HL 63: Poster: Quantum Dots and Optics

Time: Wednesday 15:00–19:00 Location: P1A

HL 63.1 Wed 15:00 P1A

Time-resolved optical spectroscopy of guiding modes a in CdZnTe/CdMgTe structure — •Jonas Vondran[1], Felix Spitzer[1], Nils Weber[2], Régis Andre[3], Henri Mariette[3], Cedrik Meier[2], Torsten Meier[2], Ilya Akimov[1], and Manfred Bayer[1] — [1]Technische Universität Dortmund, Dortmund, Germany — [2]Universität Paderborn, Paderborn, Germany — [3]Université Grenoble-Alpes, Grenoble, France

We report on pump-probe reflectivity measurements with 30 fs temporal resolution in a 170 nm thick CdZnTe waveguiding layer cladded between 100 nm width CdMgTe cap and 400 nm thick buffer layer. In order to excite and detect guiding modes gold gratings with periods from 230 to 310 nm are patterned at the top of the sample. Steady state measurements show distinct polarization, angle and wavelength-dependent features indicating the dispersion of waveguiding modes and their interaction with the excitonic resonance at 760 nm wavelength. The transient optical response is strongly influenced by the polarization of pump and probe beams as well as the grating period. The largest modulation depth is observed when the modes are resonantly excited in TM-polarization. We observe clear signatures of free induction decay at negative delay times when the probe reaches the sample earlier than the pump pulse with coherence times of 80-120 fs at T=10K.

HL 63.2 Wed 15:00 P1A

Creation of long-living exciton polariton like states: The impact of pulsed excitation to a steady-state condensate — •Daniel Schmidt[1], Bernd Berger[1], Marc Assmann[1], Martin Kamp[2], Christian Schneider[2], Sven Höfling[2], and Manfred Bayer[1] — [1]Experimentelle Physik 2, Technische Universität Dortmund, D-44227 Dortmund, Germany — [2]Technische Physik, Physikalisches Institut, Wilhelm Conrad Röntgen Research Center for Complex Material Systems, Universität Würzburg, D-97074 Würzburg, Germany

High quality GaAs microcavities offer the possibility to investigate long-living and therefore far traveling exciton polariton condensates. Although much research has been performed using continuous-wave (CW) and pulsed excitation to drive the condensation, few studies investigated the differences in the build-up of the exciton polariton condensation process. We present the impact of pulsed excitation near the threshold power on a steady-state exciton polariton condensate that is confined by a CW pumped ring potential. After the initial decay of the pulsed excited condensate, a surprisingly long-living polariton-like state arises that exceeds the polariton lifetime by an order of magnitude.

HL 63.3 Wed 15:00 P1A

On the phonon assisted absorption in Cu_2O — •Florian Schöne and Heinrich Stolz — Universität Rostock, Institut für Physik

A common approach to describe the shape of the excitonic absorption close to the band gap is based on the formalisms introduced by Elliott[1] 60 years ago utilising the transition probabilities between electronic bands. We follow his ansatz for indirect transitions via second order perturbation theory which can be visualised as an excitation into a virtual intermediate state and the subsequent relaxation to the final state through the emission of a phonon. However, instead of assuming the intermediate states to be pure band states, for materials with large exciton binding energies it is necessary to use the corresponding exciton states. This leads to the invalidity of the commonly assumed square root dependence of the absorption[2]. Applying our theory to the indirect absorption of the yellow exciton states in Cu_2O we find the 1S blue exciton states to be the dominant intermediate states. To describe the experimental observed line shape[3] it is furthermore necessary to assume a momentum dependent deformation potential for the Γ_3^- phonon.

[1] Elliott R.J., Phys. Rev. **108**, 1384 (1957)
[2] Kuper C. G., Whitfield G. D., "Polarons and Excitons." Oliver and Boyd, London (1963)
[3] Naka N., Satoshi H., Teruya I., Jpn. J. Appl. Phys. **44** 5096 (2005)

HL 63.4 Wed 15:00 P1A

Exceptional points in optically anisotropic microcavities — •Steffen Richter[1], Tom Michalsky[1], Chris Sturm[1], Bernd Rosenow[2], Marius Grundmann[1], and Rüdiger Schmidt-Grund[1] — [1]Universität Leipzig, Institut für Experimentelle Physik II, Linnéstr. 5, 04103 Leipzig, Germany — [2]Universität Leipzig, Institut für Theoretische Physik, Brüderstr. 16, 04103 Leipzig, Germany

Optical microcavities incorporating anisotropic media can yield effectively biaxial symmetries. They furthermore have dissipative character due to finite broadening of photonic modes. Generally, each mode with a given mode number N is split up into two modes with different polarization. We show that the optical biaxility can lead to the occurrence of exceptional points (EPs) in momentum space. At such points, not only mode energies and broadenings but also their polarization states degenerate, allowing only propagation of circularly polarized photons. Hence, the phenomenon of EPs is similar to singular optic axes in absorptive biaxial media. Here, we show how to realize EPs even in a fully transparent structure and how to tune their position in momentum space through the structure's geometry.

HL 63.5 Wed 15:00 P1A

Determining the band offset of Ga(NAsP)/GaP heterostructures on Si — Sebastian Gies, •Sarah Karrenberg, Wolfgang Stolz, and Wolfram Heimbrodt — Department of Physics and Materials Science Center, Philipps-Universität Marburg, Renthof 5, 35032 Marburg, Germany

The quaternary direct band-gap semiconductor Ga(N,As,P) is a promising candidate for optoelectronic integration on silicon. It can be grown lattice matched to Si and first lasing operation has been demonstrated. To optimize the laser design, it is necessary to have exact knowledge about the electronic structure of the material, especially the band-offset. In this study, we present a thorough investigation of photoluminescence properties of Ga(N,As,P)/Si heterostructures. Using temperature dependent PL we will reveal the disorder of the material and determine optizimed growth parameters. Furthermore, the conjunction of PL excitation spectroscopy and a QW model allows us to reveal the nature of the underlying transitions. In addition, we are able to determine the hitherto unknown band offset between Ga(N,As,P) and GaP with very high precision.

HL 63.6 Wed 15:00 P1A

Optical properties of Tin(IV) oxide prepared by different growth techniques — •Nils Mengel[1], Nils W. Rosemann[1,2], Martin Becker[2], Yinmei Lu[2], Angelika Polity[2], Peter J. Klar[2], and Sangam Chatterjee[2] — [1]Faculty of Physics and Materials Science Center, Philipps-Universität Marburg, Renthof 5, D-35032 Marburg, Germany — [2]Institute of Experimental Physics I, Justus-Liebig-University Giessen, Heinrich-Buff-Ring 16, D-35392 Giessen, Germany

Transparent conducting oxides (TCOs) are currently receiving broad attention for device applications in displays or photovoltaics. An emerging TCO with promising properties is Tin(IV) oxide - SnO2. This material is cheap, very transparent and very thermally and chemically stable while it is at the same time virtually non-toxic [1]. Furthermore, SnO2 shows pronounced infrared reflection which is desirable for heat-managing window-applications. Here, we compare the optical properties of Tin(IV) oxide thin films by absorption and time-resolved photoluminescence spectroscopy. The thin films were deposited by either chemical vapor deposition (CVD) or ion-beam sputter deposition (IBSD) on c-plane and r-plane cut sapphire as well as quartz substrates. The CVD-grown layers are of higher structural quality than the IBSD-grown ones. Regardless, all samples are microcrystalline and the photoluminescence properties are hence dominated by impurity emission. [1] R. G. Gordon, Criteria for Choosing Transparent Conductors, MRS Bulletin 25, 52-57 (2000)

HL 63.7 Wed 15:00 P1A

Towards deterministic fabrication of circular Bragg gratings for enhanced quantum-dot based light sources — •Sascha Kolatschek, Stefan Hepp, Marc Sartison, Simone L. Portalupi, Michael Jetter, and Peter Michler — Institut für Halbleiteroptik und Funktionelle Grenzflächen, Center for Integrated Quantum Science and Technology (IQST) and SCoPE, Universität Stuttgart,

Allmandring 3, 70569 Stuttgart, Germany

Highly efficient single photon sources are a crucial component for quantum information processes. Semiconductor quantum dots (QDs) have been proven to be excellent candidates due to their outstanding optical properties. Among different stratergies to increase light extraction, the use of photonic nanostructures enables, together with increased brightness, also an improved indistinguishability and reduced lifetime using linear optics and cavity quantum electrodynamic effects. Here we show a novel deterministic fabrication method for the integration of preselected QDs into a circular Bragg grating cavity. Besides their significant Purcell enhancement these cavities show due to the asymmetric design a more probable emission in the upside direction (i.e. upwards with respect to the substrate located underneath) with a highly directional far-field pattern.

HL 63.8 Wed 15:00 P1A

Exciton-light binding and lifetime of polaritons — •Hannes Lagemann[1] and Klaus Morawetz[2,3,4] — [1]University of Münster, — [2]Münster University of Applied Sciences, Stegerwaldstrasse 39, 48565 Steinfurt, Germany — [3]International Institute of Physics (IIP) Av. Odilon Gomes de Lima 1722, 59078-400 Natal, Brazil — [4]Max-Planck-Institute for the Physics of Complex Systems, 01187 Dresden, Germany

Polaritons are investigated as quasiparticles formed when light and matter are strongly interacting. The exciton-photon interaction is modeled with the help of a separable potential. The dipole matrix element and the dipole transition rates are calculated and various lifetimes are discussed. Two modes are found whose lifetimes differ quantitatively and qualitatively as a function of the photon frequency. The regime where the exciton decays faster respectively slower than the polariton is determined.

HL 63.9 Wed 15:00 P1A

Fermi edge singularity and the functional renormalization group — •Fabian Kugler[1,2] and Jan von Delft[1] — [1]Arnold Sommerfeld Center for Theoretical Physics, Ludwig-Maximilians-Universität München, D-80333 München — [2]Max-Planck-Institut für Quantenoptik, D-85748 Garching

We study the Fermi edge singularity, describing the response of a degenerate electron system to optical excitation, in the framework of the functional renormalization group (fRG). Results for the (interband) particle-hole susceptibility from various implementations of fRG are tested against the summation of all leading log. diagrams, achieved by a solution of parquet equations. For the (zero-dimensional) special case of the X-ray edge singularity, we analytically reproduce the (first-order) parquet formula in a consistent way from a truncated fRG flow. Reviewing the underlying diagrammatic structure, we show that this derivation relies on partial cancellations special to the form of and accuracy applied to the X-ray problem and does not generalize. In fact, we show that the truncated fRG flow can only generate a fraction of the parquet graphs.

HL 63.10 Wed 15:00 P1A

Electron transport in small CdSe Quantum Dots coupled with Methyl Viologen — •Mona Rafipoor[1,2], Jan-Philip Merkl[1], Zhi Wang[1], Gabriel Bester[1,2], and Holger Lange[1,2] — [1]Physikalische chemie, Uni Hamburg, Germany — [2]center of ultrfas imaging, Hamburg, Germany

Semiconductor nanocrystals have drawn significant interest due to their light absorption and electron transport properties which are mostly used for solar cells materials. Electron transfer and light absorption in very small CdSe quantum rods (QRs) (diameter of 1.8 nm) coupled with electron acceptors Methyl Viologen (MV+2) were investigated by Transient Absorption spectroscopy.

HL 63.11 Wed 15:00 P1A

The role of intervalley scattering and phonon softening in the ultrafast carrier dynamics of PbTe — •Manpreet Kaur, Prashant Padmanabhan, Kestutis Budzinauskas, and Paul van Loosdrecht — Physics Institute 2, University of Cologne, 50937 Cologne, Germany

PbTe is a leading thermoelectric material, notable for its low thermal conductivity and large carrier mobility at low doping levels. Using time-resolved differential reflectivity measurements, we shed light on the ultrafast relaxation of highly excited carriers, probing the dynamics of electron-phonon interactions on the femtosecond and picosecond time-scales. Our results suggest that phonon-mediated intervalley scattering involving the Σ-point band gap plays a significant role in the carrier cooling process due to its unique energy dispersion. In addition, anomalous temperature dependencies in the carrier relaxation rates support recent observations of giant anharmonic interactions between LA and TO phonons in this material.

HL 63.12 Wed 15:00 P1A

Source Development for Ultrafast Transmission Electron Microscopy — •Nora Bach, Armin Feist, Katharina E. Priebe, Nara Rubiano da Silva, Thomas Danz, Marcel Möller, Jan Gregor Gatzmann, Stefan Rost, Jakob Schauss, Stefanie Strauch, Reiner Bormann, Murat Sivis, Sascha Schäfer, and Claus Ropers — 4th Physical Institute - Solids and Nanostructures, University of Göttingen, Germany

Ultrafast transmission electron microscopy (UTEM) is a novel experimental technique that combines nanoscale spatial with femtosecond temporal resolution [1]. However, the achievable performance for imaging and diffraction is limited by the brightness of current laser-driven electron sources.

Here, we present the design and implementation of an advanced UTEM instrument based on the modification of a commercial Schottky field emission TEM [2,3]. Single-photon photoemission from a tip-shaped ZrO/W(100) emitter is employed, yielding electron pulses with a spectral bandwidth of 0.6eV, a low beam emittance of about 1-10nm mrad, and an electron probe size down to 0.9nm. We characterize the temporal structure of the electron pulses by electron-photon cross-correlation and obtain pulse widths down to 200fs (full-width-at-half-maximum). The high beam quality demonstrated will enable new applications in the study of nanoscale ultrafast dynamics, including ultrafast electron holography and phase-contrast imaging.

[1] A. H. Zewail, Science 328, 187 (2010) [2] A. Feist et al., Nature 521, 200 (2015) [3] A. Feist et al., arXiv:1611.05022 (2016)

HL 63.13 Wed 15:00 P1A

Time evolution of the non-thermal phonon gas after laser excitation in antimony — •Sergej Krylow, Bernd Bauerhenne, Tobias Zier, Eeuwe S. Zijlstra, and Martin E. Garcia — Universität Kassel, Theoretische Physik II, Heinrich-Plett-Straße 40, 34132 Kassel,Germany

We study the decay of the femtosecond-laser excited coherent A_{1g} phonon mode in antimony using electronic temperature dependent density-functional-theory molecular-dynamics simulations for supercells with 576 atoms, in which a decay time due to phonon-phonon interactions of about 3 ps can be seen. By utilizing a second type of MD simulations where the A_{1g} phonon is de-occupied after laser excitation we are able to unravel the decay channels without relying on the usual perturbative approaches. In particular, we can see two decay channels which depend on the applied laser fluence and which we account to a third and a fourth order scattering process.

HL 63.14 Wed 15:00 P1A

An ultrafast electron diffraction setup for molecules in aqueous solution — •Arne Ungeheuer, Arne Senftleben, Marlene Adrian, Silvio Morgenstern, and Thomas Baumert — Institut für Physik, Universität Kassel, 34132 Kassel, Germany

Here we present a scheme for an ultrafast electron diffraction setup for electron diffraction on liquids and molecules in aqueous solution. We adapt the idea to use two obliquely colliding single laminar jets for the creation of a leaf-shaped flatjet with submicrometer thickness required for electron diffraction in transmission mode. The issue of multiple scattering in these relatively thick samples is addressed by the use of a Wien energy-filter to increase the signal-to-noise ratio. Preliminary results of field-simulations for a suitable filter-geometry are shown.

HL 63.15 Wed 15:00 P1A

CO2 activation on ZnO surface studied by ultrafast photoelectron spectroscopy — •Sesha Vempati, Lukas Gierster, and Julia Stähler — Fritz-Haber-Institute, Berlin, Germany

We investigate the electron injection dynamics from ZnO(10-10) into an adsorbed layer of CO_2 molecules via time-resolved two-photon photoelectron spectroscopy (TR-2PPE). ZnO is known to be a catalyst for the hydrogenation of the CO_2 producing methanol like fuels in heterogeneous catalysis. CO_2 adsorbs on ZnO in a bent geometry to form a tridentate configuration possibly due to partial reduction. Despite of various studies, the energies of the frontier molecular orbitals of CO_2 on ZnO are unknown. Using TR-2PPE we unveil the energies of the frontier molecular orbitals of CO_2 on ZnO. We find that CO_2 adsorption causes a significant increase in the work function (≈ 1.2 eV for 0.5 ML) consistent with a partial reduction ($CO_2^{-\delta}$) and/or the dipole moment associated with the bent molecules. Furthermore, TR-2PPE measurements suggest that above gap excitation in fact injects electrons from ZnO into the lowest unoccupied molecular orbital (LUMO) of $CO_2^{-\delta}$ molecule. After this electron capture, the LUMO shifts below the Fermi energy within 2 ps and forms a metastable state. This down shift is presumably accompanied by the changes of the nuclear coordinates of CO_2 due to the additional charge. This is probably the stage where the CO_2 molecule is completely activated for hydrogenation.

HL 63.16 Wed 15:00 P1A

Biomimetic imitation of strongly scattering beetle scales — •Marie-Christin Angermann[1] and Georg von Freymann[1,2] — [1]Physics Department and Research Center OPTIMAS, University of Kaiserslautern, Kaiserslautern, Germany — [2]Fraunhofer Institute for Physical Measurement Techniques IPM, Kaiserslautern, Germany

The white beetle Chyphochilus is covered with 5 μm thick scales consisting of a chitin network. These scales reflect 80% of the light [1] and are strong scatterers. The composition of the scattering network is not yet understood.

To mimic the beetle, we therefore simplify this network with a tailored disordered model. The model bases on a periodic grid. All intersection points of the grid lines are shifted in up to 8 different directions. The shifting is determined by an aperiodic series, an approach similar to [2]. The optical response is theoretically calculated by a finite difference time domain method. Corresponding structures are fabricated via direct laser writing.

First results show a total reflectance of about 32% to 42% over the whole visible spectrum. The backscattered intensity is evenly distributed over the half space. The most important parameter for high reflectance is the number of layers. Furthermore, the distribution of the backscattered light depends on the disorder in a single layer. Further optimization might pave the way towards highly efficient scattering materials.

[1] Burresi, M., et al. Scientific reports 4, 6075 (2014)
[2] Renner, M., et al. Scientific reports 5, 13129 (2015)

HL 63.17 Wed 15:00 P1A

Single photons slowed down by cesium-vapour — •Lucas Bremer[1], Alexander Thoma[1], Max Strauss[1], Sarah Fischbach[1], Sven Rodt[1], Tobias Heindel[1], Jin-Dong Song[2], and Stephan Reitzenstein[1] — [1]Institut für Festkörperphysik, TU Berlin, Berlin, Germany — [2]Center for Opto-Electronic Materials and Devices, KIST, Seoul, Korea

Semiconductor quantum dots (QDs) proved to be close to ideal emitters of single and indistinguishable photons, which can be further combined with deterministic device fabrication technology [1]. Atomic vapours in contrast can be used to slow down photons spectrally in resonance with their absorption lines [2]. Thus, hybrid systems interfacing single photons from a quantum dot with atoms show promise for the storage of quantum information [3]. In this work we investigate the temporal delay introduced by the high dispersion of the excited state hyperfine resonances of cesium-vapour, which is a crucial step towards the realization of quantum memories. Tuning the QD emission into the atomic resonance we are able to study the amount of photons delayed by the atoms. Increasing the temperature of the cesium-vapour enables us to observe a maximum delay of $\tau = (11.4 \pm 0.5)$ ns.

[1] Gschrey et al., Nat. Commun. 7662, 6 (2016)
[2] Akopian et al., Nat. Photonics 5, 230 (2010)
[3] Chanelière et al., Nature 438, 833 (2005)

HL 63.18 Wed 15:00 P1A

Quantum dots interfaced with cesium atoms for photonic delay: study on the photon linewidth dependence — Hüseyin Vural[1], Jonas Weber[1], Markus Müller[1], •Simon Kern[1], Julian Maisch[1], Matthias Widmann[2], Robert Löw[3], Jörg Wrachtrup[2], Ilja Gerhardt[2], Simone Portalupi[1], Michael Jetter[1], and Peter Michler[1] — [1]Institut für Halbleiteroptik und Funktionelle Grenzflächen, Universität Stuttgart, Allmandring 3, 70569 Stuttgart, Germany — [2]3. Physikalisches Institut, Universität Stuttgart, Pfaffenwaldring 57, 70569 Stuttgart — [3]5. Physikalisches Institut, Universität Stuttgart, Pfaffenwaldring 57, 70569 Stuttgart

Hybrid quantum systems, based on semiconductor quantum dots (QDs) and alkali vapors, constitute a recent research field which is attracting a growing attention. An important step for future applications is constituted by the possibility to slow down single photons coming from a QD. This effect has been investigated with photons coming from QDs under different pumping conditions, but always focusing on the absolute achievable delay and not investigating the effect of the photon linewidth. Here we report on a study on the photonic delay for photons with different linewidths. An atomic cell filled with Cs atoms is used as a variable delay line (via vapor temperature variation). Different QDs, which emit photons spectrally on resonance with the atomic transitions, are resonantly pumped and the emitted photons are transmitted through the vapor. QDs with different linewidths bring a different ratio between delayed and non-delayed photons.

HL 63.19 Wed 15:00 P1A

Interfacing single QD photons with Cesium Vapor — •Janik Wolters[1], Tim Kroh[2], Alexander Thoma[3], Stephan Reitzenstein[3], Rinaldo Trotta[4], Eugenio Zallo[5], Armando Rastelli[4], Oliver G. Schmidt[6], and Oliver Benson[2] — [1]Universität Basel — [2]Humboldt-Universität zu Berlin — [3]Technische Universität Berlin — [4]Johannes Kepler Universität Linz — [5]Paul-Drude-Institut für Festkörperelektronik, Berlin — [6]IFW Dresden

Hybrid quantum dot-atom systems might become a key ingredient for future heterogeneous quantum networks. In such a heterogenous quantum network quantum dots may serve as fast and efficient deterministic single photon sources, while atomic ensembles can be used to store quantum information with sufficiently long storage time, fidelity and efficiency to realize e.g. long distance quantum repeater links. A first step towards this vision is to interface single photons emitted by a semiconductor quantum dot with one single atomic hyperfine transition.

We have performed this step using a strain tunable InGaAs quantum dot emitting at 894 nm, corresponding to the Cs D1 line. The QD is excited non-resonantly by 50 ps laser pulses and precisely tuned the absorption minimum between two hyperfine transitions of the Cs D1 line. Under these conditions, strong dispersion occurs and already at moderate optical densities photons are slowed down to $\sim c/20$, where c is the speed of light in vacuum. This result is an important first step towards storage of the photons in a quantum memory with on-demand storage and retrieval.

HL 63.20 Wed 15:00 P1A

Currents in a chain of quantum dots — •Klaus Morawetz — Münster University of Applied Sciences,Stegerwaldstrasse 39, 48565 Steinfurt, Germany — International Institute of Physics (IIP)Av. Odilon Gomes de Lima 1722, 59078-400 Natal, Brazil — Max-Planck-Institute for the Physics of Complex Systems, 01187 Dresden, Germany

Using the quantum kinetic equation analytical expressions for the currents in chains of quantum dots are derived. During the transient behaviour non-dissipative quantum correlations lead to a decay of the initial correlations. After this short time behaviour the total current for homogeneous electric fields is ballistic. For wavelength-modulated electric fields, an effective capacitance, inductance and Ohmic resistance can be realized given in terms of quantum parameter.

HL 63.21 Wed 15:00 P1A

Persistent Spin Textures and Quantum Interference in Arbitrary Oriented 2DEGs with Spin-Orbit Coupling — •Michael Kammermeier, Paul Wenk, and John Schliemann — Institute for Theoretical Physics, University of Regensburg, 93040 Regensburg, Germany

We discover general conditions for the realization of spin-preserving symmetries for 2DEGs with Rashba and Dresselhaus spin-orbit coupling [1]. In particular, such scenarios can be found for semiconductor heterostructures of zinc-blende type if and only if at least two Miller indices of the growth direction are equal in modulus. We determine the appropriate requirements on the leading Rashba and Dresselhaus contributions and discuss the impact of cubic Dresselhaus terms corresponding to third angular harmonics. Also, we identify the orientation of the homogeneous conserved spin state and the momentum shift which allows for a controlled spin rotation giving rise to a persistent spin helix. To support experimental probing, we provide analytical expressions for the weak (anti)localization correction and the characteristic shift of the magnetoconductivity minima which show an imprint of the peculiar symmetry. The latter enables a fitting-free determination of the system's transport parameters and is consistent with recent experimental observations [2].

[1] M. Kammermeier *et al.*, Phys. Rev. Lett. **117**, 236801 (2016).
[2] K. Yoshizumi *et al.*, Appl. Phys. Lett. **108**, 132402 (2016).

HL 63.22 Wed 15:00 P1A

High precision microscopic setup for optical analysis of TMD Monolayers — •Magnus Neumann, Jens Hübner, and Michael Oestreich — Institut für Festkörperphysik, Leibniz Universität Hannover, Appelstrasse 2, D-30167 Hannover

Transition metal dichalcogenides (TMDCs) are promising candidates for establishing valleytronic devices as their valley degree of freedom becomes both optically accessible and tunable for single layer structures [1]. The high binding energies of the resulting excitons make TMDCs favorable for room temperature applications. However, the investigation of micrometer-sized monolayers requires high spatial resolution and mechanical stability of the employed optical set-ups. Here, we design and characterize a confocal microscope applicable for transmission Faraday-rotation spectroscopy. By photoluminescence measurements on a quantum dot sample with moderate QD density we determined the spatial resolution and absolute repeatability. The high precision microscopic setup provides us with high resolution photoluminescence maps of TMDC monolayers. We will further examine the rich spin physics of TMDC monolayers by all-optical spin-noise-spectroscopy [2], as our setup is both suitable for reflection and transmission measurements. SNS does not rely on the high absorption coefficient of TMD Monolayers, leaving the sample in thermal equilibrium and thus revealing the intrinsic spin dynamics.

[1] G. Wang et al., PRL **117**, 187401 (2016).
[2] J. Hübner, F. Berski, R. Dahbashi and M. Oestreich, phys. stat. sol. (b) **251**, 1824 (2014).

HL 63.23 Wed 15:00 P1A

Proximity induced exchange interaction in graphene-YIG devices — •Alexey Kaverzin, Johannes C. Leutenantsmeyer, Magdalena Wojtaszek, and Bart J. van Wees — Zernike Institute for Advanced Materials, University of Groningen, Nijenborgh 4, 9747AG, The Netherlands

Graphene is one of the promising platforms for the realisation of various spintronics devices. Large spin relaxation length and long spin relaxation time insure a reliable transport of the spin signal over a relatively large distances. Moreover, graphene is extremely sensitive to the environment and, therefore, can potentially adopt the properties of the underlying substrate via proximity effect.

In this work we study the effect of the ferrimagnetic electrically insulating substrate on the spin transport in exfoliated monolayer graphene. As a substrate we use yttrium iron garnet which preserves the magnetic ordering even at room temperature and induces a finite exchange interaction in the nearby graphene [1,2]. The change in the band structure results in a modified behavior of spins in graphene. We extend the standard Bloch diffusion equation with an additional exchange field and employ the solutions to fit the results. The extracted exchange field is found to be around 0.2 T. With these findings we show the robust method for producing ferromagnetic graphene and demonstrate a most direct method to probe the presence of an exchange interaction.

[1] Z. Wang et.al., Phys Rev Letters 114, 016603, (2015)
[2] J.C. Leutenantsmeyer et.al., 2D Materials 4, 1 (2017)

HL 63.24 Wed 15:00 P1A

Spin noise spectroscopy on a single InAs quantum dot — •André P. Frauendorf[1], Julia Wiegand[1], Dmitry S. Smirnov[2], Mikhail M. Glazov[2], Jens Hübner[1], and Michael Oestreich[1] — [1]Institut für Festkörperphysik, Leibniz Universität Hannover, Appelstraße 2, D-30167 Hannover — [2]Ioffe Institute, Polytechnicheskaya 26, 194021 St. Petersburg, Russia

The spin dynamics of electrons and holes confined in InAs quantum dots (QDs) are of particular interest for future applications in solid state quantum information processing. We implement spin noise spectroscopy (SNS) in order to access the intrinsic spin dynamics of confined carriers in individualy selected single QDs [1]. Measurements on single heavy-hole spins reveal a strong magnetic field dependence of the longitudinal spin relaxation time for low magnetic fields with relaxation times up to 180 μs [2]. We show by high precision measurements a deviation from the spin dynamics which would be expected from the usual two level system. Particularly, accurate measurements in dependence of the probe laser detuning reveal the existence of an additional spin noise contribution that arises from the intriguing interaction with the solid state environment.

[1] J. Hübner, F. Berski, R. Dahbashi, and M. Oestreich, phys. stat. sol. (b) **251**, 1824 (2014).
[2] R. Dahbashi, J. Hübner, F. Berski, K. Pierz, and M. Oestreich, Phys. Rev. Lett. **112**, 156601 (2014).

HL 63.25 Wed 15:00 P1A

A stable laser for interferometric spin noise and high precision absorption spectroscopy
— •Selina Volkert, Michael Beck, Jens Hübner, and Michael Oestreich — Institut für Festkörperphysik, Leibniz Universität Hannover, Appelstrasse 2, D-30167 Hannover

The inherent fluctuations of external cavity diode lasers impede the next generation interferometrically enhanced homodyne detection of spin noise at low frequencies [1]. To reduce its phase and frequency fluctuations by means of the Pound-Drever-Hall technique we will stabilize an external cavity diode laser onto a self-built and characterized high finesse Fabry-Perot reference cavity made from ultra low expansion glass. We will show the indispensability of this kind of stabilized laser for amplified detection of spin noise in the kHz frequency domain [2]. Furthermore, we will demonstrate the capabilities of the complete system by high resolution absorption spectroscopy of defect bound excitons in isotopically enriched silicon which inherently exhibits an ultra narrow homogeneous linewidth below $1MHz$ [3].

[1] S. Cronenberger *et al.*, Rev. Sci. Instr. **87**, 093111, (2016).
[2] R. Dahbashi *et al.*, Phys. Rev. Lett. **112**, 156601 (2014).
[3] A. Yang *et al.*, Appl. Phys. Lett. *95*, 122113 (2009).

HL 63.26 Wed 15:00 P1A

Nuclear Spin Relaxation in n-type GaAs — •lida abaspour, jan gerrit lonnemann, eddy patrick rugeramigabo, jens hübner, and michael oestreich — Institute for Solid States Physics, Leibniz University of Hannover, Germany

The intriguing mutual interaction of nuclear and electron spins in semiconductors [1] has been identified as a major source of nuclear as well as electron spin relaxation. Their relative impact significantly depends on the doping density which determines the degree of localization and the density of free electrons. The nuclear spin diffusion is governed by the interaction with electron spins of localized impurities [2] and delocalized conduction band electrons [3], respectively. Here, we investigate the detailed impact of doping density on the nuclear spin relaxation by all optical Hanle depolarization. The n-type MBE-grown GaAs samples cover two orders of magnitude around the metal to insulator transition. Consequently, we are able to precisely determine the effects of dipole-dipole type and carrier mediated nuclear spin diffusion. Moreover, the technique allowed us to investigate the complex interaction with the spin of electrons either localized to impurities or constrained to a confining impurity band.

[1] F. Berski et al., Phys. Rev. Lett. 115, 176601, (2015).
[2] M. Kotur et al., Phys. Rev. B 94, 081201(R) (2016).
[3] M. Kotur et al., JETP Lett. 99, 37 (2014).

HL 63.27 Wed 15:00 P1A

Dependences of the spin-flip Raman scattering efficiency of Mn^{2+} ions in (Zn,Mn)Se/(Zn,Be)Se quantum wells — •Katja Barthelmi[1], Henning Moldenhauer[1], Carolin Lüders[1], Dennis Kudlacik[1], Victor Sapega[2], Jörg Debus[1], and Manfred Bayer[1,2] — [1]Experimentelle Physik 2, Technische Universität Dortmund, Dortmund, Germany — [2]Ioffe Institute, Russian Academy of Sciences, St. Petersburg, Russia

Due to the possibility of controlled manipulation of the spin properties of carriers, diluted magnetic semiconductors (DMS) are promising materials for spintronic applications. Extensive studies on DMS containing Mn^{2+} ions have investigated the carrier-Mn interactions, but still many questions remain unanswered.
In that context, we have studied the dependences of the spin-flip Raman scattering (SFRS) efficiency of Mn^{2+} ions in (Zn,Mn)Se/(Zn,Be)Se quantum wells with Mn concentrations of about 1.5%. We have shown that the Mn spin-flip scattering efficiency is strongly amplified by resonant excitation of the exciton in close-to-Faraday geometries and at certain magnetic field strengths. We could attribute this amplification to an interaction of single Mn^{2+} spins with clusters of several Mn^{2+} spins. Furthermore, we have observed that the Mn^{2+} SFRS exhibits a strong dependence on temperature and excitation density. In addition to that, we have detected a significant

difference between the Mn^{2+} SFRS shift on the Stokes and anti-Stokes side, which may result from the nonlinear dispersion of the exciton magnetic polaron involved in the SFRS process.

HL 63.28 Wed 15:00 P1A

Optical orientation of hole magnetic polarons in (Cd,Mg)Te/(Cd,Mn,Mg)Te quantum wells — •Erik Kirstein[1], Evgeny A. Zhukov[1], Yuri G. Kusrayev[2], Kirill. V. Kavokin[2,3], Dmitri R. Yakovlev[1,2], Jörg Debus[1], Alexander Schwan[1], Ilya A. Akimov[1,2], Grzegorz Karczewski[4], Tomasz J. Wojtowicz[4], Jacek Kossut[4], and Manfred Bayer[1] — [1]Experimentelle Physik 2, Technische Universit\"at Dortmund, 44221 Dortmund, Germany — [2]Ioffe Physical-Technical Institute, Russian Academy of Sciences, 194021 St. Petersburg, Russia — [3]Spin Optics Laboratory, St. Petersburg State University, 198504 St. Petersburg, Russia — [4]Institute of Physics, Polish Academy of Sciences, 02668 Warsaw, Poland

The hole magnetic polaron (HMP) formation was investigated in a CdMnTe diluted magnetic semiconductor quantum well structure. The HMP is formed by the anisotropic exchange field of holes along the sample growth axis acting on free Mn Spins. The HMP occurs as a long living non oscillating contribution to the Kerr rotation Pump Probe signal, with observed dephasing times up to 60 ns. The HMP polaron is analyzed in dependence of the magnetic field, the lattice temperature and different carrier concentrations. Moreover, the full picture of the investigated QW structures show clear dynamics of hole, Mn and high effective g-factor electron spins. One obtains a detailed view on the theory of the HMP formation and relaxation. With the heavy hole as the dominant factor of HMP complex, a potential barrier is introduced to explain the HMP relaxation.

HL 63.29 Wed 15:00 P1A

Spin dynamics and magneto-optical effects in YAG:Ce — •Kai Hühn, Jan Gerrit Lonnemann, Jens Hübner, and Michael Oestreich — Institut für Festkörperphysik, Leibniz Universität Hannover, Appelstrasse 2, D-30167 Hannover

The peculiar spin dynamics of carriers localized at Ce sites in YAG has recently drawn considerable attention [1]. Here we present the magneto-optical investigation on the $^2F_{5/2}\rightarrow\ ^2D_{3/2}$ transition in a highly doped YAG:Ce^{3+} crystal at low temperatures. The photoluminescence spectrum reveals the zero-phonon-line position at 2.53346(16) eV. We resolve the complex system of phonon replicas which are explained with an idealized theoretical model. Furthermore, we measure the magneto-optical Voigt-Effect on a linear polarized probe laser beam for transversal magnetic fields showing a strong temperature and strain dependence.
The information of spin dynamics is generally contained within its equilibrium noise spectrum. A spin noise spectrum is obtained by mapping the spin fluctuations onto the linear polarization of a transmitted probe laser beam [2]. By using this technique we determine a spin decoherence time T_2 of 10.6(13) ns which coincide well with previously reported values [3].

[1] P. Siyushev *et al.*, Nature Com. **5**, 3895 (2014)
[2] J. Hübner *et al.*, phys. stat. sol. b **251**, 1521-3951 (2014)
[3] R. Kolesov *et al.*, Phys. Rev. Lett. **111**, 120502 (2013)

HL 63.30 Wed 15:00 P1A

Spin and charge transport in epitaxial graphene nanoribbons — •Talieh Ghiasi[1], Alexey Kaverzin[1], Jantje Schommartz[1,2], Johannes Aprojanz[2], Christoph Tegenkamp[2], and Bart van Wees[1] — [1]Physics of Nanodevices, Zernike Institute for Advanced Materials, University of Groningen, the Netherlands — [2]Institut für Festkörperphysik, Leibniz Universität Hannover, Germany

Graphene Nanoribbon (GNR) is the essential component of the future graphene-based Spintronics. Investigation of charge and spin transport in these quasi-one dimensional carbon based channels is the main focus of this experimental research. Evidence of ballistic transport in epitaxially grown GNR and the controlled well-defined spin-selective edges of the channel [1], show promises for ballistic fully spin-polarized transport in GNR-based devices. In this study, epitaxially grown GNRs on templated sidewalls and natural steps of SiC substrate are probed by ferromagnetic Cobalt electrodes made by electron-beam lithography technique. The use of the combination of local and non-local measurement geometries allows us to address charge and spin transport properties of studied GNRs independently. The finite conductance of the underlying SiC substrate is eliminated via using liquid Helium temperatures where the substrate becomes an order of magnitude more resistive than the studied nanoribbon. Various multi-terminal measurement configurations are used to separate the contact contribution and study directly the properties of the charge transport in GNR at different channel lengths and temperatures.

[1] Baringhaus, Jens, et al., Nature 506,349 (2014).

HL 63.31 Wed 15:00 P1A

Probe laser induced spin polarization of donor bound electrons in ^{28}Si:P — •Michael Beck[1], Nikolay Abrosimov[2], Jens Hübner[1], and Michael Oestreich[1] — [1]Institut für Festkörperphysik, Leibniz Universität Hannover, Appelstrasse 2, D-30167 Hannover — [2]Leibniz Institut für Kristallzüchtung, Max-Born-Strasse 2, D-12489 Berlin

The decoupling of donor atoms from the nuclear spin bath of the host lattice in isotopically enriched silicon leads to very long coherence times of donor electron spins [1]. The exceptional purity of this system also entails an ultra narrow optical linewidth and well resolvable hyperfine splitting of the donor bound exciton transition [2] which is commonly used to probe spin properties of the localized electron ensemble [3]. We employ Faraday rotation spectroscopy and observe a strong spin polarization caused by the linearly polarized probe laser only [4]. The findings are explained by supplemental phase modulation absorption spectroscopy which reveals the evolution of the hyperfine coupled states in small magnetic fields.

[1] A.M. Tyryshkin *et al.*, Nature Matter. **11**, 143, (2012).
[2] M. L. W. Thewalt *et al.* J. Appl. Phys. **101**, 081724 (2007).
[3] J. Hübner *et al.*, Phys. Stat. Solidi (B), **251**, 1824 (2014).
[4] A. Yang *et al.*, Phys. Rev. Lett. **102**, 257401 (2009).

HL 63.32 Wed 15:00 P1A

Interferometrically Enhanced Spin Noise Spectroscopy of Rubidium — •Pavel Sterin, Jens Hübner, and Michael Oestreich — Institut für Festkörperphysik, Leibniz Universität Hannover, Appelstr. 2, D-30167 Hannover, Germany

Spin noise spectroscopy is a powerful method for detecting the unaltered spin dynamics in atomic gases and semiconductors [1] since the spin fluctuations in these systems implicitly contain information about the intrinsic spin correlation which can be extracted from the spin noise power spectrum. Transparent samples allow to use the Faraday effect to map these spin fluctuations onto small rotations of a linearly polarized probe laser light. Here, the probe photon energy should be in the vicinity of an optical transition in order to ease the detection of the Faraday rotation. Hence, low probe laser intensities are necessary in order to reduce residual absorption and keep the system at thermal equilibrium [2], however, at the cost of the difficulties connected with low light detection. Recent advancement on high frequency measurements were achieved using a heterodyne setup [3]. Here, we employ a homodyne approach to concentrate on low frequencies, that are not accessible in the heterodyne setup. Conversely, the homodyne setup will allow to amplify the polarization signal, thereby making very low probe laser intensities accessible. A ^{87}Rb vapor reference cell will be used as a test system during the development of this experiment.

[1] Hübner et al., phys. stat. sol. B **251**, 1824, (2014).
[2] Dahbashi et al., Appl. Phys. Lett. **100**, 031906, (2012).
[3] Cronenberger et al., Rev. Sci. Instrum., **87**, 093111 (2016).

HL 63.33 Wed 15:00 P1A

Quantitative analysis of the hole-g-tensor in low-symmetry two dimensional hole systems — Christian Gradl[1], Michael Kempf[1], •Johannes Holler[1], Roland Winkler[2], Dieter Schuh[1], Dominique Bougeard[1], Alberto Hernández-Mínguez[3], Klaus Biermann[3], Paulo Santos[3], Christian Schüller[1], and Tobias Korn[1] — [1]Institut für Experimentelle und Angewandte Physik, Universität Regensburg, D-93040 Regensburg, Germany — [2]Department of Physics, Northern Illinois University, DeKalb, Illinois 60115, USA — [3]Paul-Drude-Institut für Festkörperelektronik, D-10117 Berlin, Germany

The complex structure of the valence band in most semiconductors leads to varied and in some cases unusual properties for spin-3/2 hole systems compared to typical spin-1/2 electron systems. In particular, two-dimensional hole systems show a highly anisotropic Zeeman spin splitting. We have investigated this anisotropy in GaAs/AlAs double quantum well structures both experimentally and theoretically. By performing time-resolved Kerr rotation measurements, we found a non-diagonal hole g-tensor, manifesting itself in unusual signal shapes as well as distinct dependencies on the magnetic field direction. We quantify the individual tensor components for [110]-, [113]- and [111]-grown samples and find very good agreement with our theoretical calculations.

HL 63.34 Wed 15:00 P1A

Electronic Raman scattering from spin-density excitations in a (001)-grown GaAs-AlGaAs quantum well — •Sven Gelfert[1], Alexander Glötzl[1], Christian Reichl[2], Dieter Schuh[1], Werner Wegscheider[2], Dominique Bougeard[1], Tobias Korn[1], and Christian Schüller[1] — [1]Institut für Experimentelle und Angewandte Physik, Universität Regensburg, 93040 Regensburg, Germany — [2]Laboratory for Solid State Physics, ETH Zürich, 8093 Zürich, Schweiz

We performed inelastic light scattering experiments on a 12-nm-wide (001)-oriented GaAs-AlGaAs single quantum well. The investigated system is asymmetrically Si doped to obtain a balanced Rashba and Dresselhaus SOI contribution (α=β). The resulting effective spin-orbit field is either parallel or antiparallel to the [110] in-plane direction.

Measurements on intrasubband transitions of the conduction band in backscattering geometry feature a double peak structure for the [110] direction due to spin splitting, while the [1$\bar{1}$0] direction only shows a single peak. By rotating the sample we could demonstrate a cosine behavior of the spin splitting for intermediate angles between these crystal directions.

HL 63.35 Wed 15:00 P1A

Optical characterization of polycrystalline YMnO3 films — •Daniela Täuber[1], Mirko Goldmann[1,2], Venkata Rao Rayapati[3], Danilo Bürger[3], Ilona Skorupa[3], Ivan G. Scheblykin[1], and Heidemarie Schmidt[3] — [1]Single molecule spectroscopy group, Lund University, Sweden — [2]TU Ilmenau, Germany — [3]Nanospintronics group, TU Chemnitz, Germany

Due to its electro-optical properties multiferroic $YMnO_3$ is a promising candidate for a new generation of multifunctional materials. Depending on the chemical composition and underlying substrate $YMnO_3$ thin films may exhibit orthorhombic or hexagonal crystal structure. Here we present the room-temperature spectral ellipsometry and photoluminescence data recorded on polycrystalline $YMnO_3$ and compare the Stokes shift in dependence on chemical composition. The Stokes shift of stochiometric $YMnO_3$ is larger than 300 meV. Smaller Stokes shifts of 130 meV, 110 meV, and 60 meV have been observed for off-stochiometric $Y_1Mn_{0.99}O_3+1.0at\%Ti$, $Y_{0.94}Mn_{1.05}O_3+1.0at\%Ti$, and $Y_{0.95}Mn_{1.05}O_3$, respectively. Measured PL lifetimes are independent of chemical composition and are shorter than 200 ps.

HL 63.36 Wed 15:00 P1A

Sensing Weak Microwave Signals by Quantum Control — •Timo Joas, Andreas M. Waeber, Georg Braunbeck, and Friedemann Reinhard — Walter Schottky Institut and Physik-Department, Technische Universität München, Am Coulombwall 4, 85748 Garching

Solid state qubits, such as the Nitrogen-Vacancy (NV) center in diamond, are attractive sensors for nanoscale magnetic and electric fields, owing to their atomically small size [1]. A major key to their success have been dynamical decoupling protocols (DD), which enhance sensitivity to weak AC signals such as the field of nuclear spins from a single protein [2]. However, those methods are currently limited to signal frequencies up to several MHz.

Here, we present a novel DD protocol specifically designed to detect weak fields close to the NV's transition frequency ($\approx$ 2 GHz). Our scheme is a pulsed version of Autler-Townes spectroscopy [3] with improved spectral resolution. As a result, we demonstrate slow Rabi oscillations with a period up to $\Omega_{Rabi}^{-1} \sim T_2$ driven by a weak signal field. The corresponding sensitivity could enable various applications. Specifically, we consider detectors for radio-astronomy and ultrasound, as well as fundamental research on spin-phonon coupling.

[1] Taylor et al., Nature Physics 4 (2008) [2] Lovchinsky et al., Science 351 (2016) [3] Gordon et al., Appl. Phys. Lett. 105 (2015)

HL 63.37 Wed 15:00 P1A

Broadband Electrically Detected Magnetic Resonance using Optimal Control — •Lukas Stelzer[1], Florian M. Hrubesch[1], Wolfgang Kallies[2], Steffen J. Glaser[2], and Martin S. Brandt[1] — [1]Walter Schottky Institut and Physik-Department, Technische Universität München — [2]Chemie-Department, Technische Universität München

We present a broad-band spin resonance setup with the ability to apply shaped pulses for electrically detected magnetic resonance (EDMR). The setup uses non-resonant stripline structures for on-chip radiofrequency and microwave delivery and was tested to work in the frequency range from 4 MHz to 18 GHz. In combination with a broadband microwave amplifier with a saturated power of 10 W the stripline structures allow for B_1 fields of 0.3 mT and higher. We first demonstrate the functionality of this EDMR spectrometer using adiabatic BIR4 pulses for arbitrary rotations of both electron spins as well as nuclear spins in ENDOR experiments using adiabatic pulses only [1]. We then extend this approach to optimal control pulses and systematically explore the applicability of optimal control point-to-point, universal rotation and cooperative pulses to the various types of EDMR experiments.

[1] F. M. Hrubesch, G. Braunbeck, A. Voss, M. Stutzmann and M. S. Brandt, JMR 254, 62 (2015)

HL 63.38 Wed 15:00 P1A

Meeting the Technical Requirements for High-Power Spin Pumping in Silicon Carbide — •Moritz Fischer[1], Andreas Sperlich[1], Georgy Astakhov[1], and Vladimir Dyakonov[1,2] — [1]Experimental Physics VI, Julius Maximilian University of Würzburg, 97074 Würzburg — [2]Bayerisches Zentrum für Angewandte Energieforschung (ZAE Bayern), 97074 Würzburg

Silicon vacancies in silicon carbide (SiC) have recently been put into the focus of research due to their spin-dependent optical properties being similar to NV centers in diamond [1]. Due to spin-dependent relaxation, optical excitation results in a population inversion at room temperature. As the electron spin resonance associated with the silicon vacancy S=3/2 states can be shifted in an external magnetic field, one can preciseley tune the stimulated microwave emission to the microwave cavity resonance modes. In this study, we concentrate on strongly pumped SiC with the goal to achieve positive MASER gain. A box cavity was designed for the X-Band microwave regime (10 GHz) to be filled with stacked SiC wafers. The gain material is excited with a 15 W diode laser, operating at 810 nm. We investigate the power dependence of the electron spin resonance. The microwave resonator characteristics are analyzed in terms of the cavity Q factor and how it depends on heating due to laser light absorption.

[1] H. Kraus et al., Nature Physics **10**, 157 (2014)

HL 63.39 Wed 15:00 P1A

Commercial Silicon Carbide Diodes for Quantum Sensing Applications — •Dimitrij Poprygin[1], Christian Kasper[1], Hannes Kraus[1], Dmitrij Simin[1], Takeshi Ohshima[2], Andreas Sperlich[1], Georgy V. Astakhov[1], and Vladimir Dyakonov[1,3] — [1]Exp. Physics VI, Julius Maximilian University of Würzburg — [2]National Institutes for Radiological Science and Technology (QST, formerly Japan Atomic Energy Agency), Takasaki, Japan — [3]ZAE Bayern, Würzburg

Silicon carbide (SiC) is a technologically advanced semiconductor for high-power and high-temperature electronics and is also a viable candiate for solid-state quantum applications in sensing, rf-devices and quantum computing. This is due to the properties of atomic-scale defects, which rest in stable and cost-effective SiC crystals.

In this study, commercial SiC diodes with varying spatial distribution of Si-vacancies (V_{Si}), produced by electron irradiation, are analyzed in respect of their electrical properties. The work contains current-voltage characteristic measurements and detection of optically-active V_{Si} centers in the intrinsic layer of the diodes. The determination of an irradiation threshold to develop operative diodes with sufficient amount of V_{Si} for nanotesla magnetic field sensing is the main goal in this research. Silicon vacancies in SiC reveal a rf-free and room temperature alternative to nitrogen vacancies (NV) in diamond for sensing applications [1], which is the standard solid state system for quantum-sensing so far.

[1] D. Simin et al., Phys. Rev. X **6**, 031014 (2016).

HL 63.40 Wed 15:00 P1A

Self assembled InAs islands growth on high-index GaAs substrate by Stranski-Krastanov mode — Patrick Krawiec, Johann Peter Reithmaier, and •Mohamed Benyoucef — Institute of Nanostructure Technologies and Analytic (INA), CINSaT, University of Kassel, Heinrich-Plett-Str. 40, 34132 Kassel, Germany

Quantum dots (QDs) grown on high-index substrates are promising candidates for generating polarization-entangled photons due to their low excitonic fine structure splitting. However, QDs grown on such substrates using conventional Stranski-Krastanov (SK) mode are difficult to realize. The failure of SK-growth on e.g., (111) surfaces has driven the development of alternative growth techniques. In our work, we revisit the challenging SK growth on high-index GaAs substrates using molecular beam epitaxy. By careful control of the growth parameters it was possible to produce a low density of InAs islands, which was confirmed by atomic force microscopy (AFM) measurements. Angle measurements of the island side walls using data derived from AFM reveal clear facets. Optical properties of the grown structure such as emission wavelengths and polarization are determined by micro-photoluminescence (μ-PL) measurements. The low temperature μ-PL measurements prove the formation of 3D nanostructures.

HL 63.41 Wed 15:00 P1A

InP-based photonic crystal microcavities embedded with InAs quantum dots for telecom wavelengths — Andrei Kors, Kerstin Fuchs, Johann Peter Reithmaier, and •Mohamed Benyoucef — Institute of Nanostructure Technologies and Analytic (INA), CINSaT, University of Kassel, Heinrich-Plett-Str. 40, 34132 Kassel, Germany

Self-assembled semiconductor quantum dots (QDs) embedded in photonic crystals can be used as building blocks for future quantum information processing. Here, we report on the fabrication and optical characterization of InP-based photonic crystal microcavities embedded with optimized InP-based QDs. Medium InP-based QD density emitting at the telecom wavelengths is grown by solid source molecular beam epitaxy using special capping technique and temperature processing after the dot formation. L3-photonic crystal air-bridge cavities are fabricated by electron beam lithography, inductively coupled plasma reactive ion etching and wet etching technique. The sacrificial layer is removed by selective wet etching, forming a suspended PhC membrane. Optical properties of microcavities such as polarization, emission wavelengths and quality factors are determined by micro-photoluminescence measurements. Results reveal enhanced quantum dot emission, sharp cavity modes and measured quality factors in excess of 8500 at telecom C-band wavelengths.

HL 63.42 Wed 15:00 P1A

Effect of Gold/Silicon implantation for catalyst assisted growth of III/V-Core-Shell-Nanowires — •Marcel Schmidt, Rüdiger Schott, Sven Scholz, Arne Ludwig, and Andreas D. Wieck — Lehrstuhl für Angewandte Festkörperphysik, Ruhr-Universität Bochum

Semiconductor nanowires (NWs) have a huge potential in the aim of further miniaturization of nanoscale devices due to there large surface to volume ratio as well as there strong light and carrier confinement. A prerequisite for the fabrication of nanowire devices is their doping. With the tempting prospect to achieve doping of the NWs by just using Si-doped Au metal seeds as NW catalysts, we investigate catalyst assisted molecular beam epitaxy (MBE) grown GaAs-AlGaAs-core-shell NWs. A focused ion beam system equipped with an ExB filter and a liquid metal alloy ion source (LMAIS) is used to implant the metals seeds. We will present our results on structure, morphology and optical properties, comparing Au and AuSi catalysed GaAs-AlGaAs-core-shell NWs.

HL 63.43 Wed 15:00 P1A

Optical enhancement of quantum dot emission by surface nanowires — •Sven Scholz, Rüdiger Schott, Carlo Sgroi, Yannick Raffel, Andreas D. Wieck, and Arne Ludwig — Lehrstuhl für Angewandte Festkörperphysik, Ruhr-Universität Bochum, Germany

Molecular beam epitaxy (MBE) quantum dot (QD) structures are used as fundamental research structures to investigate quantum optical phenomena. To further enhance their optical properties we use nanowires as a subwavelength waveguide. While common photonic crystal structures work with holes or micro pillars, we use focused ion beam (FIB) to catalyze nanowire growth on QD structures. The LED-QD structure is optimized regarding the optical emission. Therefore we use a methode to remove the wetting layers (WL) PL signal. To access a wide emission spectrum we use rapid-thermal annealing (RTA) and a flushing technique coupled with the WL suppression. This results in tunable and good separated QD emission peaks. The NW growth is characterized and optimized with regards to crystalline quality and morphology. The samples are characterized by photoluminescence/electroluminescence, scanning electron microscope imaging and capacitance-voltage spectroscopy.

HL 63.44 Wed 15:00 P1A

Multi-excitonic structure of type-II quantum dots — •Petr Steindl[1,2] and Petr Klenovsky[1,2] — [1]Central European Institute of Technology, Masaryk University, Czech Republic — [2]Department of Condensed Matter Physics, Faculty of Science, Masaryk University, Czech Republic

We study the multi-particle structure of quantum dots with spatially separated electrons and holes, usually termed type II. Our calculations based on customarily developed full-configuration interaction approach reveal that exciton complexes consisting of more electrons than holes are enormously antibinding in type II making those the hallmark of that kind of confinement. By an extension of our model we obtain approximate self-consistent solution of the multi-exciton problem and we explain the elusive blue-shift of the emission with pumping as well as the reason for the large inhomogeneous spectral broadening seen for type-II systems as an effect of trap filling. The results are confirmed by detailed intensity and polarization resolved photoluminescence measurements on large number of samples.

HL 63.45 Wed 15:00 P1A

Challenges of low density indium-flushed self-assembled quantum dots growth — •Rüdiger Schott, Julian Ritzmann, Sven Scholz, Sascha R. Valentin, Andreas D. Wieck, and Arne Ludwig — Lehrstuhl für Angewandte Festkörperphysik, Ruhr-Universität Bochum, Germany

Self-assembled InAs quantum dots (QDs) have been widely investigated due to their prospect applications in futuristic optoelectronic devices like single-photon sources.

For single optically addressable QDs, growth is usually performed with a rotation stop to obtain an indium flux gradient on the sample with reasonable low QD-density (10^8 cm^{-2}) at a transition point. Starting from such a gradient sample, we report on our attempts to achieve homogeneous high quality MBE growth of low density indium-flushed QDs. We identify the main challenges to be related to substrate temperature inhomogeneity and slight indium flux variations. Detailed photoluminescence spectroscopy maps of the grown structures are presented and correlated with the profile of the heater and the indium cell geometry.

HL 63.46 Wed 15:00 P1A

Optical and Electronic Characterization of Coupled Quantum Dots — •Clara Junggebauer[1], Shovon Pal[2], Sascha R. Valentin[1], Sven Scholz[1], Andreas D. Wieck[1], and Arne Ludwig[1] — [1]Lehrstuhl für Angewandte Festkörperphysik, Ruhr-Universität Bochum, Germany — [2]NEST, Istituto Nanoscienze-CNR and Scuola Normale Superiore, Pisa, Italy

Self-assembled quantum dots are promising candidates for the development of quantum information processing units like quantum bits, single photon sources or quantum memories. Coupled quantum dots, also called quantum dot molecules (QDM) in a semiconductor solid state matrix allow for controlled charging and tuning of the electronic energy level's coupling. The research so far is mostly done in other works by optical spectroscopy on single QDMs. Here, we present capacitance-voltage spectroscopy with and without illumination to access electronically the energy level structure of a QDM ensemble coupled to an electron reservoir. This is possible due to a high size homogeneity of the prepared QDM ensembles.

HL 63.47 Wed 15:00 P1A

Resonance Fluorescence of Plasmon-Quantum Dot Hybrids — •Chiara Bauer, Gerhard Schäfer, and Markus Lippitz — Experimental Physics III, University of Bayreuth, Germany

Many groups have used resonance fluorescence spectroscopy as a powerful tool to investigate single quantum dots. We present first steps towards resonance fluorescence spectroscopy of plasmon-quantum dot hybrids using a crossed-polarizer setup. We investigate which optical elements have limiting effects on the suppression of the incident light in benefit of detecting the scattered photons. We also discuss how a Fano resonance reveals the coupling of quantum dots and plasmonic structures.

HL 63.48 Wed 15:00 P1A

Speeding up a single quantum dot pump-probe experiment

— •Gerhard Johannes Schäfer[1], Christian Dicken[1,2,3], Christian Wolpert[2,3], Armando Rastelli[4,5], and Markus Lippitz[1,2,3] — [1]Experimentalphysik III, Universität Bayreuth, Bayreuth, Germany — [2]4th Physics Institute and Research Center SCOPE, University of Stuttgart, Stuttgart, Germany — [3]Max Planck Institute for Solid State Research, Stuttgart, Germany — [4]Institute for Integrative Nanosciences, IWF Dresden, Dresden, Germany — [5]Institute of Semiconductor and Solid State Physics, Johannes Kepler University Linz, Linz, Austria

We recently showed [1], that it is possible to measure transient reflection on single semiconductor quantum dots in the far field. Here we discuss how to improve those measurements.

The lifetime of an excited quantum dot is around of 300 ps. The time delay between two laser pulses in the old setup (repetition rate 78 MHz) is 12 ns. By changing the laser system to another one with a higher repetition rate (1 GHz) we reduce this time delay to 1 ns.

We are interested in the characterization of a single quantum dot two-level system and its interaction with environment through transient absorption spectroscopy. We will add plasmonic structures to do antenna enhanced single quantum dot spectroscopy.

[1] C. Wolpert, C. Dicken, P. Atkinson, L. Wang, A. Rastelli, O. G. Schmidt, H. Giessen, and M. Lippitz, Nano Lett. 12, 453 (2012).

HL 63.49 Wed 15:00 P1A

Resonantly excited quantum dots embedded in GaAs rib waveguides — •Jonas Binz, Thomas Herzog, Mario Schwartz, Ulrich Rengstl, Matthias Paul, Simone Portalupi, Michael Jetter, and Peter Michler — Institut für Halbleiteroptik und Funktionelle Grenzflächen, Allmandring 3, D-70569 Stuttgart

One of the major goals to realize linear optic quantum computation circuits is the fully on-chip integration of single-photon sources, single-photon detectors and waveguide (WG) structures. The circuit itself needs bended WG structures for building elements like a beamsplitter. However the bend radius cannot be chosen arbitrary small since the losses are increasing. In our approach, we investigate InGaAs quantum dots (QDs) embedded in GaAs/AlGaAs single-mode WG structures with varying curvature radii. By improving our design from a cosine shaped WG to a round shaped one, we could reduce the curvature radius to 10 μm from previously 20.6 μm while maintaining losses of 2.8 dB/mm.

For experiments on the single-photon level, the laser background under resonant excitation has to be as low as possible. Our measurements via pulsed resonant excitation with the polarization parallel to the WG allow us to efficiently excite a QD having almost no unwanted laser background contribution ($\sim 1\%$). This results in observation of Rabi-oscillations with more than two periods of QD emission as a function of the laser excitation power.

HL 63.50 Wed 15:00 P1A

Two-color two-photon biexciton generation in single quantum dots — •Björn Jonas, Amlan Mukherjee, Alexander Leier, Alex Widhalm, Nand Lal Sharma, Dirk Reuter, and Artur Zrenner — Center for Optoelectronics and Photonics Paderborn (CeOPP), Universität Paderborn, Paderborn, Germany

Quantum dots are among the best controlled solid state emitters at the single photon level. One particular area of interest is the generation of single photons at emission wavelength different from the excitation wavelength using nonlinear two-photon transitions between the biexciton state and the ground state of quantum dots. A promising approach to gain even more control over the emission wavelength and polarization is to generate single photons by a stimulated downconversion process from the biexciton state. [1] As preliminary work, we performed degenerate (one-color) and nondegenerate (two-color) resonant two-photon biexciton generation in InGaAs-quantum dots embedded in a n-i-Schottky-photodiode. This allows for the detection of the resulting excitations in the photocurrent with good accuracy. We demonstrate two-color two-photon excitation of the biexciton state and compare it to the degenerate process. Furthermore, we measure the biexciton peak amplitude as function of the energy separation between the two excitation lasers.

[1] D. Heinze et al., Nature Communications 6, 8473 (2015).

HL 63.51 Wed 15:00 P1A

Towards coherent optical coupling of two single quantum dots in a microdisk photonic molecule — •Simon Seyfferle[1], Fabian Hargart[1], Matthias Paul[1], Michael Jetter[1], Tsung-Li Liu[2], Evelyn Hu[2], and Peter Michler[1] — [1]Institut für Halbleiteroptik und Funktionelle Grenzflächen, Universität Stuttgart, Allmandring 3, 70569 Stuttgart — [2]School of Engineering and Applied Sciences, Harvard University, 29 Oxford Street, Cambridge, MA 02138

The coherent control of the interaction of two quantum dots in a coupled quantum system promises e.g. the implementation of parallel qubit operation for quantum information processing applications. To grant individual addressability and selective tunability of each quantum dot, attempts are undertaken to realize coherent coupling between two dots each in a different GaInP-based microdisk resonator.

We apply optical spectroscopy and mode selective real space imaging as well as photoluminescence mapping to discern single quantum dots possibly coupled to a microdisk supermode. These means provide evidence of mode coupling across the inter-disk gap as well as dots in resonance with such coupled modes. Second-order correlation measurements performed on a quantum dot located in the non-excited disk reveal an antibunching, thus indicating that its excitation is mediated via the coupled disk mode.

HL 63.52 Wed 15:00 P1A

Hole spin mixing due to biaxial strain on GaAs/AlGaAs quantum dots — •Fritz Weyhausen-Brinkmann[1] and Gabriel Bester[1,2] — [1]Universität Hamburg, Grindelallee 117, 20146 Hamburg, Germany — [2]The Hamburg Centre for Ultrafast Imaging, Luruper Chaussee 149, 22761 Hamburg, Germany

We calculate the spin-resolved light-hole and heavy-hole (LH-HH) band mixing in GaAs/AlGaAs quantum dots (QDs). The exciton emission spectrum of these QDs show optical anisotropy in their growth plane and the directions of polarization are strongly influenced by the LH-HH mixing. In the field of quantum information and quantum processing QDs are hot candidates, e.g. as single photon sources or quantum repeaters, which requires a good understanding of their optical properties. We are using the atomistic empirical pseudopotential approach including spin-orbit coupling to determine the spin-resolved LH-HH mixing of the single particle wave function as a function of biaxial strain for different types of QDs [1]. We find a heavy-hole spin mixing when LH-HH mixing is strong. The degree of linear polarization (DLP) is related to the heavy-hole weight of the wave function. This allows the determination of the latter by measuring the in-plane polarization, but the results are different in comparison to the model. We also find a universal relation between DLP and the polarization in z-direction for lens shaped QDs.

[1] Y. Huo et al., Nature Physics 10, 46-51 (2014).

HL 63.53 Wed 15:00 P1A

Analyzing quantum-light sources via a photon-number-resolving transition edge sensor — •Martin von Helversen[1], Alexander Thoma[1], Marco Schmidt[1,2], Manuel Gschrey[1], Peter Schnauber[1], Jan-Hindrik Schulze[1], André Strittmatter[1], Jörn Beyer[2], Sven Rodt[1], Tobias Heindel[1], and Stephan Reitzenstein[1] — [1]Institut für Festkörperphysik, Technische Universität Berlin, 10623 Berlin, Germany — [2]Physikalisch-Technische Bundesanstalt, Abbestraße 1, 10587 Berlin, Germany

Solid-state quantum-light sources based on single semiconductor quantum dots (QDs) are promising candidates for a variety of applications in the research fields of quantum communication and quantum metrology. In order to better understand and directly access the photon statistics emitted by such sources, we employ a state of the art photon-number-resolving detection system consisting of a transition edge sensor (TES). Using the TES-detectors, we investigate two different types of sources, namely a single-photon source [1] and a twin-photon source [2], both based on deterministic QD devices. The obtained results enable us to reconstruct the photon number distribution emitted by the respective quantum emitter.

[1] M. Gschrey, A. Thoma et al., Nature Commun. 6, 7662 (2015)
[2] A. Thoma, T. Heindel et al., A bright triggered twin-photon source in the solid state, arXiv:1608.02768 (2016)

HL 63.54 Wed 15:00 P1A

Optical Spectroscopy of Single Elongated CdSe/CdS Core/Shell Nanoparticles — •Alexandra Hinsch, Sven-Hendrik Lohmann, Christian Strelow, Tobias Kipp, and Alf Mews — Institut für Physikalische Chemie, Universität Hamburg, Grindelallee 117, 20146 Hamburg, Deutschland

Semiconductor nanoparticles show great potential for a multitude of opto-electronic applications such as LEDs or photovoltaic cells. Core/shell nanoparticles allow the tailoring of the emission wavelength via composition and size of the system. In elongated nanoparticles with a dot-like core and a rod-like shell, the length of the system is a further parameter for the control of optical properties. Here we present elongated CdSe/CdS core/shell nanoparticles with varying rod- and core-size. We show that green-fluorescent dot/rods are strongly polarized emitters at room temperature. Orange-fluorescent dot/rods with larger dots, however, exhibit a decreased degree of polarization at room temperature. At cryogenic temperatures the typical blinking of single dot/rod particles rarely occurs and an increase in polarization can be observed. We further show that it is possible to directly correlate TEM and PL measurements to visualize single measured particles.

HL 63.55 Wed 15:00 P1A

Quasi-resonant pulsed excitation of quantum dots emitting in the telecom O-band — •Jonatan Höschele, Fabian Olbrich, Jan Kettler, Matthias Paul, Simone L. Portalupi, Michael Jetter, and Peter Michler — Institut für Halbleiteroptik und Funktionelle Grenzflächen, Center for Integrated Quantum Science and Technology (IQST) and SCoPE, University of Stuttgart, Allmandring 3, 70569 Stuttgart, Germany

Efficient quantum computing and quantum information require high quality single photons. In particular for long distance quantum communication one may want to benefit from low losses in standard fibers at telecom wavelength. QDs have demonstrated to fulfill both requirements: they are sources of high performance single photons and can be grown to reach telecom emission. In our case, we showed efficient emission up to the telecom O-band. This gives the possibility to profit from low absorption and zero dispersion at this wavelength.

While In(Ga)As QDs grown on a GaAs substrate already serve as high quality single-photon sources at 900 nm, sticking to this material system at higher wavelengths gives perspective to equally high performances. The MOVPE-process used to grow the QDs makes our single-photon sources even more industrially relevant.

In order to improve the source performance, we implement a pulsed quasi-resonant excitation scheme, which helps in reducing phonon contribution to pure dephasing and minimizes the time jitter. This yields triggered single-photon emission in the telecom O-Band with high coherence time and small linewidth.

HL 63.56 Wed 15:00 P1A

Capacitance calculations for charge detection in indium arsenide nanowires — •Felix Jekat[1], Moritz Sallermann[1], Sebastian Heedt[2], Patrick Zellekens[3], Stefan Trellenkamp[4], Werner Prost[5], Marcus Liebmann[1], and Markus Morgenstern[1] — [1]II. Institute of Physics B, RWTH Aachen — [2]Qutech, Kouwenhoven Lab, TU Delft — [3]PGI-9, Forschungszentrum Jülich, Germany — [4]PGI-8, Forschungszentrum Jülich, Germany — [5]Center for Semiconductor Technology and Optoelectronics, University of Duisburg-Essen

Indium arsenide (InAs) nanowires have been shown to be suitable as tips for scanning tunneling microscopy (STM) with similar quality compared to tungsten tips [1]. We present a device with the goal to enable time-resolved counting of single electrons directly at these InAs nanowire STM tips. To realize electron counting in the nanowire tip we place a second nanowire in close proximity and couple the two wires with a floating gate [2]. In order to determine the sensitivity of this setup we preformed capacitance calculation using Comsol Multiphysics. The results show that the sensitivity is high enough to detect individual electrons in the Quantum Dot of the nanowire STM tip.

[1] K. Flöhr et al. "Scanning tunneling microscopy with InAs nanowire tips", Appl. Phys. Lett. 101, 243101 (2012)

[2] Y. Hu et al. "A Ge/Si heterostructure nanowire-based double quantum dot with integrated charge sensor", Nature Nanotechnol. 2, 622 (2007)

HL 63.57 Wed 15:00 P1A

Design and Fabrication of a Double Quantum Dot System with Two Independent Charge Detectors — •Friso Öhlschläger, Johannes C. Bayer, Timo Wagner, Eddy P. Rugeramigabo, and Rolf J. Haug — Institut für Festkörperphysik, Leibniz Universität Hannover

We designed a tunable system of two tunnel-coupled quantum dots in series. The fabrication procedure includes optical lithography as well as electron beam lithography on an MBE-grown GaAs/AlGaAs heterostructure forming a 2DEG 110 nm beneath the surface. High tunability should be achieved using standard split gate technique. The quantum dots are then electrostatically defined by applying negative potentials to each gate. We designed a specific double quantum dot system (DQD) with two separate quantum point contacts enabling independent and simultaneous real-time detection of single electron tunneling events in the DQD. This allows the investigation of many different phenomena including feedback experiments [1].

[1] T. Wagner, et al., Nature Nanotechnology (2016)

HL 63.58 Wed 15:00 P1A

Internal wavelength stabilization of a quantum dot photon source — •Amran Al-Ashouri[1], Annika Kurzmann[1], Benjamin Merkel[1], Arne Ludwig[2], Andreas D. Wieck[2], Axel Lorke[1], and Martin Geller[1] — [1]Faculty of Physics and CENIDE, University of Duisburg-Essen, Germany — [2]Chair for Applied Solid State Physics, Ruhr-Universität Bochum, Germany

Single-photon sources are desirable for many quantum optical experiments and are essential for a practicable implementation of quantum networks. Being able to emit antibunched, indistinguishable photons with a high flux, epitaxially grown quantum dots (QDs) are a realistic choice for building such sources. Furthermore, QD systems are conveniently integrable into existing semiconductor technologies, however, charge and spin noise are ubiquitous in common host materials, introducing random wavelength fluctuations of the emitted photons.

In this work, single self-assembled InAs QDs are used to demonstrate a noise-suppressing, internal feedback loop [1]. This feedback loop leads to a stabilization scheme that relies solely on charge carrier dynamics inside a Schottky diode heterostructure, in which a QD layer is embedded. Key to the observed effect is micropillar patterning, leading to charge storage near the QDs. First measurements show a noise filtering bandwidth of 10 Hz and model calculations are in good agreement with our data. With optimized material parameters, our model predicts bandwidths of several 100 kHz, enough for eliminating most noise and enabling wavelength-stabilized photon emission.

[1] B. Merkel et al., arXiv:1606.03215 [cond-mat.mes-hall] (2016).

HL 63.59 Wed 15:00 P1A

Fock states, annihilation and creation operators, and quantum statistical applications of quasinormal modes — •Sebastian Franke, Andreas Knorr, and Marten Richter — Institut für Theoretische Physik, Nichtlineare Optik und Quantenelektronik, EW 7-1, Technische Universität Berlin, Hardenbergstrasse 36, 10623 Berlin, Germany

A quantum description of an open optical cavity, e.g. a metal nanoparticle or a micropillar cavity, is of high interest in the field of quantum optics of nanostructures. The open and dissipative character of these systems prevents the use of a canonical quantization scheme with photon modes for such cavities.

Our objective is to develop a quantization scheme via a Green's function approach[1] for an inhomogeneous and dispersive medium for the open cavity. Therefore, we use quasinormal modes[2] (QNM) with complex eigenfrequencies ω_μ and complex eigenfunctions $\mathbf{f}_\mu$ as a basis for the quantization. We construct suitable non-bosonic annihilation and creation operators $\hat{\boldsymbol{\alpha}}_\mu, \hat{\boldsymbol{\alpha}}_\mu^\dagger$ for every quasinormal mode ω_μ in the cavity. Furthermore the calculation of commutation relations and Heisenberg equations of motion for these operators coupled to quantum emitters (like quantum dots) will be shown together with a construction of the analogue of Fock states.

[1]T. Gruner and D.-G. Welsch, Phys. Rev. A 53, 1818, 1996

[2]P. T. Leung, S. Y. Liu, and K. Young, Phys. Rev. A 49, 3057, 1994

HL 63.60 Wed 15:00 P1A

Energy scales in quantum dots for single electron pumps — •Tobias Wenz[1], Friederike Stein[1], Frank Hohls[1], Hans Werner Schumacher[1], and Vyacheslavs Kashcheyevs[2] — [1]Physikalisch-Technische Bundesanstalt (PTB), 38116 Braunschweig, Germany — [2]Faculty of Physics and Mathematics, University of Latvia, LV 1002 Riga, Latvia

Quantum dots with tunable barriers can be used as single electron pumps. By capturing a well-defined number of electrons n from source and emitting them to drain with a high frequency f a quantized current $I = nef$ is produced, where e is the electron charge [1]. This concept is useful for on-demand electron sources for electron quantum optics and for the redefinition of the ampere by fixing the value of e. Several theoretical models, like the decay cascade model [2], describe the performance of tunable-barrier pumps in different regimes of operation. While they yield good fits, the respective energy scales cannot be easily obtained. This work aims at putting a number to these energy scales. One approach is to investigate the performance of single electron pumps at different temperatures and observe the broadening of transition lines in different pumping regimes. Another method is to use custom-tailored waveforms to extract tunneling rates during the loading phase of the quantum dot. Furthermore, this method can be used to study excited states in the quantum dot and reveal two-electron effects.

[1] B. Kaestner & V. Kashcheyevs, Rep. Prog. Phys. 78, 103901 (2015)
[2] V. Kashcheyevs & B. Kaestner, Phys. Rev. Lett. 104, 186805 (2010)

HL 63.61 Wed 15:00 P1A

Spectral tuning of GaAs-based photonic crystal cavities for the deterministic coupling of individual quantum dots — •Stephanie Bauer, Stefan Hepp, Simone L. Portalupi, Michael Jetter, and Peter Michler — Institut für Halbleiteroptik und Funktionelle Grenzflächen, Center for Integrated Quantum Science and Technology IQ^{ST} and Research Center SCoPE, University of Stuttgart

Quantum dots (QDs) have been proven to be ideal candidates as single-photon sources especially when they are placed inside a cavity to benefit from cavity quantum electrodynamic effects. For sufficient enhancement it is important to spatially position the QD inside the field maximum of the cavity mode and to reduce the spectral mismatch between the cavity and the emitter. Recently, a lot of efforts have been made in terms of quality factor optimization and the deterministic positioning of individual QDs in nanostructures. However, the high Q-factor results in narrow cavity linewidth and the sensitivity of the spectral position due to unavoidable fabrication imperfections makes the deterministic coupling to preselected QDs complicated. Therefore, a postprocessing tuning mechanism is required to reduce the spectral detuning between the cavity and the embedded emitter. Here we show that we can tune the resonant wavelength of L3-photonic crystal cavities via several digital etching steps independently from individual QD lines to the wavelength of interest. This process can be repeated several times whereby the typical tuning is in the range of 3 nm. Furthermore, an improvement of the Q-factor could be observed for a large number of cavities depending on the initial design parameters of the cavity.

HL 63.62 Wed 15:00 P1A

Epitaxial growth and characterization of InP-based coupled quantum well - quantum dot structures — •Sven Bauer[1], Vitalii Sichkovskyi[1], Wojciech Rudno-Rudziński[2], Grzegorz Sek[2], and Johann Peter Reithmaier[1] — [1]Technische Physik, Institute of Nanostructure Technologies and Analytics (INA), CINSaT, University of Kassel, Heinrich-Plett-Str. 40, 34132 Kassel, Germany — [2]Institute of Physics, Wrocław University of Technology, Wybrzeze Wyspiańskiego 27, 50-370 Wrocław, Poland

InP-based directly modulated quantum dot (QD) lasers are promising candidates for usage in telecommunication at 1.55 μm. In order to improve the performance of these lasers, limited by the intraband carrier relaxation time, one might use a so called tunnel injection scheme. Carriers are captured and relax in a quantum well (QW) and tunnel through a thin barrier for recombination into the QDs. In order to get better understanding of the mechanisms involved in this scheme, coupled QW-QD structures have been grown on Fe-doped InP substrates. These consist of a compressively strained $In_{0.66}Ga_{0.34}As$ QW and InAs QDs separated by a thin InAlGaAs barrier. High density QD growth was optimized beforehand. A set of samples with different QW (2.4 nm, 4 nm, 5.6 nm) and barrier thickness (2 nm, 4 nm, 10 nm) combinations was grown and investigated with photoluminescence and photoreflectance spectroscopy. The working principle with respect to coupling strength as well as the importance of a favourable band alignment for performance and dominating recombination channel could be shown.

HL 63.63 Wed 15:00 P1A

All-optical tailoring of single-photon spectra in quantum-dot microcavity systems — •Dominik Breddermann[1], Dirk Heinze[1], Rolf Binder[2], Artur Zrenner[1], and Stefan Schumacher[1,2] — [1]Department of Physics and Center for Optoelectronics and Photonics Paderborn (CeOPP), Paderborn University, Warburger Strasse 100, 33098 Paderborn, Germany — [2]College of Optical Sciences, University of Arizona, Tucson, Arizona 85721, USA

Quantum-dot microcavity systems are promising nanostructures for solid-state based on-demand generation of single photons. Commonly, the spectral properties, such as frequency and linewidth, of the emitted single photon are pre-determined by the characteristics of the system, such as electronic transition energies and spectral properties of the resonator. Here, we theoretically analyze the spectral properties of a single photon generated from partly stimulated non-degenerate two-photon transitions [1] in quantum-dot-based multilevel systems in different configurations. We demonstrate that frequency and linewidth of the single photon are determined by the external control beam [2], and thus can be all-optically controlled during the photon-creation process.

[1] D. Heinze, D. Breddermann, et al., Nature Commun. 6, 8473 (2015) [2] D. Breddermann, D. Heinze, et al., Phys. Rev. B 94, 165310 (2016)

HL 63.64 Wed 15:00 P1A

Build-up of electron spin precession modes upon pulsed optical excitation in (In,Ga)As/GaAs quantum dots — •Eiko Evers[1], Vasilii Belykh[1], Alex Greilich[1], Dmitri Yakovlev[1,2], Dirk Reuter[3], Andreas Wieck[4], and Manfred Bayer[1,2] — [1]Experimentelle Physik 2, TU Dortmund University, 44221 Dortmund, Germany — [2]Ioffe Physical-Technical Institute, Russian Academy of Sciences, 194021 Saint Petersburg, Russia — [3]Optoelectronic Materials and Devices, Paderborn University, 33098 Paderborn, Germany — [4]Angewandte Festkörperphysik, Ruhr-Universität Bochum, 44780 Bochum, Germany

The electron-spin orientation of an ensemble of singly charged quantum dots with a periodic train of laser pulses in an external magnetic field leads to spin precession mode-locking. The recently developed extended pump-probe technique enables to tailor the number of polarizing pump pulses as well as to vary the delay of the probe pulse with a resolution limited only by the pulse duration over a time of several laser repetition periods. It is used to measure the electron-spin polarization build-up in the time domain as well as to monitor the decay of spin polarization after a given number of polarizing pulses which gives the mode structure of the electron-spin precession. Subsequently, we applied a continuous radio-frequency electromagnetic field decoupling the nuclear spin bath from the electron-spin polarization. This gives us the opportunity to study the build-up without nuclear effects such as frequency focusing and allows to determine their influence on the precession modes build-up.

HL 63.65 Wed 15:00 P1A

Magneto-optical study to reveal the exciton fine structure in InP/ZnSe core/shell quantum dots. — •Annalisa Brodu[1], Mariana Ballottin[2], Dorian Dupont[3], Zeger Hens[3], Peter C. M. Christianen[2], Celso de Mello Donega[1], and Daniel Vanmaekelbergh[1] — [1]Debye Institute for Nanomaterials Science, Utrecht University, The Netherlands — [2]High Field Magnet Laboratory, IMM, Radboud University, The Netherlands — [3]Physics and Chemistry of Nanostructures, Ghent University, Belgium

Colloidal quantum dots (QDs) are of significant interest in nanoscience and opto-electronic applications due to their size-tunable emission spectrum in combination with broad absorption and excitation spectra. For decades, Cd-chalcogenide QDs have been the workhorse in this field. However, application in devices requires toxicologically harmless materials. As a result, the demand for Cd-free colloidal QDs is rising rapidly and therefore the knowledge of the electronic structure of InP-based core/shell QDs is of large interest.

In this work we studied the exciton fine-structure of InP/ZnSe QDs with various core diameters using different techniques: fluorescence line-narrowing spectroscopy, polarized photoluminescence (PL) spectroscopy and time-resolved PL spectroscopy, in high magnetic fields up to 30 T at temperatures down to 4 K. The high magnetic field allowed us to obtain a considerable Zeeman splitting of spin degenerate states and to induce significant mixing of exciton levels with different angular momentum. Combined with detection of the polarization of the emitted photons, the nature of the states has been resolved unambiguously.

HL 63.66 Wed 15:00 P1A

Investigation of quantum-well and defect luminescence of PAMBE-grown AlGaN/GaN nanowires for single-photon applications — •Johannes Dühn[1], Pascal Hille[2], Jörg Schörmann[2], Martin Eickhoff[1,2], Jürgen Gutowski[1], and Kathrin Sebald[1] — [1]Institute of Solid State Physics, University of Bremen, Germany — [2]Institute of Experimental Physics I, Justus-Liebig University, Giessen, Germany

Efficient single photon sources are of pivotal importance for experimental quantum optics and cryptography. Currently available schemes of single photon sources and detectors are subject to low signal-to-noise ratios, which greatly inhibits their utilisation in quantum optical applications. A promising approach to this problem is the usage of confined excitons in wide-band-gap materials. Due to confinement, these excitons also possess large binding energies, even exceeding thermal energy at room temperature, which makes them suitable emitters for high-temperature operation. In this work we investigate the micro-PL properties of individual plasma-assisted (PA)MBE-grown nanowires with GaN nanodiscs embedded in AlGaN barriers. We identify emission from single nanowires centered at 3.47eV and 3.45eV belonging to donor-bound excitons and inversion domain boundaries, respectivly. Furthermore, two emission bands from the nanodiscs centered at 3.55eV and 3.66eV are investigated, belonging to the quantum well emission and inversion domain boundaries. The emission from single excitons bound to defects is investigated with respect to their single-photon emission properties by using an HBT interferometer.

HL 63.67 Wed 15:00 P1A

Numerical Investigation of the Nonlinear Optical Properties of Quantum Dot Molecules (QDM) — •Peter Kölling and Jens Förstner — Universität Paderborn, Germany

We theoretically study the optical properties of epitaxially grown InAs quantum dot molecules which are integrated in Schottky diode structures. From optical experiments one knows that the electronic states inside the single quantum dots are coupled [1]. Applying gate voltages at these diode structures allows manipulation of the relative energies inside the single quantum dots as well as manipulation of carrier tunneling between the dots [2,3]. This in turn can be used to achieve switching between electronic states at nano- or picosecond time scales. Nonlinearities arise due to the excitation of exciton complexes with variable numbers of electrons and holes.

We investigate single particle eigenenergies and eigenstates under the influence of an external electric field by means of k.p-theory with the nextnano3 software package [4]. From the resulting single particle eigenstates we calculate Coulomb matrix elements and optical matrix elements required for Heisenberg equations of motion for a reduced density operator of the underlying system. The Heisenberg equations of motion are then solved to calculate theoretical nonlinear absorption spectra.

[1] G. Ordner et al., Phys. Rev. Lett. **94**, 157401 (2006)
[2] E. A. Stinaff et al., Science **311**, 636-639 (2006)
[3] M. Schreibner et al., Solid State Comm. **149**, 1427-1435 (2009)
[4] http://www.nextnano.de/nextnano3/

HL 63.68 Wed 15:00 P1A

Microsecond two-electron spin relaxation in self-assembled quantum dots — •Kevin Eltrudis[1], Amran Al-Ashouri[1], Andreas Beckel[1], Arne Ludwig[2], Andreas D. Wieck[2], Axel Lorke[1], and Martin Geller[1] — [1]Faculty of Physics and CENIDE, University of Duisburg-Essen, Lotharstr. 1, 47057 Duisburg — [2]Chair for Applied Solid State Physics, Ruhr-Universität Bochum, Universitätsstr. 150, 44780 Bochum, Germany

Self-assembled quantum dots (QDs) are promising candidates for quantum computation devices that require a two level system. One possibility is the two-electron excited spin triplet and its singlet ground state. The self-assembled InAs QDs are embedded in a GaAs/AlGaAs heterostructure (FET), where an electron reservoir (2DEG) coupled to the QDs serves as charge reservoir as well as sensitive detector for the electron states. By charging the QDs resonantly into the triplet states and observing the electron emission during discharge, we are able to record the temporal decay of the triplet states by time-resolved transconductance spectroscopy [1]. This allows us to determine - by electrical means - the spin relaxation time after the injection of the second electron into the p- or d-shell. We find spin relaxation times of 25 μs (p-shell) and 23 μs (d-shell), orders of magnitude longer compared to optical experiments where an additional hole is present [2]. Future measurements in presence of a magnetic field are expected to demonstrate even longer spin-relaxation times in such an electrical device. [1] B. Marquardt. et al., Nature Commun. 2, 209 (2011) [2] F. Sotier et al., Nature Physics 5, 352 - 356 (2009)

HL 63.69 Wed 15:00 P1A

Angle-dependent magnetotransport measurements on single GaN nanowires — •Patrick Uredat, Matthias T. Elm, Pascal Hille, Martin Eickhoff, and Peter J. Klar — I. Physikalisches Institut, Justus Liebig University, Heinrich-Buff-Ring 16, D-35392 Giessen, Germany

III-V nanowires increasingly attract attention as building blocks for nanotechnological devices, in particular for optoelectronic devices such as light-emitting diodes or sensors. Thus, it is essential to study the influence of dopants on the transport properties. Angle-dependent magnetotransport measurements yield detailed information about electron transport in nanowires.

Here, we present investigations of the transport properties of GaN nanowires grown by molecular beam epitaxy. Single nanowires have been electrically contacted in four-point geometry using photo- and electron-beam lithography. Temperture-dependent measurements show semiconducting behavior for slightly doped nanowires, whereas nanowires with high doping concentration exhibit a metallic behavior. Magnetotransport measurements reveal a negative magnetoresistance due to weak localization reagardless of the doping concentration. In addition, universal conductance fluctuations (UCFs) have been observed for highly doped wires. Angle-dependent magnetotransport measurements have been performed by varying the angle between magnetic field and nanowire axis. From the angle-dependence of the UCFs one can deduce the distribution of elastic scattering centers and thus reveal the motion of electrons within a single nanowire.

HL 63.70 Wed 15:00 P1A

Computer-aided cluster expansion: An efficient algebraic approach for open quantum many-particle systems — •Alexander Foerster[1], Alexander Leymann[2], and Jan Wiersig[1] — [1]Otto-von-Guericke University Magdeburg, D-39016 Magdeburg, Germany — [2]Max Planck Institute for the Physics of Complex Systems, D-01187 Dresden, Germany

We introduce a computer-aided algebraic approach for a microscopic description of open quantum systems that we made available as open-source software[1]. The presentation combines the conceptual ideas of the computer-aided cluster expansion with the application to a current research topic - superradiance of semiconductor quantum dots. We exploit a configuration formulation that allows for an exact treatment of a subsystem e.g. a multilevel quantum dot [2,3]. The fundamental object of the system is described exactly while correlations between objects can be treated on different levels of approximation. Our program provides an efficient algebraic approach to derive equations of motion, while the user can focus on the physical modeling and conceptional questions. The procedures offer a variety of approximations applicable for finite systems with strong coupling as well as large systems where augmented mean-field theories apply.

[1] A. Foerster, H.A.M. Leymann, and J. Wiersig , Comput. Phys. Commun., http://dx.doi.org/10.1016/j.cpc.2016.10.010, (2016)
[2] H.A.M. Leymann, A. Foerster, et al., Phys. Rev. Applied **4**, 044018 (2015)
[3] F. Jahnke, ..., A. Foerster, et al., Nat. Comm. **7**, 11540 (2016)

HL 63.71 Wed 15:00 P1A

Spatial and temporal evolution of coherent polariton modes in ZnO microwire cavities — Tom Michalsky, Marcel Wille, •Evgeny Krüger, Stefan Lange, Marius Grundmann, and Rüdiger Schmidt-Grund — Institut für Experimentelle Physik II, Universität Leipzig, Linnéstraße 5, D-04103 Leipzig, Germany

We present experimental results for the spatial and ps-temporal evolution of coherent polariton states in ZnO based hexagonal microwires at room temperature. The estimation of the carrier density at the threshold excitation power reveals that the gain process is connected to the recombination out of an electron-hole plasma. The small spatial region of the cavity which is optically highly excited ensures together with a large intrinsic coupling constant of $V \approx 300$ meV that the cavities remain in the strong coupling regime as the highly excited region acts only as a small perturbation and source for the polariton population. We furthermore show that the model developed for the real- and k-space evolution of Bose-Einstein condensates based on the Gross-Pitaevskii equation [1] applies to our observations and gives similar results as obtained from nonlinear ray optics using a spatially varying particle density dependent refractive index for the cavity material.

[1] M. Wouters, I. Carusotto and C. Ciuti, Phys. Rev. B **77**, 115340 (2008)

HL 63.72 Wed 15:00 P1A

Numerical modeling of InP/AlGaInP quantum dots semiconductor optical amplifier — •Thomas Breier, Zhihua Huang, Michael Jetter, and Peter Michler — Institut für Halbleiteroptik und Funktionelle Grenzflächen and Research Center ScoPE and

IQST, University of Stuttgart, Allmandring 3, 70569 Stuttgart, Germany

Semiconductor Optical Amplifiers (SOAs) show great promises in many applications (e.g. optical communication networks, laser amplifications). Nowadays, the active regions of most SOAs are still mainly focused on the bulk materials and quantum wells. However, quantum dots (QDs) as active region have shown remarkable advantages in SOAs due to its higher material gain, larger gain bandwidth, faster gain recovery and lower threshold current density. This research work is aimed on numerically modeling of a tapered InP/AlGaInP quantum dots SOA emitting at around 660nm. The material gain of the QD layers was obtained by measuring the net model gain in combination with T-Matrix calculations of the confinement-factor of the QDs embedded in waveguides. Based on the measured gain value, the small signal gain, the output saturation power, and the amplified spontaneous emission (ASE) power were estimated. Furthermore, the output electrical field of the tapered waveguide was simulated by using traveling-wave equations (TWE), in order to evaluate the fundamental mode output. Additionally, the field distribution for different taper angles and taper shapes were compared. The simulation results provide a guideline to find the trade-off between high amplification and high beam quality.

HL 63.73 Wed 15:00 P1A

Optical gain and laser characteristics of InP/AlGaInP quantum dots red-emitting laser — •Zhihua Huang, Thomas Breier, Stefan Hepp, Roman Bek, Michael Jetter, and Peter Michler — Institut für Halbleiteroptik und Funktionelle Grenzflächen and Research Centers ScoPE and IQST, University of Stuttgart, Allmandring 3, 70569 Stuttgart, Germany

Quantum dots (QDs) as an active layer in laser sources are attractive for many applications due to their excellent properties resulting from their zero-dimensional density of states, e.g. higher optical gain, larger gain bandwidth, lower threshold current density, and temperature insensitivity. In this contribution, we experimentally investigate the properties of the single- and double-layers of InP quantum dots assembled in AlGaInP barrier emitting in the wavelength range around 660 nm, as well as the characteristics of edge emitting lasers with the above mentioned QDs as active region. The self-assembled InP quantum dots layers were grown in the Stranski-Krastanow growth mode by MOVPE at 710 degree with an estimated density of 1e10 cm-2. The optical gain and internal optical loses were measured at room temperature by utilizing segmented contact method at different injected current density, to analyze the amplified spontaneous emission (ASE) as a function of contact stripe length. For a 1-mm long laser with uncoated facets, the experimental results indicated that the single-layer QDs laser has lower threshold current density of 550 A/cm-2 at the heatsink temperature of 278 K. Furthermore, an output power of more than 100 mW per fact was achieved.

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Absorptive lasing mode suppression in highly excited ZnO nano- and microcavities — •Marcel Wille, Tom Michalsky, Chris Sturm, Evgeny Krüger, Marius Grundmann, and Rüdiger Schmidt-Grund — Institut für Experimentelle Physik II, Universität Leipzig, Germany

A variety of lasing experiments in nano- and microstructures reveal different lasing mode energies as well as linewidths for various excitation conditions. However, a conclusive explanation of the resonator mode properties is missing so far. Here, we explain the spectral position and linewidth of lasing modes of three ZnO nano- and microstructures, tetrapod-like nanoparticles, nanowires and microwires. We found that the structure size strongly influences the emission properties. The limited penetration depth of usually used excitation lasers and carrier diffusion lead to an inhomogeneous carrier distribution [1]. Hence, weakly or even nonexcited areas remain present after excitation and lead to strong absorption. This effect is most pronounced for whispering-gallery modes in microwires due to their larger dimensionality. Furthermore, the absorptive lasing mode suppression will be demonstrated for a single nanowire by varying the spot size of the excitation laser. In time-resolved PL measurements we found an ultrafast energy loss of the resonant modes, leading to a linewidth broadening in time-integrated spectra [2]. A model of the time dependent dielectric function fits the experimental observations quite well.

[1] M. Wille et al., Appl. Phys. Lett. 109, 061102 (2016)
[2] M. Wille et al., Nanotechnology 27, 225702 (2016)

HL 63.75 Wed 15:00 P1A

Magnetotransport in narrow-gap semiconductor nanostructures — •Johannes Boy[1], Olivio Chiatti[1], Christian Heyn[2], Wolfgang Hansen[2], and Saskia F. Fischer[1] — [1]Novel Materials Group, Humboldt-Universität zu Berlin, 12489 Berlin, Germany — [2]Institut für Angewandte Physik, Universität Hamburg, 20355 Hamburg, Germany

The Shubnikov de-Haas effect is a powerful tool to determine the electric transport parameters of a two-dimensional electrongas (2DEG). Our experimental work has been directed at the magnetotransport under the influence of in-plane gates. We have combined quantum point contacts (QPCs) with in-plane gates and Hall-bars (HB) in a narrow-gap semiconductor heterostructure with strong spin-orbit interaction. The investigated structures were fabricated by micro-laser photolithography and wet-chemical etching from an InGaAs/InAlAs/InAs quantum well [1]. The 2DEG has carrier densities of about $6.7 \cdot 10^{11}$ cm^{-2}, mobilities of $0.8 - 1.8 \cdot 10^5$ cm^2/Vs and an effective mass of $0.042 \cdot m_e$ after illumination. We have performed magnetotransport measurements at temperatures down to 250 mK. Hall-bar structures were investigated in tilted magnetic fields up to 10 T. Combined QPC and HB structures were studied using various gate voltages in perpendicular magnetic fields up to 10 T. We determined the effective Lande-factor $g^* = 16$ and the Landau-level broadening $\Gamma = 2.2$ meV. We observed the transition of reflection of the quantum Hall edge channels at the QPC to transmission by changing the gate voltage.

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

HL 63.76 Wed 15:00 P1A

Impact of rotational twin boundaries of GaP/Si(111) substrates on III-V nanowire growth — •Matthias Steidl[1], Christian Koppka[1], Lars Winterfeld[2], Katharina Peh[1], Peter Kleinschmidt[1], and Thomas Hannappel[1] — [1]Photovoltaics Group, Institute of Physics, Technische Universität Ilmenau, 98693 Ilmenau, Germany — [2]Theoretical Physics I, Institute of Physics, Technische Universität Ilmenau, 98693 Ilmenau, Germany

The epitaxial integration of III-V nanowires (NWs) with silicon has attracted considerable interest as one of the most promising ways of combining the tuneable, high-performance properties of III-V materials with the well-established Si technology. The Au-mediated vapor-liquid-solid (VLS) growth represents a common, powerful technique for the fabrication of III-V NWs. As direct growth of NWs on Si(111) entails several difficulties, a widespread approach is to grow a III-V-transition layer prior to NW growth. However, this is generally accompanied by the formation of rotational twins. In the present study we thoroughly investigate the impact of rotational twin boundaries (RTBs) in GaP/Si on the NW growth both for GaP and GaAs NWs. RTBs can either suppress NW growth at all or lead to different undesired growth directions, such as horizontal and diagonal growth. It was found that homoepitaxial NW growth (GaP) and hetereoepitaxial NW growth (GaAs) differs in many aspects. To explain these experimental findings, we developed a model based on classical nucleation theory.

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Growth and characteristics of lateral $In_{1-x}Ga_xAs$ nanowires on silicon substrates — •Thorsten Wierzkowski[1,2], Martin Mikulics[1,2], Hilde Hardtdegen[1,2], and Detlev Grützmacher[1,2] — [1]Peter Grünberg-Institut 9, Forschungszentrum Jülich, 52425 Jülich, Germany — [2]JARA - Fundamentals of Future Information Technology

The integration of low direct band gap and high electron mobility III/V-nanostructures, such as $In_{1-x}Ga_xAs$ nanowires, into conventional silicon circuits is a promising approach to overcome limits in future Si-CMOS technology. Our approach is to realize $In_{1-x}Ga_xAs$ nanowire structures horizontally on Si (110) and Si (100) substrates by using low pressure selective area (SA) MOVPE instead of the employment of gold to induce growth since it is detrimental for silicon technology. Another advantage over the catalyst-induced growth method is the position-controlled deposition, which simplifies further processing. Conventionally, $In_{1-x}Ga_xAs$ nanowires grown vertically in [111] direction exhibit stacking faults in growth direction i.e. the current direction of the future device, which can be detrimental to the carrier mobility. By growing the nanostructures laterally on the Si (110) and Si (100) surface the direction of the stacking faults may have less influence on electron mobility. In this contribution, we will present the effect of trench orientation on lateral nanowire growth on Si (110) substrates and a growth study of lateral nanowires with different $In_{1-x}Ga_xAs$

compounds on technological important Si (100) substrates.

HL 63.78 Wed 15:00 P1A

InAs quantum dots without wetting layer photoluminescence — Sven Scholz, •Yannick Raffel, Sascha René Valentin, Carlo Alberto Sgroi Penagos, Andreas D. Wieck, and Arne Ludwig — Lehrstuhl für Angewandte Festkörperphysik, Ruhr-Universität Bochum, Universitätsstrasse 150, D-44780 Bochum, Germany

InAs quantum dots (QDs) are promising hosts for various applications and can be used as a model system for zero dimensional quantum physics. During strain driven growth of QDs by the Stranski-Krastanow (SK) mechanism, also a monolayer of InAs is formed. This so called wetting layer (WL) acts as a two dimensional quantum well. While SK-QDs usually come along with such a WL, it is an interesting question whether we can purify our QD photoluminescence (PL) from the influence of this. We found a reliable growth mechanism described and analyzed in this contribution. With this mechanism we are indeed able to grow QD samples with all dominant PL peaks stemming from the QDs and not from the wetting layer. Capacitance voltage measurements to monitor the QD loading with single electrons allow deeper insights in the conduction band energy structure.

HL 63.79 Wed 15:00 P1A

Investigation of spatial variation in molecular beam flux - gradients — •Vivienne Bippus, Rüdiger Schott, Pia Eickelmann, Julian Ritzmann, Andreas D. Wieck, and Arne Ludwig — Lehrstuhl für Angewandte Festkörperphysik, Ruhr-Universität Bochum, Universitätsstrasse 150, D-44780 Bochum, Germany

Semiconductor quantum wells (QWs) are essential tools for many research fields and devices such as LEDs, laser diodes or tunnel structures. To precisely control the emission wavelength, QWs are typically grown by molecular beam epitaxy (MBE) which offers monolayer precision. Due to the cell geometry of the MBE-setup, flux gradients can lead to spatial variations in the layer thickness on the wafer. A typical mitigation measure is to rotate the wafer during the epitaxy.

However, alloy composition and thickness variations of the QWs still appear. Therefore, we perform a systematic investigation to study the inhomogenities of the Ga, In and Al content via photoluminescence mapping of full three inch wafers. This will also be compared to MBE-growth without rotation, i.e. intentional flux gradients.

HL 63.80 Wed 15:00 P1A

Spin-flip Raman scattering in colloidal CdSe nanoplatelets — •Dennis Kudlacik[1], Victor Sapega[2], Jörg Debus[1], Benoit Dubertret[3], Dmitri Yakovlev[1], and Manfred Bayer[1,2] — [1]Experimentelle Physik 2, Technische Universität Dortmund, 44227 Dortmund, Germany — [2]Ioffe Institute, Russian Academy of Sciences, 194021 St. Petersburg, Russia — [3]Laboratoire de Physique et d'Etude des Matériaux, UMR8213 du CNRS, ESPCI, 75231 Paris, France

Colloidal CdSe nanoplatelets (NPLs) are highly efficient light emitting materials exhibiting unique optical properties that are very promising for many applications in nanotechnology. Even though there has been a continuous study on these colloidal nanostructures investigating their optical properties, a comprehensive and unified picture of electronic spin-based interactions is still missing up to now. Therefore, we have studied the resonant spin-flip Raman scattering (SFRS) in self-assembled colloidal CdSe nanoplatelets in Faraday and tilted geometries at external magnetic fields of up to 10 T. We have observed an intense first and second order Raman signal, which can be attributed to a spin-flip of a resident electron induced by a photocreated exciton inside of this colloidal quantum well. From a magnetic field dependence of the electron spin-flip energy, measured in Faraday and Voigt geometry, isotropic g-factors of g_e = 1.623 and 3.242 have been determined. Furthermore, we have observed that the SFRS exhibits a strong dependence on temperature. With increasing temperature, the electron spin dephasing time is considerably reduced.