited target accuracy. Indeed we consider a convergence criterion of 0.02 eV in the GW band gap, more stringent than the 0.05 eV target of this previous study. Moreover, the latter relied on a plasmon-pole model, while the present analysis also focus on contour-deformation and analytic continuation methodologies which are computationally more expensive and theoretically better justified. Like Van Setten et al, we use ABINIT, and stay at the non-self-consistent G_0W_0 level. Besides, the parallel speedup and efficiency of the implementation have been investigated.

HL 25.45 Wed 18:00 P2

Two-Photon Absorption Induced Photoluminescence in CuI Single Crystals — •Andreas Müller[1], Evgeny Krüger[1], Lukas Trefflich[1], Steffen Blaurock[2], Harald Krautscheid[2], Marius Grundmann[1], and Chris Sturm[1] — [1]Felix-Bloch-Institut für Festkörperphysik, Universität Leipzig — [2]Institut für Anorganische Chemie, Universität Leipzig

The intrinsically *p*-type copper iodide (CuI) with a direct band gap of 2.95 eV at 300 K [1] and high exciton binding energy is a promising material for transparent semiconductor devices. The photoluminescence (PL) emission properties of CuI crystals have been recently reported [2]. However, the PL emission induced by two-photon absorption (TPA-PL) has not been discussed in detail, so far.

We report on TPA-PL phenomena in CuI single crystals. A redshift compared to the conventional PL emission was observed. The TPA-PL spectrum can be nicely described by means of a simplified approach which takes into account the internal emission spectrum at the focal point, the propagation of the emitted photons inside the crystal and the absorption coefficient of CuI (determined by ellipsometry and taken from [2]). For the entire TPA-PL intensity we observed a non-linear power dependence, namely $I \propto P^\gamma$. The exponent γ depends on the excitation wavelength and ranges from 2 (expected for TPA-PL excitation via a virtual state) down to 1.5. The latter value was justified by a two-step TPA-PL process via a real state i.e. defect level.

[1] M. Grundmann *et al.*, Phys. Status Solidi A **210**, 1671 (2013)
[2] E. Krüger *et al.*, APL Mater. **9**, 121102 (2021)

HL 25.46 Wed 18:00 P2

Time-Resolved Nanoscale X-ray Analysis to Investigate Luminescence Dynamics of Co in ZnO-Material Systems — •Adrian Nowotnick[1], Christian Plass[1], Valentina Bonino[2], Maurizio Ritzer[1], Lukas Jäger[1], Jaime Segura-Ruiz[2], Gema Martinez-Criado[2], and Carsten Ronning[1] — [1]Institut für Festkörperphysik, Friedrich-Schiller-Universität Jena, Max-Wien-Platz 1, 07743, Jena — [2]ESRF - The European Synchrotron, 71 Avenue des Martyrs, 38043 Grenoble, France

High resolution synchrotron based methods like X-ray fluorescence (XRF) and X-ray exited optical luminescence (XEOL) are well established characterization techniques. A highly focused X-ray nanobeam at the ID16B-NA station of the European Synchrotron Radiation Facility provides an excellent spatial resolution of about 50nm. This enables compositional mapping of nanometerials. Uniquely, the beam line was equipped with a streak camera allowing analysis of the spectral dynamics of optical luminescence. Consequently, one can investigate the influence of elemental compositions and local environments on the emission properties of e.g. color centers in semiconductor nanomaterials. These are able to provide high quality single photon emitters, which have drawn a lot of interest in recent years. Simultaneous XRF and XEOL measurements of Co in ZnO systems were conducted and by analyzing the emitted X-ray fluorescence radiation together with the corresponding optical luminescence correlating maps were obtained. Additionally, the dynamic of the luminescence could be determined depending on the Cobalt concentration and the system morphology.

HL 25.47 Wed 18:00 P2

Photoluminescence observation of Erbium implanted semiconductor nanostructures — •Nico Brosda, Cristian Düputell, Arne Ludwig, and Andreas Wieck — Lehrstuhl für angewandte Festkörperphysik, Ruhr-Universität Bochum, D-44801 Bochum, Germany

The rare earth element Erbium is known for its spectral transitions around 1.5 μm. This wavelength region coincides with the absorption minimum of optical fibers. How to maximize the photoluminescence of Er doped semiconductor nanostructure is therefore a reasonable research topic.

The doping of GaAs semiconductor structures was achieved with focussed ion beam implantation. To recover the crystal structure and activate the Er atoms the samples are thermally annealed. Finding the optimal annealing parameters requires PL measurements in the near-infrared regime. A suitable PL setup was build around an InGaAs detector and a He-flow cryostat, allowing to measure the PL signal of Er. A 805 nm laser diode was used for the excitation. Optical parts in the setup were chosen with an antireflection coating for light around 1.5 μm.

The comparison between different annealing respectively implantation parameters allowed to identify values resulting in a brighter PL spectrum of the Er.

HL 25.48 Wed 18:00 P2

Semiclassical and quantum optical field dynamics in an optical cavity with a finite number of quantum emitters — •Kevin Jürgens[1], Frank Lengers[1], Daniel Groll[1], Doris E. Reiter[1,2], Daniel Wigger[3], and Tilmann Kuhn[1] — [1]Institute of Solid State Theory, University of Münster, Germany — [2]Condensed Matter Theory, Technische Universität Dortmund, Germany — [3]School of Physics, Trinity College Dublin, Ireland

Ensembles of quantum emitters (QE) coupled to the quantized light field inside a photonic cavity are promising building blocks in quantum technologies. Due to the interaction of several QEs with a single light mode, the emitters can produce interesting collective behavior. We calculate the spectra and dynamics of such an ensemble with up to $N = 60$ emitters after excitation by a short external laser pulse within the Tavis-Cummings model and compare the findings with those obtained in the semiclassical limit ($N \to \infty$) [1]. When increasing the pulse amplitude we find a sharp transition in the semiclassical limit from exciton-polariton-like behavior to Rabi oscillations. The full quantum calculations reproduce such a transition behavior independent of N, but in particular for smaller N the transition between these regimes is broadened over a certain range of pulse amplitudes.

Wigner functions are calculated to investigate the properties of the light field and show the emergence of quantum features [1]. On longer time scales we see the formation of $N + 1$ quasi coherent states with Schrödinger-cat-like interferences between each pair.

[1] Jürgens et al., Phys. Rev. B 104, 205308 (2021)

HL 25.49 Wed 18:00 P2

Temperature dependence of phonons of CuI — •R. Hildebrandt[1], M. Seifert[2], S. Botti[2], C. Sturm[1], and M.

Grundmann[1] — [1]Universität Leipzig, Felix Bloch Institute for Solid State Physics, Germany — [2]Fridrich-Schiller-Universität Jena, Institute of Condensed Matter Theory and Optics, Germany

Cuprous iodide (CuI) is unique as intrinsic transparent p-type semiconductor with high figure of merit regarding various optical and electrical properties [1]. Properties and processes like thermal conductivity, electron-phonon coupling, phonon scattering, phonon-decay and elastic constants are influenced or mediated by different types of phonons. Their characteristics will be investigated here by Raman scattering.

We present temperature dependent Raman scattering spectra for CuI by using a 532nm incident laser source on solution grown single crystals. The allowed TO and LO modes are observed as well as the weaker second order Raman spectrum, which contains the full information of CuI's phonon dispersion [2]. It is used to determine the energy of the - usually forbidden - acustic and optic zone boundary phonons by modeling the two-phonon sum spectrum [3].

Up to about 170 K the temperature dependence of the acustic phonons could be tracked and compared with computational as well as other experimental results [3]. All results are in agreement and provide high accuracy information for the phonon dispersion of CuI.

[1] M. Grundmann *et al.*, Phys. Stat. Sol. (a), **210**, 1671, 2013.
[2] J. Birman, J., Phys. Rev., **131**, 1489, 1963.
[3] Z. Vardeny *et al.*, Phys. Rev. B, **18**, 44876, 1978.

HL 25.50 Wed 18:00 P2

Manipulating light-emission in direct band gap hexagonal Silicon Germanium nanowire arrays — •David Busse[1], Victor van Lange[2], Elham Fadaly[2], Wouter Peeters[2], Marco Vettori[2], Jos Haverkort[2], Erik Bakkers[2], Gregor Koblmüller[1], and Jonathan Finley[1] — [1]Walter Schottky Institut, Garching near Munich, Germany — [2]Eindhoven University of Technology, Eindhoven, Netherlands

We present results on the redistribution and enhancement of light within a 2D photonic crystal array formed by a hexagonal array of standing $Si_{1-x} - Ge_x$ nanowires (NWs). It was previously shown that these NWs are direct bandgap semiconductors when the crystal lattice has a hexagonal crystal structure. Fully 3D FDTD-simulations were performed to calculate the frequency of the photonic bands and their dependence on the lattice pitch and radius of the NW array. Essentially, the peak of the photoluminescence (PL) emission from the $Si_{1-x} - Ge_x$ NWs at 0.352eV, can be continuously tuned through the dielectric and air photonic band edges by changing lattice pitch and radius. For NW radius r=210nm, length l=6mu and variable distance between the NWs (pitch a = 0.8mu up to 1.95mu) we tune the photonic band edges through NW PL emission. Crucially, for situations close to resonance we observe an increase in the time-integrated PL intensity and transient carrier recombination dynamics measured using time-resolved pump-probe reflectance spectroscopy.

HL 25.51 Wed 18:00 P2

Influence of encapsulation material on organic magnetoconductance effect in organic light emitting diodes (OLED) — •Annika Morgenstern[1], Dominik Weber[2], Apoorva Sharma[1], Daniel Schondelmaier[2], Dietrich R.T. Zahn[1,3], and Georgeta Salvan[1,3] — [1]Semiconductor Physics, TU Chemnitz, 09107 Chemnitz, Germany — [2]Nanotechnology and Functionalized Surfaces, Westsächsische Hochschule Zwickau, 08056 Zwickau, Germany — [3]Center of Materials, Architectures and Integration of Nanomembranes, TU Chemnitz, 09126 Chemnitz, Germany

Organic semiconductors are the basic building block of organic light-emitting diodes (OLED). It was reported that certain OLEDs based on Alq3, P3HT, etc. when exposed to an external magnetic field show a change in the electrical resistance. This phenomenon is called the organic magnetoconductance (OMC) effect, which stems from the influence of the magnetic field on the charge carrier density and/or mobility. OLEDs are also known to degrade due to the infiltration of oxygen and moisture into the constituting layers. In this work, we present a systematic study of the influence of polymethyl methacrylate (PMMA) and soda-lime glass encapsulation layer on the OMC effect, using a homebuilt electrical test bench based on a magnetic field modulation technique to remove the time-dependent change in the current. Additionally, we compare the passivation efficacy of the investigated encapsulation material on the lifetime of OLEDs. The lifetime of the studied OLEDs were measured using a test setup equipped with a photodiode, allowing to record the OLED light output over time.

HL 25.52 Wed 18:00 P2

The Impact of Mechanical Stress on Structural, Morphological and Electrical Properties of Transferable Organic Semiconductor Nanosheets — •Veronika Reisner, Sirri Batuhan Kalkan, and Bert Nickel — Faculty of Physics and CeNS, Ludwig-Maximilians-Universität, Geschwister-Scholl-Platz 1, 80539 Munich, Germany

Recently, we presented a technique to transfer organic small-molecule nanosheets using a sacrificial water-soluble polymer layer. This approach enables the transfer of highly ordered organic films on substrates, which are unfavorable for direct growth by physical vapor deposition. However, the transferable nanosheets experience a considerable amount of mechanical stress during the release and transfer process. Here, we investigate the structural and morphological changes induced in the transferable nanosheets to optimize the transfer technique. For this purpose, we use pentacene films as stress sensors. Pentacene films show a distinct response to the mechanical stress by an irreversible phase change from the thin-film phase to the Campbell bulk phase. To reveal these structural and morphological changes, we employ X-ray diffraction analysis and atomic force microscopy technique. We find that thinner pentacene nanosheets show a lower Campbell bulk phase contribution after the transfer process. Finally, we use an optimized transfer technique to fabricate transistors based on the transferable organic small-molecule DNTT. DNTT nanosheets are more brittle compared to pentacene nanosheets but exhibit superior device performance.

HL 25.53 Wed 18:00 P2

Damping and detecting vibrational modes in organic semiconductors with tunable graphene cavities — •Lukas Renn and Thomas Weitz — I. Physical Institute, Georg-August-University, Friedrich-Hund-Platz 1, 37077, Göttingen

The true nature of charge transport in organic semiconductors (OSC) is still not fully understood. A novel picture to describe the charge transport is the so-called transient localization, where the charge transport is intrinsically limited by inter- and intramolecular vibrations, which are a direct consequence of the weak van der Waals interactions in OSCs. Recently it was discovered that the mobility in OSCs is mainly hampered by single low-frequency sliding modes, which in some molecules contribute more than 80% of the total thermal disorder. (1) The aim of this work is to first detect the lattice vibrations in OSCs and subsequently manipulate them using 2D cavities. To this end, we deposit monolayer thin, highly crystalline OSC films (PDI1MPCN2) from solution onto graphene flakes, which should result in quenching of a broad spectral range of IR-active vibrational modes in the OSC. First measurements show that we are able to detect the vibrational modes via Raman and a SNOM-based Nano-FTIR measurement setup. One step further, we want to tune the plasmon frequencies of the graphene cavities via lithography-patterning and thereby selectively couple to molecular vibrations in this frequency range and measure their relative impact on the charge carrier mobility. (1) Schweicher et al., Adv. Mat. 1902407 (2019)

HL 25.54 Wed 18:00 P2

Towards charge-carrier transport studies in organic semiconductors strongly coupled to the electromagnetic vacuum field — •Daniel Vitroler[1,2], James W. Borchert[1], and R. Thomas Weitz[1] — [1]Universität Göttingen, Göttingen, Deutschland — [2]LMU München, München, Deutschland

Strong coupling between the vacuum field and an excitonic transition in a semiconductor using plasmonic resonators or optical cavities leads to the formation of exciton polaritons [1]. Among the many prospective uses of strong coupling, recent studies have demonstrated that the formation of polaritons is an intriguing potential approach for improving charge transport in e.g. organic semiconductors [2]. However, there have so far been limited experimental demonstrations of strongly-coupled organic transistors [3], leaving many questions about the detailed physics of charge-carrier transport in these devices. In this work, we investigate light-matter coupling in thin films based on a perylene diimide derivate (PDI1MPCN2) which has previously shown electron mobilities as high as 4 cm^2/Vs in organic transistors [4]. Tuned Fabry-Pérot cavities were implemented to achieve strong coupling to an excitonic transition of PDI1MPCN2 dispersed in a polymer matrix.

[1] Garcia-Vidal, F. J. *et al. Science.* **373**, eabd0336 (2021).
[2] Hagenmüller, D. *et al. Phys. Rev. Lett.* **119**, 223601 (2017).
[3] Orgiu, E. *et al. Nature Mater.* **14**, 1123-1129 (2015).
[4] Vladimirov, I. *et al. Nano Lett.* **18**, 9-14 (2018).

HL 25.55 Wed 18:00 P2

Influence of the probe-to-semiconductor contact on the electrical characterization of nanowire structures — •Juliane Koch[1], Lisa Liborius[2], Peter Kleinschmidt[1], Nils Weimann[2], Werner Prost[2], and Thomas Hannappel[1] — [1]Fundamentals of energy materials, Ilmenau University of Technology, Germany — [2]Components for high frequency Electronics (BHE), University of Duisburg-Essen, Germany

For the purpose of well-defined III-V semiconductor junctions, various sophisticated tip-based methods such as multi-tip scanning tunnelling microscopy (MTSTM) can be employed to study the electrical behaviour with high spatial resolution. We investigated a variety of upright, freestanding GaAs-based axial as well as co-axial nanowires on the growth substrates covered with native oxide. Based on our studies with MTSTM, we demonstrate that in tip-based measurement methods, the probe-to-semiconductor contact is essential for interpreting the properties of the sample. Our investigation reveals charging currents at the interface between the measuring tip and the semiconductor via the native insulating oxide, which acts as a MIS-capacitor in the operating voltage range. All the samples investigated displayed a strong dependency of the overall electrical behaviour on the condition of the tip-to-semiconductor contact. We analyse in detail the observed I-V characteristics and propose a strategy to achieve an optimized measuring tip-to-semiconductor junction which minimizes the influence of the native oxide layer on the overall electrical measurements.

HL 25.56 Wed 18:00 P2

Efficient spectral separation of single and entangled photons — •Patricia Kallert, Lukas Hanschke, Eva Schöll, Björn Jonas, and Klaus D. Jöns — Institute for Photonic Quantum Systems, Center for Optoelectronics and Photonics Paderborn, and Department of Physics, Paderborn University, 33098 Paderborn, Germany

Experiments and protocols based on single-photons with different properties are crucial to develop photonic quantum technologies. Semiconductor quantum dots are a promising platform for the emission of single, indistinguishable, and entangled photons. The efficient routing and filtering of frequency-mismatched photons, for example, from the biexciton-exciton cascade, is crucial to facilitate the full potential of quantum dots. The separation of photons of different energies allows for efficient entanglement swapping and teleportation experiments, which rely on multiphoton coincidences. Spectral separation and simultaneous detection of adjacent wavelengths are complex to realise. Here we exploit a strategy to build a blaze grating-based transmission spectrometer with outstanding figures of merit. We shed light on the basic principle and the pitfalls that lead to a severe decrease of the efficiency or deterioration of the resolution and how to overcome them. Balancing the main properties, our overall efficiency exceeds 66 %, and our resolution is 21 GHz. Simultaneously, wavelengths distanced by 0.2 nm can be separated. Our self-built setup offers all functionalities to characterise single-photon sources and efficiently incorporate them in modern quantum optics experiments.

HL 25.57 Wed 18:00 P2

Telecom wavelength InP based quantum dots: Growth and characterization — •Ranbir Kaur, Mohanad Alkaales, Johann Peter Reithmaier, and Mohamed Benyoucef — Institute of Nanostructure Technologies and Analytics, University of Kassel, Kassel, Germany

InP-based semiconductor quantum dots (QDs) represent an attractive light source for quantum communication applications due to their ability to emit photons at the telecom C-band. Self-assembled low-density QDs can be realized by careful control of the growth conditions. Here, we investigate the effect of different growth parameters to optimize telecom wavelengths

InP-based QD structures using molecular beam epitaxy with controlled properties in photonic and pin-diode structures. The QDs structures with and without doping were grown on distributed Bragg reflectors to enhance the light emission. Using proper doping levels, high-quality QDs can be embedded in pin-diode structures. Low-temperature *-PL measurements show bright single QD emission around 1.55 *m with narrow linewidth and low fine-structure splitting. Furthermore, studies related to doped QD structures and fabrication of pin-diode structures emitting at telecom wavelength are presented.

HL 25.58 Wed 18:00 P2

Energy dependent tunnel coupling of QDs to a reservoir at elevated temperatures — •Ismail Bölükbasi[1], Ibrahim Engin[1], Patrick Lindner[2], Arn Baudzus[1], Andreas D. Wieck[1], Björn Sothmann[3], and Arne Ludwig[1] — [1]Ruhr-Universität Bochum, D-44780 Bochum, Germany — [2]TU Dortmund, D-44221, Dortmund, Germany — [3]Theoretische Physik, Universität Duisburg-Essen and CENIDE, D-47048 Duisburg, Germany

Quantum dots have interesting physical properties and allow research in zero dimensional systems. They are used in modern displays and are highly efficient sources of high-fidelity single photons [1]. For their applicability, it is advantageous to understand the electrical properties and tunnelling behaviours of QDs coupled to a charge reservoir. Capacitance-voltage spectroscopy is used to characterize quantum dots by electronically accessing the quantized states. A resonance shift with temperature in the ground-state charging peaks, the s-type states [2] originates from the degeneracy of the one- and two electron quantum states. An approach to model these measurements with a master equation [3] can describe these shifts including excitonic and non-equilibrium states. It is however limited to constant tunnel-coupling. We present experimental observations like frequency dependent peak shifts that need an extended model and propose an improved master equation approach to address this behaviour.

[1] Tomm et al. (2021) Nat. Nanotechnol. 16(4) [2] Brinks et al. (2016) New Journal of Physics, 18(12). [3] Valentin et al. (2018) Physical Review B, 97(4).

HL 25.59 Wed 18:00 P2

Auger Recombination Rate: Magnetic Field Dependence in a Self-Assembled Quantum Dot — •Fabio Rimek[1], Hendrik Mannel[1], Marcel Zöllner[1], Arne Ludwig[2], Andreas D. Wieck[2], Axel Lorke[1], and Martin Geller[1] — [1]Faculty of Physics and CENIDE, University Duisburg-Essen, Germany — [2]Chair of Applied Solid State Physics, Ruhr-University Bochum, Germany

A quantum dot (QD) is an ideal system to study electron-electron interaction in a confined nanostructure [1]. The Auger recombination is a special case, where the recombination energy is transferred to a third charge carrier that leaves the dot [2] or is excited to a higher energy level. Therefore, the Auger effect destroys the radiative recombination of the charged exciton (trion) - an effect, which should be minimized for future applications of QDs that use spin states as stationary qubits, which can be transferred to photons via the trion transition.

In this work, we investigate how the Auger rate is affected by an external magnetic field, applied perpendicular to the plane of the dots. In the magnetic field, the trion transition of a QD is no longer spin degenerate and splits up. We use two-color, time-resolved resonance fluorescence to investigate the quenching of the trion recombination by the Auger effect. Two-color excitation allows us to excite two quantum dot transitions and neglect spin relaxation as well as spin-flip Raman scattering. This ensures that we can directly measure the Auger and the tunneling rate of an electron into the dot.

[1] A. Kurzmann et al., Nano Lett. 16, 3367-3372 (2016)
[2] P. Lochner et al., Nano Lett. 20, 1631-1636 (2020)

HL 25.60 Wed 18:00 P2

Effects of bias-cooling on charge noise in gated Si/SiGe quantum dots — •Julian Ferrero[1], Daniel Schroller[1], Thomas Koch[1], Viktor Adam[1], Ran Xue[2], Inga Seidler[2], Lars Schreiber[2], Hendrik Bluhm[2], and Wolfgang Wernsdorfer[1] — [1]Physikalisches Institut, KIT Karlsruhe — [2]II. Physikalisches Institut, RWTH Aachen

Electron spins in gated Si/SiGe quantum dots provide a great potential in scalable quantum-computing platforms due to their long coherence times and wide tunability. However, charge noise in the vicinity of the qubit region decreases the two-qubit gate fidelities that are needed for up-scaled error correction. Furthermore, the devices drift to different working points and need to be retuned regularly. The source of fast charge noise is thought to arise from twolevel fluctuators in the aluminium oxide dielectric, whereas the drift can be caused by slow charging of the silicon cap. A feasible possibility to suppress such noise and drift is the application of a bias voltage on all gates during cool down. This project strives to investigate the effects of different bias-coolings on charge noise using simultaneous current spectroscopy and peak tracking of two single electron transistors. Since the involved processes range on a wide time scale, the noise spectrum is investigated between 50 microhertz and 1 kilohertz.

HL 25.61 Wed 18:00 P2

Characterization of InGaAs quantum dots as active region

for edge emitting laser with emission in the telecom O-band — •Philipp Noack — Institut für Halbleiteroptik und funktionelle Grenzflächen, Universität Stuttgart, Deutschland

Generally, laser diodes with quantum dots as active region are superior to quantum well laser diodes in terms of threshold current and temperature stability. Additionally, stacking of quantum dot layers can provide a broad gain spectrum, which can be ideally used for the fabrication of tunable laser devices with large bandwidth.

To this end, indium gallium arsenide quantum dots with emission in the telecom O-band wavelength range around 1300nm are grown at high densities with MOVPE and characterized with photoluminescence and atomic force microscopy measurements. We have designed edge emitting structures with waveguide simulations and characterized them using the segmented contact method. Parameters for the growth, like the V/III material ratio, were adjusted to create high density InGaAs quantum dots in a single layer. The emission intensity was further enhanced by the incorporation of a dots in well structure, an arsine interruption during growth and vertical stacking of quantum dot layers.

Following the design of the laser device, characterizations of edge emitting structures with one and multiple QD layer with regards to absorption characteristics were performed, which allowed for the characterization of the intrinsic losses of differently structured devices.

HL 25.62 Wed 18:00 P2

Wavelength tuning mechanisms in GaAs based-photonic integrated circuits — •Ulrich Pfister[1], Florian Hornung[1], Stephanie Bauer[1], Eric Reutter[2], Michael Jetter[1], Simone L. Portalupi[1], Jürgen Weis[2], and Peter Michler[1] — [1]Institut für Halbleiteroptik und Funktionelle Grenzflächen (IHFG), Center for Integrated Quantum Science and Technology (IQST) and SCoPE, Universität Stuttgart — [2]Max-Planck-Institut für Festkörperforschung (MPI)

InGaAs quantum dots (QDs) grown in GaAs-based photonic integrated circuits are promising candidates to fulfill the requirements for basic on-chip photonic quantum computing gates. The necessary optical elements like beam splitters, on-chip detectors and waveguide structures have already been realized. An important step towards more complex experiments is to control the emission wavelength of the QDs. Recently, we matched the emission wavelength of a QD with a cavity-waveguide mode by applying strain with piezo electric actuators, resulting in Purcell enhancement [1]. Additionally, we discuss other tuning mechanisms like the crystallization of HfO_2 which has been already demonstrated for self-standing GaAs waveguides [2].

[1] Hepp, Stefan et al. Appl. Phys. Lett. 117, 254002 (2020)
[2] Grim, Joel Q. et al. Nat. Mater. 18, 963-969 (2019)

HL 25.63 Wed 18:00 P2

High-resolution spectroscopy of single photons from a self-assembled quantum dot — •Lucas Stahl[1], Hendrik Mannel[1], Fabio Rimek[1], Marcel Zöllner[1], Andreas Wieck[2], Arne Ludwig[2], Martin Geller[1], and Axel Lorke[1] — [1]Faculty of Physics and CENIDE, University of Duisburg-Essen, Duisburg, Germany — [2]Chair of Applied Solid State Physics, Ruhr-University Bochum, Germany

Self-assembled quantum dots (QD) are highly promising as building blocks for applications in future quantum information technologies, where single confined spin states can form a qubit that can be transferred to a single photon. This requires long spin and photon coherence times [1], which have been demonstrated to be limited by spin- and charge-noise as well as co-tunneling with a reservoir [1]. These dephasing mechanisms affect the linewidth of the emitted photons.

In order to study various dephasing processes that occur on the exciton and trion transition in resonance fluorescence on a single dot, we set up a laser-stabilized high-finesse Fabry-Perot-interferometer. By using a single-photon detector in combination with a picosecond time-tagger and a newly-developed post-processing method for stabilization, we obtained an interferometer resolution of 8 MHz.

This high-resolution enables us to detect dephasing mechanisms in the linewidth of the dot and to understand the influence of the Auger-scattering [2] of the trion transition in resonance fluorescence.

[1] G. Gillard et al., Quant. Inf. **7**, 43 (2021). [2] A. Kurzmann et al., Nano Lett. **16**, 5, 3367-3372 (2016).

HL 25.64 Wed 18:00 P2

Growth and characterisation of local droplet etched InAs quantum dots in an InGaAs matrix — •Nikolai Spitzer, Arne Ludwig, and Andreas Wieck — Ruhr- Universitaet Bochum, Lehrstuhl fuer Angewandte Festkoerperphysik, Universitaetsstraße 150, 44801 Bochum, Germany

We present a new local droplet etching (LDE) method for selforganized InGaAs quantum dots (QDs). We use gallium droplets to etch on an InGaAs matrix layer and fill the nanoholes with InAs. The impact of the indium concentration in the InGaAs-layer and of the deposited InAs amount after etching is investigated by atomic force microscopy and photoluminescence spectroscopy.

HL 25.65 Wed 18:00 P2

Three-photon excitation of InGaN quantum dots — •Viviana Villafane[1], Bianca Scaparra[1], Manuel Rieger[1], Stephan Appel[1], Rahul Trivedi[2], Tongtong Zhu[3], John Jarman[3], Rachel Oliver[3], Robert Taylor[4], Jonathan Finley[1], and Kai Mueller[1] — [1]Walter Schottky Institut, TUM, Garching, Germany — [2]Max-Planck-Institute for Quantum Optics, Garching, Germany — [3]Department of Materials Science, University of Cambridge, UK — [4]Clarendon Laboratory, University of Oxford, UK

Solid-state quantum emitters are prominent examples of systems showing excellent agreement between theoretical predictions and experimental measurements, being commonly taken as evidence that the fundamental physics of quasi two-level quantum emitters is almost fully understood. In our work, we explore multi-photon absorption selection rules in semiconductor quantum dots within the dipole approximation. It can be proven that given a two-level quantum system, if the excitation scheme involves N-photons of the same energy and polarization, either all even or odd resonances are enhanced, based on the parity of the ground and excited states. We demonstrate that semiconductor quantum dots can be excited efficiently in a resonant three-photon process, whilst resonant two-photon excitation is highly suppressed. Time-dependent Floquet theory is used to quantify the strength of the multi-photon processes and model the experimental results. Our resonant three-photon excitation scheme alows us to measure directly the radiative lifetime of InGaN QDs and obtain a greater degree of linear polarization.

HL 25.66 Wed 18:00 P2

Lattice thermal expansion of as-grown GaAs nanowires due to optical excitation measured by X-ray pump probe experiment — •Taseer Anjum[1,2], Francisca Largo[2], Waheed Salehi[1], Matthias Rössle[3], Oliver Brandt[2], Lutz Geelhaar[2], and Ullrich Pietsch[1] — [1]Festkörperphysik, Universität Siegen, Siegen, Germany — [2]Paul-Drude-Institut für Festkörperelektronik, Leibniz-Institut im Forschungsverbund Berlin e.V., Berlin, Germany — [3]Helmholtz-Zentrum Berlin für Materialien und Energie, Wilhelm-Conrad-Röntgen Campus, BESSY II, Berlin, Germany

We investigated the transient structural response in the ensemble of AlxIn1-xAs/GaAs core-shell NWs, grown on Si (111) substrate when irradiated with femtosecond laser pulses via x-ray pump-probe experiment at KMC3-XPP & P08 beamlines of Bessy II & PETRA III respectively. Femtosecond laser irradiation of solids excites photoelectrons from valance band to conduction and triggers a cascade of fundamental dynamical processes that occur on the picosecond to nanosecond time scales such as excitation and thermal equilibration of phonons. We observe a linear behavior of strain and temperature for the first few hundreds of picoseconds followed by the thermal relaxation up to few ns. Thinner NWs cool down slowly in comparison to thicker NWs which suggests a direct dependence of thermal conductivity on the diameter. Through time-resolved x-ray pump-probe experiments we identified the thermal relaxation processes and the dynamics of the structural response of two NW samples.

HL 25.67 Wed 18:00 P2

Investigation of the Correlation between Quantum Dot Density and Photoluminescence Intensity — •Simon Schlombs, Nikolai Spitzer, Nikolai Bart, Andreas Wieck, and Arne Ludwig — Angewandte Festkörperphysik, Ruhr-Universität Bochum, Universitätsstraße 150, D-44780 Bochum

Semiconductor devices based on quantum dots (QDs) require good knowledge of the QD density. Capacitance voltage spectroscopy (C(V)) enables the measurement of buried QDs; however, it requires extensive prior processing of the samples and only allows small areas to be measured. In this work the correlation between QD density and photoluminescence (PL) intensity is investigated. For this purpose, the quantum dot density along a density gradient has been determined and compared to PL measurements. The measured intensity is strongly dependent on the sample structure (absorption, thin-film interference). Because of this the intensity is corrected by an experimentally determined factor. The results allow for an optical determination of the QD density of entire wafers for an arbitrary sample structure.

HL 25.68 Wed 18:00 P2

Metallic nanowires assembled by DNA Origami — •Borja Rodríguez-Barea[1], Shima Jazavandi-Ghamsari[1], Archa Jain[1], Türkan Bayrak[1], Jingjing Ye[2], Ralf Seide[2], Enrique Samano[3], and Artur Erbe[1] — [1]Institute of Ion Beam Physics and Material Science, Helmholtz-Zentrum Dresden-Rossendorf, Germany — [2]Peter Debye Institute for Soft Matter Physics, Universität Leipzig, Germany — [3]Centro de Nanociencias y Nanotecnología-UNAM, Ensenada, B.C., México

In the pursuing to increase the processing power, electronic circuits look for new bottom-up strategies. Namely, (DNA) nanotechnology has shown valuable tools for the creation of nanostructures of arbitrary shape that can be used as templates. Here we demonstrate the formation of 1D Au nanostructures based on DNA Origami templates. DNA nanomolds are employed, inside which gold deposition is employed by site-specific attached seeds. To prove their metallic nature, top-down approach allows us to perform temperature-dependent charge transport measurements along the nanostructures. Transport through these assemblies is strongly nonlinear and shows a decrease in conductance towards low temperatures. Thanks to the converging of both fabrication approaches, the shape of the nanowires can be controlled and measured. We use DNA-origami templates which are functionalized on their surface in order to create desired shapes of the metallic nanostructures and the nanoparticles show temperature dependent charge transport measurements reveal the dominating charge transport mechanisms along these wires.

HL 25.69 Wed 18:00 P2

Multi-Orbital Kondo Effect in Few-Electron Quantum Dots — •Olfa Dani[1], Johannes Bayer[1], Timo Wagner[1], Gertrud Zwicknagl[2], and Rolf J. Haug[1] — [1]Institut für Festkörperphysik, Leibniz Universität Hannover, Germany — [2]nstitut für Mathematische Physik, Technis- che Universität Braunschweig, Germany

The Kondo effect is a many particle entangled system, that involves the interaction between a localized spin in the quantum dot and free electrons in the electron reservoirs. This entanglement can be calculated using simplifying assumptions concerning the electronic structure of the quantum dot.

We investigate a lateral quantum dot with a small number of electrons, formed electrostatically in a two-dimensional electron gas using top-gates. A quantum point contact was operated as a sensitive charge detector allowing the detection of single-electron tunneling through the system, which enables us to know the exact number of electrons N in the quantum dot. The latter is varied by changing the applied gate voltage.

For a strong coupling to the leads and possible symmetrical tunnel barriers, a Zero-bias anomaly (ZBA) is observed. This Kondo resonance appears for successive N showing a deviation from the conjectured odd-even behavior. The observed ZBA is strongest for N=9 and displays a particle-hole symmetry for N=7,..,11. It is absent for N=6 and N= 12. This observations indicate the influence of the shell structure of the electronic states in the quantum dot where orbital degeneracy is present.

HL 25.70 Wed 18:00 P2

Grating Couplers on a III-V Semiconductor Platform for Single-Photon Applications — •Valentino Merkl, Stephanie Bauer, Robert Sittig, Simone Luca Portalupi, Michael Jetter, and Peter Michler — Institut für Halbleiteroptik und Funktionelle Grenzflächen, Center for Integrated Quantum Science and Technology (IQ^{ST}) and SCoPE, University of Stuttgart, Allmandring 3, 70569 Stuttgart

Photonic quantum computing is one of the most studied fields of the 21st century, with the potential to revolutionize computation as we know it today. Using integrated quantum photonics to miniaturize setups, it is possible to increase the computation complexity drastically. For this purpose a III-V semiconductor platform is highly advantageous, as it enables the possibility of integrating quantum dots as single photon sources, which cannot be done on silicon based platforms. They utilize the beneficial aspects of non-classical light for the computation. In some applications it is necessary to couple light from a chip into single mode fibers or vice versa. For this purpose, grating couplers, which demonstrated high coupling efficiencies of up to 89% on the silicon platform, are a highly versatile and promising method. In this contribution, we will present simulation results, fabrication steps and measurements on grating couplers constructed on the GaAs/AlOx platform. Using 2D and 3D FDTD simulations, these structures are optimized to have high coupling efficiencies in the near infrared regime and common telecom frequencies matching the emission wavelength of the QDs.

HL 25.71 Wed 18:00 P2

Heat Radiation of Semiconductor Wafers — •Bastian Schmülling, Timo Kruck, Andreas D. Wieck, and Arne Ludwig — Lehrstuhl für Angewandte Festkörperphysik, Ruhr-Uni Bochum

This work is about the struggles of pyrometer measurements of substrate temperature during molecular beam epitaxy (MBE) growth. During the growth of a typical GaAs wafer, a substrate temperature of 300 to 650 degree celsius is required. In our setup, a wafer is mounted in front of a radiation heater. To measure the substrate temperature, a pyrometer measures the thermal radiation. During growth, the substrate temperature is of utmost importance. However, the reflectivity and thus the emissivity changes with each additional layer deposited and the temperature measured by the pyrometer varies accordingly. These pyrometer measurements can be used to measure the growth rate. We plan to combining reflectometry and pyrometry during growth, to determine the actual temperature of the wafer.

HL 25.72 Wed 18:00 P2

Density Modulation of InAs/GaAs Quantum Dots and Pre Dots — •Peter Zajac[1], Nikolai Bart[1], Christian Dangel[2], Kai Müller[3], Andreas D. Wieck[1], Jonathan Finley[2], and Arne Ludwig[1] — [1]Ruhr-Universität Bochum, Universitätsstraße 150, 44801 Bochum, Germany — [2]Walter Schottky Institut and Physik Department, Technische Universität München, Am Coulombwall 4, 85748 Garching, Germany — [3]Walter Schottky Institut and Department of Electrical and Computer Engineering, Technische Universität München, Am Coulombwall 4, 85748 Garching, Germany

Epitaxial layer-by-layer growth without rotation of the substrate creates a thickness gradient along the surface with alternating smooth and rough layer areas. InAs quantum dots (QDs) grown on top of a GaAs gradient layer exhibit a density modulation along this gradient, which is studied with macro photoluminescence spectroscopy and atomic force microscopy (AFM). The periodicity of the modulation can be varied from a few hundred microns to several millimeters, depending on the thickness of the underlying gradient layer. Automated AFM measurements, covering multiple modulation periods along the gradient allow the investigation of wetting layer roughness, QD density and density of a smaller species of QDs, termed pre dots. AFM data analysis and extraction of parameters such as QD and monolayer step density is presented.

Bart, N., Dangel, C. et al. Wafer-scale epitaxial modulation of quantum dot density. *Nat Commun* **13**, 1633 (2022).

HL 25.73 Wed 18:00 P2

Calibrating Photoluminescence Yield for Quantum Emitters in Planar Photonic Heterostructures — •Timo Kruck, Hans-Georg Babin, Danial Kohminaei, Sayed Sadat, Andreas D. Wieck, and Arne Ludwig — Ruhr-Universität-Bochum; Lehrstuhl für angewandte Festkörperphysik, Bochum, Deutschland

When performing photoluminescence (PL) measurements, the spectral intensity of the emitted radiation strongly depends on the dielectric structure sourrounding the quantum emitter. Here we show a method for calibrating PL measurements to obtain the unaltered spectrum of the optically active medium. For this purpose, the spectral reflectivity and the wavelength dependent standing wave field are used. The reflectivity is determined by reflectometer measurements and a simulation based on the transfer matrix method are used to compensate for the true layer thickness. This is then used to calculate the standing wave field, the outcoupling efficiency and the quantum yield. To validate the method, the calibrated spectra are compared with cleaved-edge PL measurements where the QDs are excited from the side and the light is also collected from the side.

HL 25.74 Wed 18:00 P2

Development of deterministic fabrication of quantum systems for single photon delay at Cesium wavelength — •Avijit

Barua[1], Monica Pengerla[1], Lucas Bremer[1], Lucas Rickert[1], Jin-Dong Song[2], and Stephan Reitzenstein[1] — [1]Technische Universität Berlin, Berlin, Germany — [2]Korea Institute of Science and Technology, Seoul, Republic of Korea

Semiconductor QDs are extensively investigated as single-photon sources for photonic quantum technology. The information that is encoded in single photons may be used as quantum interfaces between stationary and flying qubits. Here, we develop bright and strain-tunable QD single-photon sources at the Cs D1 transition wavelength (894 nm) to explore the storage ability of semiconductor QD in atomic quantum memories. The devices are designed and numerically optimized to maximize the extraction efficiency using the FEM solver JCMSuite. By considering circular Bragg resonators with up to 2 rings with integrated QDs and an Au-backside mirror we numerically demonstrate a photon extraction efficiency as high as 65% (NA = 0.4) and a Purcell factor of 0.72. In the experimental development, we realized hybrid CBGs which facilitate Piezo-strain tuning of the QD device. We then implement in-situ electron-beam lithography to precisely integrate the selected single QD at 894 nm in such a structure to create bright single-photon sources. Furthermore, the emission from the developed structures is studied by means of photon autocorrelation measurements, and light-matter interaction with Cs vapor is investigated.

HL 25.75 Wed 18:00 P2

Purcell enhanced two indistinguishable emissions from two separated quantum dots for on-chip complex photonics quantum circuits — •Yuhui Yang[1], Shulun Li[1,2], Johannes Schall[1], Sven Rodt[1], Zhichuan Niu[2], and Stephan Reitzenstein[1] — [1]Institut für Festkörperphysik, TU Berlin, Berlin, Germany — [2]State Key Laboratory for Superlattice and Microstructures, Institute of Semiconductors, Chinese Academy of Sciences, Beijing, China

Quantum dots (QDs) are excellent single-photon emitters with a close to ideal quantum nature of emission. For large-scale integrated photonic quantum circuits, indistinguishable and bright single photons emitted by independent QDs are required. In this regard, QDs integrated into nanocavities that are compatible with on-chip waveguide systems are highly interesting since they have a small footprint while providing strong Purcell enhancement.

Here, we demonstrate the deterministic integration of two spectrally similar single QDs in separate, one-dimensional photonic crystal nanobeam cavities with significant Purcell enhancement. Our flexible and accurate deterministic fabrication concept allows us to combine the nanobeam waveguides with integrated QDs into a 2 2 on-chip multimode interferometer (MMI) beam splitter with a 50/50 splitting ratio to perform on-chip Hanbury Brown and Twiss (HBT) and Hong-Ou-Mandel (HOM) measurements. The obtained results demonstrate that our approach is very promising toward two-photon interference from monolithic independent single-photon emitters, and fully integrated photonic quantum circuits.

HL 25.76 Wed 18:00 P2

Experimental and numerical investigation of the evanescent coupling between an integrated micropillar laser and a ridge waveguide — •Léo Roche[1], Imad Limame[1], Ching-Wen Shih[1], Yuhui Yang[1], Shulun Li[1,2], and Stephan Reitzenstein[1] — [1]Institut für Festkörperphysik, Technische Universität Berlin, Hardenbergstraße 36, 10623 Berlin, Germany — [2]State Key Laboratory for Superlattice and Microstructures, Institute of Semiconductors, Chinese Academy of Sciences, Beijing 100083, China

Integrated Quantum Photonic Circuits (IQPCs) are very promising candidates for scalable and flexible on-chip quantum computation and quantum communication hardware. One critical requirement for their realization is the scalable integration of on-demand indistinguishable single-photon emitters. This is potentially possible through the resonant excitation of an integrated QD in a waveguide by means of an on-chip integrated coherent light microlaser. Towards this goal, we investigate the coupling and lasing properties of coherent light laterally emitted from a whispering gallery mode (WGM) type micropillar laser evanescently coupled to a single mode ridge waveguide. Using finite element method (FEM) simulations, we investigate the coupling efficiency and the Q-factor of the pillar-waveguide system for different angular mode number and various pillar-waveguide air gap distances. The III-V semiconductor type nanostructures composed of a GaAs cavity with InAs QDs and distributed Bragg reflectors are carefully processed using electron beam lithography and then measured using micro-photoluminescence spectroscopy.

HL 25.77 Wed 18:00 P2

Building charge detection in indium antimonide nanowires for scanning tunneling microscopy using gate-defined quantum dots — •Kanji Furuta[1], Felix Jekat[1], Benjamin Pestka[1], Sasa Gazibegovic[2], Diana Car[2], Sebastian Heedt[3], Marcus Liebmann[1], Thomas Schäpers[3], Erik Bakkers[2], and Markus Morgenstern[1] — [1]II. Phys. Inst. B, RWTH Aachen Univ., Germany — [2]Dept. of Appl. Phys., Eindhoven Univ., The Netherlands — [3]PGI-9, FZ Jülich, Germany

InSb nanowires are investigated with respect to suitability as a charge detector to be combined with scanning tunneling microscopy. Mechanically exfoliated hexagonal boron nitride (h-BN) as a dielectric is placed onto bottom finger gates (50 nm wide, 30 nm spacing). The nanowires are then aligned and placed mechanically onto h-BN. We present transport measurements on gate-defined quantum dots at temperatures down to 300 mK. Due to the dielectric, the time stability of our device improved to around 5 μeV/h. The charge stability diagram shows Coulomb diamonds with a charging energy of 2.5 meV and an orbital energy of 0.3 meV. Depending on the gate and magnetic field, additional transport channels are occasionally observed, causing additional lines in the charge stability diagram and a shift of the Coulomb peak pattern around a magnetic field of $\approx$ 400 mT. This points to the presence of an unintentional second quantum dot in the gate region. Different configurations are discussed in terms of their coupling to the leads and the main dot, and their effects on charge detection.

HL 25.78 Wed 18:00 P2

Coherent manipulation of GaAs quantum dot spin qubits using microwaves — •Ankita Choudhary[1], Nand lal Sharma[1], Moritz Langer[1], Ghata Satish Bhayani[1], Uri Vool[2], and Caspar Hopfmann[1] — [1]Leibniz Institute for Solid State and Materials Research, Dresden — [2]Max Planck Institute for Chemical Physics of Solids, Dresden

Spin qubits in semiconductor quantum dots are attractive resources for performing quantum computations. In these systems single optically addressable spin qubits can be realized by single confined charge carriers, electrons, heavy holes, and their excited states. The quantum dot spin qubit coherence is however limited due to their semiconductor environment due to spin-orbit coupling to the magnetic moments of the atomic nuclei. Our goal is to facilitate the heralded and deterministic spin state preparation as well as to minimize the decoherence. While the all-optical heralded preparation of spin states in GaAs quantum dots has been demonstrated by us [1], the latter may be achieved by coherent manipulation of the spin states using the spin echo technique [2]. Our immediate goal is therefore to enable coherent manipulation of quantum dot spin qubits via injection of microwave pulses by superconducting co-planar waveguide structures. This technique will allow us to achieve full manipulation of the quantum dot and we expect to be able to achieve strong interaction between microwaves and quantum dot spin qubits, which could enable the coherent coupling between superconducting and quantum dot qubits. [1] C. Hopfmann et al, PRB 104, 75301 (2021). [2]F. H. L. Koppens et al, PRL 100 (2008).

HL 25.79 Wed 18:00 P2

Synthesis of ZnS nanoparticles investigated by in-situ X-ray scattering and spectroscopy — •Lars Klemeyer, Tjark Groene, Olga Vasylieva, Francesco Caddeo, Sani Harouna-Mayer, and Dorota Koziej — Universität Hamburg, Insititut für Nanostruktur- und Festkörperphysik, Center for Hybide Nanostructures, Luruper Chaussee 149, 22761 Hamburg

Transition metal sulfides are promising materials for a variety of applications. Especially the electronic configuration of the d-orbitals leads to unique electronic properties of transition metals and their compounds. Zinc sulfide (ZnS) is one of the most widely used transition metal sulfide due to its broad availability and relatively low toxicity as well as saturated d-orbitals. However, the synthesis approaches of ZnS nanoparticles in solution are not fully understood. We show complementary analysis with in-situ pair distribution function (PDF) and in-situ X-ray spectroscopy of the solvothermal synthesis of ZnS for a comprehensive picture of the nucleation and growth from precursors to nanoparticles.

HL 25.80 Wed 18:00 P2

Efficient frequency filtering of quantum dot photons using a self-constructed transmission grating monochromator — •Moritz Meinecke, Sven Höfling, and Tobias Huber — Lehrstuhl für Technische Physik, Universität Würzburg, 97074

Würzburg, Germany

Many spectroscopic measurements for characterizing quantum dot emission lines require spectral signal filtering that is narrower or matched to the expected line widths to analyze photons from different single excitonic charge complexes. Furthermore, to use the quantum dot photons for applications, this filtering should be efficient. A classical reflection monochromator is not ideal for this purpose, since it often comes with a low filter efficiency when the light is coupled to fiber, which is required for photon detection with superconducting nanowire detectors and for usage in any application. Furthermore, a reflection monochromator is strongly polarization dependent, which limits its use to non-polarization sensitive measurements, or requires polarization projection before frequency filtering. Alternative filter optics, like bandpass filters, have low flexibility and often need time consuming adjustments.

Here, we present a self-constructed transmission grating monochromator. It allows efficient, frequency filtering of quantum dot emission lines in the near infrared region. It is fully automatized and precise in approaching any filter position. Furthermore, the nearly polarization independent performance allows for polarization sensitive measurements.

HL 25.81 Wed 18:00 P2

Establishment of a method to make PL measurements on optically active layers in different dielectric structures comparable — •Sayed Shkeebullah Sadat, Danial Kohminaei, Timo Kruck, Hans-Georg Babin, Andreas Wieck, and Arne Ludwig — Ruhr-Universität Bochum, Bochum, Deutschland

To improve extraction of photoemission from optically active layers such as quantum dots (QDs) or quantum wells (QWs) one can e.g. grow them inside dielectric structures (DBR - distributed Bragg reflector). However, the emerging wavelength-dependent standing wave field alters the spectral intensity of the quantum emitters, which means straightforward comparisons of photoluminescence (PL) measurements are no longer possible. Therefore we present a method by which you can obtain the unaltered spectrum. To calculate the standing field we determine the specific reflectivity first and adjust it to the true thickness of the layers. From here it is possible to determine the efficiency of the photon extraction and thus the quantum yield, which allows us to calibrate and transfer the spectra back to its unmodified form. Since this can be performed on any dielectric structure it now is possible to compare the calibrated spectra with each other. Furthermore there is a possibility to automate this process, allowing the instantaneous comparison of PL measurements on optically active layers in DBR surroundings. To verify the validity of this method the calibrated spectrum is compared to the spectra of cleaved-edge probes, where the DBR has no notable influence since the photons are detected from the side here.

HL 25.82 Wed 18:00 P2

Quantum efficiency boost by photoneutralization of charges in GaAs quantum dots based entangled photon emitters — Jingzhong Yang[1], •Tom Fandrich[1], Frederik Benthin[1], Robert Keil[2], Nand Lal Sharma[2], Weijie Nie[2], Caspar Hopfmann[2], Oliver G. Schmidt[2,3,4], Michael Zopf[1], and Fei Ding[1,5] — [1]Institut für Festkörperphysik, Leibniz Universität Hannover — [2]Institute for Integrative Nanosciences, Leibniz IFW Dresden — [3]Material Systems for Nanoelectronics, Technische Universität Chemnitz — [4]Nanophysics, Faculty of Physics and Würzburg-Dresden Cluster of Excellence ct.qmat, TU Dresden — [5]Laboratorium für Nano- und Quantenengineering, Leibniz Universität Hannover

Single- and entangled-photon sources are a key component of photonic applications in i.e. quantum communication. GaAs quantum dots are very promising candidates because of their compatibility to integrated photonic structures and the ability to generate photons on demand with low multiphoton emission, near-unity entanglement fidelity and high indistinguishability. One limiting factor is the emission blinking of the resonance fluorescence. This reduces the efficiency and limits the scalability in quantum networks. The neutral biexciton is resonantly excited via two-photon excitation displaying such blinking behavior. By introducing an additional weak off-resonant excitation, the balance of free charges close to the quantum dot was controlled. This leads to a reduction of blinking caused by the intrinsic Coulomb blockade due to captured charges. This method increases the excitation efficiency by 30% while maintaining the fidelity of the entangled-photon pairs.

HL 25.83 Wed 18:00 P2

Frequency Shift of Electronic Resonances in Self Assembled InAs Quantum Dots — •Ibrahim Azad Engin[1], Ismail Bölükbasi[1], Arn Baudzus[1], Patrick Lindner[2], Andreas Wieck[1], Björn Sothmann[3], and Arne Ludwig[1] — [1]Lehrstuhl für Angewandte Festkörperphysik, Ruhr-Universität Bochum, 44801 Bochum — [2]Experimentelle Physik 2, Technische Universität Dortmund, 44227 Dortmund — [3]Fakultät für Physik, Universität Duisburg-Essen, 47048 Duisburg

Self-assembled InAs quantum dots (SAQD) proved to be promising semiconductor structures for applications as single-photon sources [1]. Especially, charge stabilization by coupling to a reservoir is important for quantum memory resources [2].

In this contribution, we investigate InAs SAQDs in a diode structure coupled to an electron reservoir by capacitance-voltage-spectroscopy to electrically probe QD energy levels and vary parameters like ac-frequency and bath temperature. For the lowest energy s-states a thermal shift in equilibrium has been reported [3]. Non-equilibrium coupling has been observed and described with a master equation [4], where resonance shifts at higher frequencies and temperature remain unexplored. We rectify this here by proposing a more elaborated model and experimental data interpretation.

[1] Tomm, N. et al., Nat. Nanotechnol. 16, 399-403 (2021). [2] Prechtel, J. et al., Nat. Mater. 15, 981-986 (2016) [3] Brinks, F. et al., New J. Phys. 18, 123019 (2016). [4] Valentin, S. et al., Phys. Rev. B 97, 045416 (2018).

HL 25.84 Wed 18:00 P2

Droplet epitaxy of InGaAs quantum dots for spin-photon interface devices — •Xuelin Jin[1,2], David Fricker[1,2], Nils Von den driesch[1,3], Alexander Pawlis[1,3], Renu Rani[1,3], Minh Bui[1,3], Detlev Grützmacher[1,2], and Beata Kardynal[1,2] — [1]PGI 9, Forschungszentrum Jülich, 52425 Jülich, Germany — [2]Department of Physics, RWTH Aachen, 52074 Aachen, Germany — [3]PGI 10, Forschungszentrum Jülich, 52425 Jülich, Germany

Abstract. Quantum networks use photonic qubits to send information, that means photonic qubits need to be converted into stationary qubits at the network nodes. A transfer information from a photonic to a spin qubit has been already demonstrated. Here we study the possibility of transferring photonic qubits into spin qubits which offer a potential of scaling into quantum processors, ones in gate-defined quantum dots in GaAs. Since gate-defined quantum dots do not confine holes, a direct conversion of photon qubits into spin qubits in these quantum dots is not possible. Here, we explore the possibility of using self-assembled InGaAs quantum dots grown by droplet epitaxy as an optical interface to the gated quantum dots defined in GaAs. We will discuss the conditions that the heterostructure has to fulfil to facilitate tunable tunnel coupling between the two quantum dots and we will show the progress in its growth and characterisation. In order to maintain the stable operation of the gated quantum dots, we use droplet epitaxy to grow InGaAs QDs. We will show that this method allows us to create quantum dots with energies suitable for tunnel coupling and minimize the impact of the wetting layer on the two-dimensional electron gas.

HL 25.85 Wed 18:00 P2

Deterministic Coupling of Gold Nanorods with GaAs Quantum Dots — •Yinan Wang[1], Pengji Li[1], Chenxi Ma[1], Andreas Schell[1,2], Michael Zopf[1], and Fei Ding[1,2] — [1]Institut für Festkörperphysik, Leibniz Universität Hannover, Appelstraße 2, 30167 Hannover, Germany — [2]Laboratorium für Nano- und Quantenengineering, Leibniz Universität Hannover, Schneiderberg 39, 30167 Hannover, Germany

Coupling single-photon sources with metal nanoparticles is an emerging topic in quantum optics. Thus the deterministic fabrication of metal nanoantennas is crucial. Here we report our recent efforts on coupling single gold nanorods to single GaAs quantum dots. Two different techniques were investigated: (1) drop-casting a gold nanorod containing solution on the quantum dot sample, and (2) deterministic nano-manipulation of gold nanorods via Pick-and-Place functionalities of an atomic force microscope. We observed the modified photoluminescence of quantum dots, due to their coupling to the localized surface plasmons of the gold nanoparticles. The experimental details and also kinetic modeling will be also shown in detail.

HL 25.86 Wed 18:00 P2

Measurement and calculation of spectral emissivity of semiconductor quantum emitters in dielectric environments — •Danial Kohminaei, Sayed Shkeebullah Sadat, Timo Kruck, Hans-Georg Babin, Andreas D. Wieck, and Arne Ludwig — Ruhr-Universität Bochum; Lehrstuhl für angewandte Festkörperphysik, Deutschland

Quantum dots (QDs) emit light divergently. For improved outcoupling of this photon emission, QDs are grown above so-called distributed Bragg reflectors (DBRs), which have a maximum reflectivity at the wavelength of the light of the QDs. Reflection also occurs unwantedly at the interface of the semiconductor to the vacuum. Therefore, when performing photoluminescence (PL) measurements, the measured spectral intensity of the emitted radiation strongly depends on the (dielectric) structure of the sample. Here we show a method for calibrating PL measurements to obtain the unaltered spectrum of the optically active medium. First, the spectral reflectivity is determined by reflectometer measurements, and compared to a simulation based on the transfer matrix method for the true layer thickness. This is then used to calculate the wavelength dependent standing wave field, the outcoupling efficiency and the quantum yield. Furthermore, the influence of the absorption of the exciting laser light in the semiconductor, on the overall spectrum will be analyzed. To validate the method, the calibrated spectra are compared with cleaved-edge PL measurements, where the QDs are excited from the side and the light is also collected from the side.

HL 25.87 Wed 18:00 P2

Fabrication & Electrical Characterization of Silicon-Germanium Nanowire Schottky Barrier Transistors — •Muhammad Moazzam Khan[1], Oliver Steuer[1], Slawomir Prucnal[1], and Yordan M Georgiev[1,2] — [1]Institute of Ion Beam Physics and Materials Research, Helmholtz-Zentrum Dresden-Rossendorf, Bautzner Landstraße 400, D-01328 Dresden, Germany — [2]Institute of Electronics at the Bulgarian Academy of Sciences, 72, Tzarigradsko chaussee blvd, 1784-Sofia, Bulgaria

CMOS scaling is reaching physical limits in near future. Therefore, new approaches are required to continue achieving high speed and high performance devices. Replacing silicon with silicon-germanium alloy as a channel material having higher mobility contributes to faster and energy-efficient devices. In this work, we are investigating the transistor properties built from silicon germanium based nanowire channel. Schottky Barrier Field Effect Transistors are fabricated, which also have an additional functionality of re-configurability. This means that a single device can be operated as an N or P channel just by controlling the electric potential applied at the gate terminals. The devices are fabricated by top-down approach with nickel metal pads on both sides of the silicon-germanium nanowire. To form schottky junctions, flash lamp annealing is performed to diffuse metal into the nanowires. The schottky junctions formed at the interface between nickel-germanosilicide and nanowire are electrically controlled to operate the device. Transfer characteristics of these devices are measured to investigate the transistor properties.

HL 25.88 Wed 18:00 P2

realization of on-chip wavelength multiplexing with self-assembly InGaAs quantum dot in telecom C-band — •Dongze Wang, Stephanie Bauer, Michael Jetter, Simone Portalupi, and Peter Michler — Institut für Halbleiteroptik und Funktionelle Grenzflächen, Stuttgart, Germany

Photonic integrated circuits (PIC) are a highly appealing platform for the realization of quantum photonic devices on a scalable dimension. The technology of PIC has enabled the generation, processing, and detection of the quantum state of light. Several different material platforms for the realization of PIC were proposed and are currently under intense investigation. Gallium arsenide-based (GaAs) PIC provides a straightforward combination with a self-assembled quantum dot (QD), which can serve as an efficient on-demand single-photon source with high purity and indistinguishability. In this work, we present a wavelength-division multiplexing system based on indium gallium arsenide (InGaAs) waveguides containing self-assembled InGaAs QDs located at the telecom C-band. The waveguide core is deposited on aluminum gallium arsenide (AlGaAs), which provides large refractive index contrast resulting in good confinement for the propagating photons. The dimensional parameters of the single-mode waveguide were simulated by a finite-difference time-domain method. Afterwards, standard semiconducting nanofabrication processes including electron beam lithography and inductively coupled plasma-reactive ion etching technology were used to fabricate the InGaAs photonic chip.

HL 25.89 Wed 18:00 P2

Magnetotransport in narrow-gap semiconductors with nanostructured constrictions — •Olivio Chiatti[1], Johannes Boy[1], Christian Riha[1], Christian Heyn[2], Wolfgang Hansen[2], and Saskia F. Fischer[1] — [1]Novel Materials Group, Humboldt-Universität zu Berlin, 10099 Berlin, Germany — [2]Institut für Nanostruktur- und Festkörperphysik, Universität Hamburg, 20355 Hamburg, Germany

Measurements in magnetic fields are an effective tool to investigate transport properties of low-dimensional electron systems. We investigate the magnetotransport of semiconductor heterostructures and nanostructures with spin-orbit interaction (SOI), under the influence of in-plane and out-of-plane electric fields. The nanostructures are quantum point contacts (QPCs) etched in Hall-bars with in-plane gates. The Hall-bars and the constrictions were defined by micro-laser photolithography and wet-chemical etching from an InGaAs/InAlAs quantum well with an InAs-inserted channel [1]. We have performed transport measurements at low temperatures in the combined QPC and Hall-bar structures in magnetic fields. We can tune the gate-voltages to control the filling-factor mismatch between bulk Hall-bar and QPC. We observe a crossover from reflection to transmission of the quantum Hall edge channels at the QPC and a tunneling across the QPC between reflected edge states, which depends on the magnitude and direction of the in-plane electric field.

[1] Chiatti *et al.*, Appl. Phys. Lett. **106**, 052102 (2015).

HL 25.90 Wed 18:00 P2

Acquisition and analysis of photocurrent spectra for 850 nm oxide-confined vertical-cavity surface-emitting lasers — Arndt Jaeger[1], Marwan Bou Sanayeh[2], Helmut Meinert[1], •Manuel Haerer[1], Oleg Yu. Makarov[2], Ilya E. Titkov[2], Nikolay Ledentsov Jr.[2], and Nikolay N. Ledentsov[2] — [1]Esslingen University of Applied Sciences, Flandernstrasse 101, 73732 Esslingen, Germany — [2]VI Systems GmbH, Hardenbergstrasse 7, 10623 Berlin, Germany

Vertical-cavity surface-emitting lasers (VCSELs) are of utmost importance as key components for high-speed datacom, sensor and free-space applications. Therefore, for a successful further optimization of their performance, understanding their aging behavior is of crucial importance. The 850 nm oxide-confined VCSELs used in this study were intentionally operated at extreme conditions to accelerate their degradation until reaching optical damage. For monitoring operation-induced changes, a photocurrent spectroscopy (PCS) setup was established and applied before and after accelerated aging. The PCS results at different reverse biases reveal changes that can be explained by non-radiative recombination centers generated during accelerated aging. This finding contributes to the understanding of the aging mechanisms in these tiny devices.

HL 25.91 Wed 18:00 P2

Polariton condensation with extreme confinement of light — •Maria Vittoria Gurrieri[1], Philip Kristensen[1], Jesper Mork[1], and Emil Denning[2] — [1]Department of Electrical and Photonics Engineering, Technical University of Denmark, 2800 Kgs. Lyngby, Denmark — [2]Nonlinear Optics and Quantum Electronics, Technical University of Berlin, 10623 Berlin, Germany

Strong coupling between light and electronic excitations mixes the constituent eigenstates into hybrid polaritonic quasiparticles. Under certain conditions it is possible to predict the formation of a polariton condensate with macroscopic occupation number and spontaneous coherence in the ground state. This condensate is a source of coherent matter waves and photons.

In this work we theoretically investigate the possibility of achieving polariton condensation in an extended sheet of 2D semiconductor coupled to a novel dielectric nanocavity with deep subwavelength confinement and featuring a spectrally isolated mode. Such coupling leads to the formation of a spatially localized polariton state, which interacts with the continuum of excitons through Coulomb interaction. The system is modelled by a Born-Markov master equation for the polariton subsystem, where the exciton continuum is traced out. This enables the derivation of a rate equation model to describe the dynamics of the lower polariton population.

HL 25.92 Wed 18:00 P2

Time resolved spin dynamics in lead halide hybrid organic perovskite $Fa_{0.9}Cs_{0.1}PbI_{2.8}Br_{0.2}$ — •Erik Kirstein[1], Eiko Evers[1], Vasilli V. Belykh[1,2], Evgeny A. Zhukov[1], Dennis Kudlacik[1], Ina V. Kalitukha[3], Olga Nazarenko[4], Maxim V.

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Lead halide hybrid organic perovskites attract increased attention due their promising applications, related to their high quantum efficiency and easy synthesis. The spin dynamics in perovskite materials is not studied in detail so far, but shows promising results. The studied $Fa_{0.9}Cs_{0.1}PbI_{2.8}Br_{0.2}$ bulk sample was grown out of solution of respective ions in polar solvents. Its bandgap of 1.51 eV makes this material well-suited for the resonant excitation with Ti:Sapphire laser. We study the coherent spin dynamics of electrons and holes by means of time-resolved pump-probe Kerr rotation technique at cryogenic temperatures and magnetic fields up to 6 T. We measure longitudinal spin relaxation times T_1, transverse dephasing times T_2^*, g-factor values and their spread Δg.

HL 25.93 Wed 18:00 P2

Temperature dependence of the bandgap of ^{28}Si and its use as time-resolved, high precision thermometer — Eduard Sauter[1], Nicolay V. Abrosimov[2], •Jens Hübner[1], and Michael Oestreich[1] — [1]Institut für Festkörperphysik, Leibniz Universität Hannover, Appelstraße 2, 30167 Hannover, Germany — [2]Leibniz-Institut für Kristallzüchtung, Max-Born-Straße 2, 12489 Berlin, Germany

We measure by high resolution absorption spectroscopy of the extremely narrow donor bound trion ^{28}Si:P transition the precise temperature dependence of the indirect bandgap of isotopically purified ^{28}Si in helium exchange gas in the regime from 0.1 K to 2 K. The measurements evidence that the trion frequency can be used as an efficient, contactless, local temperature sensor with a demonstrated time-resolution of a few microseconds. Furthermore, the all-optical sensor is also quite sensitive to changes of the local electric field and of the helium cooling gas pressure allowing detailed studies of the complex ^{28}Si:P system dynamics after perturbations.

[1] M. Beck, N. V. Abrosimov, J. Hübner, and M. Oestreich, Phys. Rev. B, **99**, 245201 (2019).
[2] E. Sauter, N. V. Abrosimov, J. Hübner, and M. Oestreich, Phys. Rev. Lett. **126**, 137402 (2021).

HL 25.94 Wed 18:00 P2

Spin noise spectroscopy of a single InGaAs quantum dot at high magnetic fields — •Kai Hühn, Pavel Sterin, Jens Hübner, and Michael Oestreich — Institut für Festkörperphysik, Leibniz Universität Hannover, Appelstraße 2, 30167 Hannover, Germany

Single holes in InGaAs quantum dots hold great promise as potential qubits due to the slow relaxation of selected spin degrees of freedom. However, the impact of phonon induced spin relaxation and occupancy noise for high magnetic fields remained unclear so far. Here, we use the method of spin noise spectroscopy (SNS) to gain a detailed insight into such mechanisms and measure the spin and charge dynamics for magnetic fields up to 4T and temperatures between 1.8K and 10K. Here, we combine, the quasi non-disturbant measurement scheme of SNS with an extrapolation to truly zero disturbance of the QD system. We find that the total noise power originates not just only from the hole-spin but from several processes including the relaxation of the hole spin and the charge state dynamics of the QD due to Auger recombination. In addition, our measurements indicate a long term stability of the intrinsic hole spin life time on the order of months. We compare our results with theoretical calculations which explicitly address one and two phonon processes as the limiting mechanism of the intrinsic hole spin relaxation.

HL 25.95 Wed 18:00 P2

Thermal Transport in c-plane GaN Membranes Characterized by Raman Thermometry — •Wilken Seemann[1], Joachim Ciers[2], Isabell Hüllen[1], Mahmoud Elhajhasan[1], Jean-François Carlin[3], Nicolas Grandjean[3], Åsa Haglund[2], and Gordon Callsen[1] — [1]Institute of Solid State Physics, University of Bremen, Germany — [2]Department of Microtechnology and Nanoscience, Chalmers University of Technology, Gothenburg, Sweden — [3]Institute of Physics, École Polytechnique Fédérale de Lausanne (EPFL), Switzerland

Excess heat often limits the lifetime or stability of semiconductor devices, like laser strcutures, e.g. by affecting the refractive index or defect formation. It is therefore vital to understand how thermal energy is dissipated from the active region. In this contribution, we analyze the in-plane thermal transport in GaN-based membranes which can be applied in UV-visible light emission. The temperature of the material is probed by the shift and width of Raman modes under heating with a UV laser. This method allows for a contactless characterization without the need for additional processing steps often needed for alternative thermometry. We find, that the thermal conductivity, κ, is significantly reduced compared to bulk GaN due to the finite thickness of the analyzed membranes. Phonon scattering due to roughness and porosity of the membrane is found to further reduce κ. Studying in-plane thermal transport lays the foundation for subsequent thermal studies on entire device structures; exploiting a subtle balance of in- and cross-plane thermal transport which could improve device designs.

HL 25.96 Wed 18:00 P2

A ultrafast Optical-pump/THz-probe spectrometer based on sub-diffraction field confinement — •Julia A. Lang, Michael Seidel, and Georg Herink — Experimental Physics VIII, University of Bayreuth, Germany

Time-resolved THz spectroscopy is a powerful tool for characterizing transient carrier dynamics in electronic materials and devices. In this contribution, we present an optical-pump/THz-probe spectrometer based on a high-repetition rate femtosecond fiber laser and photoconductive antennas combined with resonant microstructures for signal amplification. In particular, this approach exploits sub-diffraction Terahertz confinement in metallic microstructures to reduce the large mismatch between optical and THz foci. We demonstrate local spectroscopy of carrier dynamics in a semiconductor material inside a single resonator and corroborate our findings with finite-element simulations.

HL 25.97 Wed 18:00 P2

In depth comparison of Raman and Hall measurements for the determination of the electrical transport parameters of N-doped 4H-SiC — •Hannes Hergert[1,2], Matthias T. Elm[1,2,3], and Peter J. Klar[1] — [1]Institute of Experimental Physics I, Giessen, Germany — [2]Center for Materials Research, Giessen, Germany — [3]Institute of Physical Chemistry, Justus Liebig University, 35392 Giessen, Germany

A precise characterisation of the impact of doping on the electronic transport properties is necessary for the application of silicon carbid (SiC) in semiconductor devices. Hall effect measurements yield reliable results for mobility and carrier density but electrical contacts are needed. These are often not desired. An alternative approach is the analysis of the longitudinal optical phonon electron plasma coupled (LOPC) mode using Raman spectroscopy. This approach also delivers non-invasively information about the charge carrier density and the electron mobility. In this work, we compare the results obtained by Hall and Raman measurements. We show that the effective carrier density and the mobility obtained by Hall measurements deviate from those determined using Raman spectroscopy. The deviations arise as only electrons in the conduction band couple to the LO mode, while electrons in the impurity band do not, but still contribute to the electrical transport. To extract the charge carrier density in the conduction band from Hall measurements, a three-band model is employed. In addition, the two measurement methods yield different values of the mobility due to its frequency-dependence.

HL 25.98 Wed 18:00 P2

Electrical characterization of core/shell GaAs/InAs/Al nanowire-based Josephson junctions — •Farah Basaric[1], Anton Faustmann[1], Marvin M. Jansen[1], Alexander Pawlis[1,2], Erik Zimmermann[1], Hans Lüth[1,2], Detlev Grützmacher[1,2], and Thomas Schäpers[1,2] — [1]Peter Grünberg Institut (PGI-9), Forschungszentrum Jülich, 52425 Jülich, Germany — [2]JARA-Fundamentals of Future Information Technology, Jülich-Aachen Research Alliance, Forschungszentrum Jülich and RWTH Aachen University, Germany

Epitaxially grown phase-pure GaAs/InAs core/shell nanowires offer uniformity in their electrical, mechanical and optical properties. High electron mobility, large g-factor and strong Rashba spin-orbit coupling in combination with phase-pure wurtzite GaAs core offer heterostructure with transport properties governed by the presence of confined states in the InAs shell. A Josephson junction was realized by wet chemical etching of an *in-situ* deposited Al half-shell. Clean semiconductor-superconductor interface by such deposition was important for obtaining high critical current and good electrical transport control. The nanowire system was fabricated fully *in-situ* in a state-of-the-art nanofabrication clustertool, enabling precisely defined interfaces. Magnetotransport measurements at variable temperature regime were carried out for structures with normal and superconducting contacts under applied in-plane magnetic field, with varying gate potential. Such hybrid structure represents a promising candidate in realizing superconducting qubits and Majorana circuits.