HL 8: Poster Session II

Topics:
- Functional semiconductors for renewable energy solutions
- Heterostructures, interfaces and surfaces
- Nitrides: Preparation and characterization
- Organic semiconductors
- Oxide semiconductors
- Perovskite and photovoltaics
- When theory meets experiment: Hybrid halide perovskites for applications beyond solar

Time: Tuesday 10:00–13:00 Location: P

HL 8.1 Tue 10:00 P

Design optimization for bright electrically-driven quantum dot single-photon sources emitting in telecom O-band — Sergey Blokhin[1], Mikhail Bobrov[1], Nikolai Maleev[1], •Jan Donges[2], Lukas Bremer[2], Alexey Blokhin[3], Alexey Vasil'ev[3], Alexander Kuzmenkov[3], Evgenii Kolodeznyi[4], Vitaly Shchukin[2,5], Nikolay Ledentsov[5], Stephan Reitzenstein[2], and Victor Ustinov[3] — [1]Ioffe Institute, Politekhnicheskaya 26, St. Petersburg 194021, Russia — [2]Technische Universität Berlin, Hardenbergstr. 36, 10623 Berlin, Germany — [3]Research and Engineering Center for Submicron Heterostructures for Microelectronics, Politekhnicheskaya 26, St. Petersburg 194021, Russia — [4]ITMO University, Kronverksky pr. 49, St. Petersburg 197101, Russia — [5]VI Systems GmbH, Hardenbergstr. 7, 10623 Berlin, Germany

To enable long distance quantum communication, electrically-driven single-photon sources with almost ideal optical properties are desired. Through 3D finite-difference time-domain modelling, we present a design based on self-assembled quantum dots which delivers promising results in the telecom O-band by employing a broadband bottom distributed Bragg reflector (DBR) and a top DBR formed in a dielectric micropillar with an additional circular Bragg grating in the lateral plane. The design provides broadband emission enhancement (8-10nm) with an overall photon-extraction efficiency of 83% into the upper hemisphere, while photon coupling into single-mode fibers reaches efficiencies up to 40% for a HNA fiber (NA = 0.42). Blokhin et al., Opt. Express 29, 6582-6598 (2021)

HL 8.2 Tue 10:00 P

Examination of time-energy-entanglement on the biexciton-exciton-system under resonant two-photon driving via Franson interferometry — •Marcel Hohn, Matthias Kunz, Samir Bounouar, and Stephan Reitzenstein — Institut für Festkörperphysik, Technische Universität Berlin, D-10623 Berlin, Germany

We investigate the degree of time-energy entanglement from the XX-X-system under resonant two-photon driving. The dressing of this "three-level ladder" system leads to new eigenstates and previous experiments showed correlated emission of paired photons with manipulatable time ordering of the cascade [1]. In addition, a recent theoretical treatment indicated possibilities and limitations for the visibility of two-photon interference using Franson interferometry [2]. We measured the degree of time-energy-entanglement of the emitted pairs by Franson interferometry and observed a strong dependence of the visibility on excitation power and detuning. In particular, our measurements show that the degraded energy time entanglement of the XX-X-system under off-resonant excitation can be enhanced via strictly resonant two-photon-excitation.

[1] S. Bounouar et al., Physical Review Letters 118 (2017).
[2] K. Barkemeyer et al., Physical Review A 103 (2021).

HL 8.3 Tue 10:00 P

Focused ion beam implantation of rare-earth ions in semiconductor nanostructures — •Christian Düputell, Arne Ludwig, and Andreas D. Wieck — Chair of Applied Solid State Physics, Ruhr University, Bochum

We report on focused ion beam (FIB) implantation of rare-earth ions in semiconductor nanostructures. Semiconductor nanostructures have attracted a lot of attention due to their unique optical, electrical and mechanical properties. To use nanostructures for a certain purpose, often very specific properties have to be achieved. An elegant method to tune the electrical and optical properties of semiconductor nanostructures is focused ion beam implantation. Using ion beams offers high-resolution lateral engineering, local band gap modulation due to ion-induced intermixing as well as local doping applications and even isotopic resolution. To carry out implantation of rare-earth ions in semiconductor nanostructures, we especially focus on the incorporation of erbium ions into GaAs. Erbium shows two unique properties. First, it has a huge magnetic moment, which could lead to a rich spectrum of possible spin coupling processes in the host material. And second, the optical transitions of erbium should lead to an emission of electromagnetic radiation at the important telecom-C-band wavelength of 1.54 μm, which has minimal absorption in glass fibres. We are presenting the current status of our studies on both of these properties as a function of the implantation pattern, the ion fluence and the used annealing parameters. We also report on the preparation and composition of the corresponding liquid metal alloy sources for FIB.

HL 8.4 Tue 10:00 P

Using a novel scanning probe technique to strongly couple a single quantum dot to a tunable plasmonic nanogap antenna at room temperature — •Michael A. Becker[1], Hsuan-Wei Liu[1], Korenobu Matsuzaki[1], Randhir Kumar[1], Stephan Götzinger[2,1], and Vahid Sandoghdar[1,2] — [1]Max Planck Institute for the Science of Light — [2]Friedrich Alexander University of Erlangen-Nürnberg

Scanning probe techniques are indispensable methods for optical investigations of structures smaller than the diffraction limit. Moreover, techniques like atomic force microscopy and scanning near-field optical microscopy can be utilized to measure electrical and thermal conductance and probe near-field light-matter interactions. However, these types of experiments typically require sensitive and expensive state-of-the-art equipment. Here, we report on a novel and simple press-roll scanning probe technique (PRoScan) capable of performing optical near-field measurements with remarkable stability, even in the absence of any stabilization mechanism. We demonstrate its performance by a precise coupling of an individual quantum dot to a gold nanoparticle, where we can control the Purcell enhancement with nanometer-resolution. Next, we utilize the technique to create an open and tunable nanogap antenna. By tuning the resonance of the nanogap antenna and controlling the position of the single quantum dot, we can drive the system from the weak to the strong light-matter coupling regime, evidenced by a vacuum Rabi splitting and a characteristic anticrossing behaviour.

HL 8.5 Tue 10:00 P

Capacitance-voltage spectroscopy on quantum dots without electronic wetting layer states — •Ismail Bölükbasi, Sven Scholz, Andreas D. Wieck, and Arne Ludwig — Ruhr-Universität Bochum, D-44780 Bochum, Germany

Quantum dots have interesting physical properties and allow research in zero dimensional systems. They are used in modern displays and may become important for the progress of semiconductor and information technology in the form of qubits in quantum computers and quantum memories or sources of high-fidelity single photons in quantum communication applications.

Quantum dots are created by molecular-beam-epitaxy (MBE) in the so-called Stranski-Krastanov growth mode. InAs arranges epitaxially on GaAs in a strained layer of up to 1.5 monolayers without relaxation before nucleation of coherently strained islands takes place. This layer remains between the islands and is called the wetting layer.

We find that a monolayer of AlAs deposited after the growth of the quantum dots can suppress certain states in this wetting layer [1], allowing to purify their photoluminescence spectra from electronic contributions such as for example a two-dimensional-electron gas would induce. Capacitance-voltage and photoluminescence measurements are carried out to investigate the effects of this monolayer of AlAs on the physical properties of the quantum dots and the modified charging behaviour around flat band conditions.

[1] Löbl, M. C. et al. Excitons in InGaAs quantum dots without electron wetting layer states. Commun. Phys. 2, 93 (2019).

HL 8.6 Tue 10:00 P

Surface Morphology of Self-Assembled InAs/GaAs Quantum Dots and Pattern Definition Layers grown by Molecular Beam Epitaxy — •Peter Zajac, Nikolai Bart, Andreas D. Wieck, and Arne Ludwig — Ruhr-Universität Bochum, Universitätsstraße 150, 44801 Bochum

The nucleation of self-assembled InAs/GaAs Quantum Dots (QDs), grown by molecular beam epitaxy, can be locally influenced by growing them on gradient pattern definition layers. Macro Photoluminescence Spectroscopy (PL) mapping reveals a modulation of QD density in a striped pattern along the gradient direction. Automated Atomic Force Microscopy (AFM) was employed to study the morphology of pattern definition layers over several millimeters, revealing a sinusoidal behavior of the monolayer step density. Local PL contrast is used to locate areas of highest QD density modulation. It is proposed that the periodic variation of roughness locally modifies the QD nucleation condition leading to the observed pattern [1].

[1] Bart et al., arXiv:2011.10632 (2020).

HL 8.7 Tue 10:00 P

Wafer Scale Density Modulation of Self-Assembled Quantum Dots by Epitaxial Surface Roughness Control — •Nikolai Bart, Nikolai Spitzer, Peter Zajac, Marcel Schmidt, Andreas D. Wieck, and Arne Ludwig — Ruhr-Universität Bochum, Lehrstuhl für Angewandte Festkörperphysik, Universitätsstraße 150, 44801 Bochum, Germany

The effect of nanoscale roughness of GaAs surfaces on the nucleation of self-assembled InAs quantum dots (QD) is investigated with photoluminescence (PL) spectroscopy. We control the roughness in-situ by simple epitaxial layer-by-layer growth: Depositing integer (fractional) values of GaAs monolayer thicknesses yields a smooth (rough) surface. We report significant differences in both PL intensity and QD surface density at the critical threshold of nucleation. By growing GaAs thickness gradients, we create and control various density modulation patterns on whole 3-inch wafers. Moreover, we investigate the influence of surface annealing time and temperature on the modulation and demonstrate how to utilize this mechanism for density control of high quality single QD photonic device wafers.

HL 8.8 Tue 10:00 P

Semiconductor nanophotonic light sources with site- and number- controlled quantum dots for the investigation of collective effects — •Ching-Wen Shih, Jan Grosse, Imad Limame, Chirag Palekar, Yuhui Yang, Lasse Kosiol, Sebastian Krüger, and Stephan Reitzenstein — Institut für Festkörperphysik, Technische Universität Berlin, Berlin, Germany

Sub- and superradiance are intriguing collective radiative emission processes which occur when coherence is built up among the emitters spontaneously via exchange of photons. Semiconductor quantum dots (QDs) are attractive candidates to study these collective emission processes. However, a systematic study of the collective effects in these semiconductor nanostructures requires a control over the position, number, and emission energy of the quantum dot emitters. We report on the development of nanophotonic light sources via a buried-stressor approach, which enables a precise position control of the InGaAs QDs by tailoring the strain induced by an oxidation aperture. Furthermore, the number of such site-controlled QDs is successfully varied from 0 to 20 across each device via a careful balance between the aperture size and the MOCVD growth condition. Finally, electron beam lithography is implemented to pattern micro-mesa cavity structures, which enhance the photon extraction efficiency of the QDs to facilitate the observation of sub- and superradiance.

HL 8.9 Tue 10:00 P

A Master Equation centered foundation for an open-source project for quantitative simulation of the transition dynamics in finite state quantum systems. — •Arn Baudzus, Andreas Wieck, and Arne Ludwig — Angewandte Festkörperphysik, Ruhr-Universität Bochum, Universitätsstraße 150, D-44780 Bochum

We present a novel approach and status on the implementation of a program to quantitatively simulate the electronic, photonic and phononic behaviour of a quantum dot that is embedded in a semiconductor device. Our main aim is to start an open-source project, everyone can expand and contribute to.

We outline a theoretical framework that is developed to break this complex system down into modules that can be treated one at a time.

The framework is centered around the generation and solution of master equations with constant or time dependent coeffitients. The coeffitients in the master equation and the information of the relevant states can be calculated by different programs, each governing another kind of interaction.

We use a graph data structure to manage the system states and interface with the other program parts in an intuitive way. A C++ implementation for this structure has been developed.

At the moment we are mainly focusing on the simulation of electron tunneling dynamics between a single quantum dot and a two dimensional electron gas. We illustrate how the tunnel dynamics can be simulated using our framework.

HL 8.10 Tue 10:00 P

Spatially resolved multi-probe electrical characterization of GaAs-based nanowire structures — •Juliane Koch[1], Lisa Liborius[2], Peter Kleinschmidt[1], Werner Prost[2], and Thomas Hannappel[1] — [1]Fundamentels of energy materials, Ilmenau University of Technology, Germany — [2]Components for High Frequency Electronics (BHE), University of Duisburg-Essen, Germany

To achieve high performance optoelectronic devices with III-V semiconductor nanowire (NW) heterostructures sophisticated junctions with controlled properties are required. In order to study microscopic details of the NW structure and its composition, we investigated upright standing p-GaAs/i-GaInP/n-GaInP core-shell-shell NWs on the growth substrates. Cores of the NWs were grown via the vapor-liquid-solid mode followed by epitaxial shell growth in a low-pressure horizontal metalorganic vapor-phase epitaxy reactor. We employ a combination of material-selective wet chemical etching of as-grown coaxial NWs and a multi-tip scanning tunnelling microscope operated as a four-point nano-prober to obtain spatially resolved I-V analysis. These revealed a leakage mechanism causing degraded core-shell pn-junction performance, which is localized at the NW base where a buried contact of the n-GaInP shell to the p-GaAs substrate is formed. Furthermore, the combination of SEM with EDX and XRD measurements reveal the contrast of NW shell and planar layer growth. Our high-end characterization methods enable a direct relation between the NW structures and the electronic properties of as-grown coaxial NWs, which provides precise advice for future NW core-shell pn-junction optimization.

HL 8.11 Tue 10:00 P

Examination of self-assembled quantum dots in a density-modulated pattern with capacitance-voltage and photolulminescence spectroscopy — •Nikolai Spitzer, Nikolai Bart, Arne Ludwig, and Andreas Wieck — Ruhr-Universität Bochum

Self-assembled InAs quantum dots (QDs) on GaAs with a QD density modulation upright to the growth direction were grown by molecular beam epitaxy. The QDs can be arranged in stripe patterns whose properties can be changed by a gradient in the GaAs sublayer beneath the QDs. We suspect that the formation of QDs is favoured by atomic rough areas as opposed to flat areas during molecular epitaxial growth. The differences in the sublayer are due to the profile of the molecular beam. Capacitance-voltage spectroscopy and photoluminescence spectroscopy are used to investigate the properties of the quantum dots arranged in this way at different densities.

HL 8.12 Tue 10:00 P

Design and fabrication of waveguide-based nanobeam cavity for on-chip single photon source — •Yuhui Yang[1], Uğur Meriç Gür[1,2], Johannes Schall[1], Ronny Schmidt[1], Arsenty Kaganskiy[1], Michael Mattes[2], Samel Arslanagić[2], Stephen Reitzenstein[1], and Niels Gregersen[3] — [1]Institut für Festkörperphysik, TU Berlin, Germany — [2]Department of Electrical Engineering, Technical University of Denmark, Denmark — [3]Department of Photonics Engineering, Technical University of Denmark , Denmark

In quantum technology, the two-photon interference acts as an important role related to the indistinguishability of single-photon. One approach to improve the indistinguishability of single-photon is to enhance the spontaneous emission into cavity mode by Purcell effect. In this regard, nanobeam cavities, are promising candidates because they can easily be integrated with other on-chip components. In this contribution, we optimize the geometrics of nanobeam cavities. A numerically optimized nanobeam cavity design yields a high directional spontaneous emission β factor of 0.73 with broadband enhancement of 9 nm. The nanobeam cavity containing embedded InGaAs/GaAs quantum dots fabricated structures demonstrates the cavity effect. By micro-photoluminescence (μPL) characterization, three distinct Fabry-Pérot resonance peaks as well as cavity effects are observed. Due to the Purcell enhancement from the cavity, the spontaneous emission rate of a resonance (non-resonance) peak is (1.59 * 0.09) ns^{-1} [(1.14 * 0.14) ns^{-1}], indicating the potential of nanobeam cavity for full on-chip single-photon source.

HL 8.13 Tue 10:00 P

Frequency Shift of Electronic Resonances in Self Assembled InAs Quantum Dots — •Ibrahim Azad Engin, Ismail Bölükbaşi, Sven Scholz, Andreas D. Wieck, and Arne Ludwig — Lehrstuhl für Angewandte Festkörperphysik, Ruhr-UniversitätBochum, D-44780 Bochum, Germany

Self-assembled InAs quantum dots (SAQD) proved promising semiconductor structures as single-photon sources and provide possibilities for quantum memories. Therefore understanding the physical properties is important and in progress. We investigate electronic resonances in InAs SAQDs by using C(V)-spectroscopy.

The thermal shift of the s-states has been reported and described with a master equation [1], which has been improved further to model excitonic and non-equilibrium states in such SAQD [2]. The model shows contrarily shifting in dependence of frequency and temperature.

Here we investigate both s- and p-states in dependence of temperature and frequency to measure the shifting characteristics of p-peaks and observe the dominancy of the frequency shift for s-states. The superposition of thermal and frequency shift are being analyzed. Adjustments to the master equation model are needed.

[1] Brinks, F. et al., "Thermal shift of the resonance between an electron gas and quantum dots: what is the origin?" New J. Phys. 18, 123019 (2016).

[2] Valentin, S. et al., "Illumination-induced nonequilibrium charge states in self-assembled quantum dots", Phys. Rev. B 97, 045416 (2018).

HL 8.14 Tue 10:00 P

Metamorphic buffer layer based single-photon sources for application in quantum telecommunications — •Piotr Andrzej Wronski, Sven Höfling, and Fauzia Jabeen — 1Technische Physik, University of Würzburg and Wilhelm-Conrad-Röntgen-Research Center for Complex Material Systems, Am Hubland, D-97074 Würzburg, Germany

Obtaining single-photon sources requires them not only to characterize by low FSS, low g(2)(0), and high emission rate, it is also essential for them to be built-in telecommunication network. Ideally, obtained sources should emit at spectral range aligned with the lowest attenuation window (C-band) for silicon fibers. So far, such emitters are reported only on InP, but the low refractive contrast of lattice-matched materials makes it difficult to obtain complete photonic structures with efficient outcoupling.

Metamorphic buffer layer on GaAs substrate as a base for InAs QDs leads to strain relaxation and induces required emission shift. Past attempts in this matter lacked low surface roughness required for development of top DBRs and fabricating micropillars

By implementing our approach of introducing a stepwise increase of "In" composition inside a digitally alloyed superlattice, we can observe a shift of emission wavelength, improvement of surface quality, and observation of single-photon emission in 1550 nm spectral range from InAs QDs grown on GaAs (001) substrate, confirmed by autocorrelation experiments. The incorporation of AlAs/GaAs DBRs improved the emission intensity.

HL 8.15 Tue 10:00 P

Purcell-enhanced single-photon emission from a strain-tunable quantum dot in a cavity-waveguide device — •Florian Hornung[1], Stefan Hepp[1], Stephanie Bauer[1], Erik Hesselmeier[1], Xueyong Yuan[2,3], Michael Jetter[1], Simone Luca Portalupi[1], Armando Rastelli[2], and Peter Michler[1] — [1]Institut für Halbleiteroptik und Funktionelle Grenzflächen, Center for Integrated Quantum Science and Technology (IQST) and SCoPE, University of Stuttgart, 70569 Stuttgart, Germany — [2]Institute of Semiconductor and Solid State Physics, Johannes Kepler University Linz, 4040 Linz, Austria — [3]School of Physics, Southeast University, Nanjing, 211189, China

The miniaturization of optical elements to chip-size in so-called photonic integrated circuits has attracted a lot of attention in recent years. Due to its great scalability, the approach seems highly promising for the efficient realization of photon-based quantum technologies.

In this study, we show the coupling of an In(Ga)As quantum dot (QD) to a waveguide-integrated cavity. The chip is bonded to a piezoelectric actuator, enabling the strain-tuning of both the emission energy of the QD and the cavity mode. As the QD is more sensitive to the applied strain, a differential tuning factor of four is obtained, allowing to compensate the initial energy mismatch of the QD and the cavity. A clear Purcell-enhancement as well as the single-photon emission of the device are demonstrated. This combination of a strain-tunable quantum emitter and a waveguide-integrated cavity represents an important building block for large scale quantum photonic circuits.

HL 8.16 Tue 10:00 P

Full Wafer Property Control of Local Droplet Etched GaAs Quantum Dots — •Hans-Georg Babin, Nikolai Bart, Marcel Schmidt, Andreas D. Wieck, and Arne Ludwig — Ruhr-Universität Bochum, Germany

Local droplet etched GaAs quantum dots (LDE-QDs) are a promising candidate for excellent single and entangled photon sources. Taking further steps towards application, this requires structures of increasing complexity, engineering the electronic and photonic environments of the QDs. Therefore, it is important to get perfectly matched QDs for the required photonic structures. In this submission, we show a way to compensate for non-perfectly adjusted growth conditions and to accelerate required parameter studies.

We induce certain flux gradients by stopping sample rotation and using the parallax of the effusion-cells. This results in a gradual change of deposited material and cell flux, as well as an induced surface roughness modulation. By this we can vary properties of the QDs like density and emission wavelength over the hole wafer range. Additionally, we induce a stripe patterned density modulation, which was shown before with Stranski-Krastanov QDs. As an example, the widest achieved wavelength shift of the ground state emission energy at 100 K, measured by photoluminescence spectroscopy, extends over the range of 795 nm to 737 nm. The change in surface roughness leads to an additional periodical modulation of the ground state of approximately 3 nm on a mm scale.

HL 8.17 Tue 10:00 P

Changes of transport properties in individual carbon nanotubes due to MOF growth — •Marvin J. Dzinnik[1], Benedikt Brechtken[1], Hendrik A. Schulze[2], Adrian Hannebauer[2], Enes Akmaz[1], Peter Behrens[2], and Rolf J. Haug[1] — [1]Institut für Festkörperphysik, Leibniz Universität Hannover, Appelstraße 2, 30167 Hannover, Germany — [2]Institut für Anorganische Chemie, Leibniz Universität Hannover, Callinstrasse 9, 30167 Hannover, Germany

Metal-organic frameworks (MOF) are porous structures with tunable pore size and adsorption sites but mostly non-conducting. In combination with carbon nanotubes (CNTs) these hybrid structures preserve porosity of the MOFs while gaining conductivity through the CNTs [1,2]. The mechanism of MOF growth on CNTs is accountable to the functionalization of the carbon nanotubes [1]. To study the interaction between MOF and CNTs and the influence of the synthesis, we prepared samples of contacted multi-walled CNTs. We drop-casted CNTs from ethanol solution on a silicon dioxide surface and contacted them with Cr and Au by electron beam lithography and lift-off. DC transport measurements were performed. In a second step, the sample with the contacted CNT was given into a UiO-66 MOF synthesis. Later transport measurements show drastically increased two-terminal resistance.

[1] H. A. Schulze et al., ChemNanoMat, 5, 1159-1169, (2019).

[2] M.-Q. Wang et al., Electrochimica Acta, 190, 365-370, (2016).

HL 8.18 Tue 10:00 P

Optimal Bandwidth in Quantum Event Measurements Using Post-Processing — •Jens Kerski[1], Hendrik Mannel[1], Pia Lochner[1], Eric Kleinherbers[1], Annika Kurzmann[2], Arne Ludwig[3], Andreas D. Wieck[3], Jürgen König[1], Axel Lorke[1], and Martin Geller[1] — [1]Faculty of Physics and CENIDE, University of Duisburg-Essen, Germany — [2]2nd Institute of Physics, RWTH Aachen University, Germany — [3]Chair of Applied Solid State Physics,

Ruhr-University Bochum, Germany

The realization of novel applications, such as quantum computing or quantum sensing, is largely limited by the time resolution and accuracy with which individual quantum events can be measured. For the measurement of single electron tunneling, radio-frequency single-electron transistors and quantum point contacts have been the most successful detection methods. A promising alternative to this is to exploit an optical transition. For this purpose, resonance fluorescence of the excitonic transition is detected at 4.2 K from a self-assembled quantum dot embedded in a tailored diode structure.

In this work, we use single photon signal post-processing to identify the optimal time resolution for the analysis of our data. We show how the bandwidth affects both the determination of the tunneling rates and the statistical evaluation by full counting statistics, and demonstrate that we can evaluate our data with sampling rates up to 340 kHz. Using a simple model, we discuss the limiting factors for reaching the highest time resolution and propose how a time resolution of more than 1 MHz could be achieved.

HL 8.19 Tue 10:00 P

Topological superconductivity in (3D) topological insulator-based hybrid devices — •Dennis Heffels[1], Declan Burke[2], Malcolm R. Connolly[2], Peter Schüffelgen[1], Kristof Moors[1], and Detlev Grützmacher[1] — [1]Peter Grünberg Institut (PGI-9), Forschungszentrum Jülich — [2]Imperial College London

Topological insulator (TI) nanostructures have been proposed as a host system for one-dimensional topological superconductivity. This is made possible by the special properties of the TI surface states in combination with an external magnetic field and proximity-induced superconductivity. Recently, however, it was shown that specific conditions are required to realize fully gapped topological superconductivity. In this talk, I will report on tight-binding simulations with Kwant that allow for a detailed investigation of the formation of a topological band gap in experimentally realizable hybrid devices. We model the TI hybrid device in full three-dimensional detail which allows us to compare different device layouts and proximitization schemes. In general, we find that a topological gap can be opened by breaking the transverse symmetry of the system. One possibility for such a symmetry breaking is the consideration of a ribbon which is only proximitized via the top surface. Our simulation approach also allows us to optimize the device layout in order to maximize the size of the gap. I will also comment on related experimental activities on TI nanostructure-based hybrid devices and tunnel junctions as well as magnetic TI-based hybrid devices.

HL 8.20 Tue 10:00 P

Deterministically fabricated GaAs quantum dot based single-photon sources with emission at Cs wavelengths — •Monica Pengerla[1], Lucas Bremer[1], Jin Dong Song[2], Sven Rodt[1], and Stephan Reitzenstein[1] — [1]Institut für Festkörperphysik, Technische Universität Berlin, Hardenbergstraße 36, 10623 Berlin, Germany — [2]Center for Opto-Electronic Materials and Devices, Korea Institute of Science and Technology, Seoul 02792, Republic of Korea

In this work, we investigate GaAs based quantum dot (QD) single photon sources at 894 nm. The goal is to control the emission of single photon sources time delay with Cs vapor. To increase the photon extraction efficiency, the device design includes a gold mirror on back side. Numerical simulations reveal a photon extraction efficiency of approximately 52% with numerical aperture NA = 0.4. The flip chip gold bonding process results in a thin QD membrane, which includes wet etching of AlGaAs and GaAs layers. The preliminary low temperature micro photoluminescence and cathodoluminescence results of Au bonded samples are fair enough to pursue further device fabrication steps. With In-situ electron-beam lithography (EBL), QDs at target wavelength, based on their intensity can be selected prior to the structure patterning. We are planning to deterministically integrate quantum dots at 894 nm into mesa and one ring structure with in-situ electron beam lithography. Later, the emitted single photon properties of fabricated structures will be studied with photon autocorrelation measurements.

HL 8.21 Tue 10:00 P

Structural and Optical Properties of Hexagonal Pyramids Containing GaInN Quantum dots Formed by Wet Etching of GaInN/GaN Quantum Wells — •Samar Hagag, Sidikejiang Shawutijiang, Heiko Bremers, Uwe Rossow, and Andreas Hangleiter — Technische Universität Braunschweig, Institut f. Angewandte Physik, 38106 Braunschweig,Germany

We present first results from our studies of the structural and optical properties of hexagonal pyramids containing GaInN Quantum Dot(QD)-like structures located close to the tip of pyramids with a smooth side facets of the type (1-10-1) and very sharp tips obtained through the wet chemical etching of GaInN/GaN Quantum Well(QW)structures grown on N-face GaN. The photoluminescence spectrum of the QD's shows the intuitive additional quantum confinement manifested by a blue shift of the photoluminescence peak and narrow emission lines have been observed in the microphotoluminescence spectra. A comparison between the peak energy separation observed in the microphotoluminescence spectrum of pyramidal structures containing several quantum disks and calculations of the quantization energy of the quantum disks shows that the top most QD has a diameter of 18.5nm. In a further attempt to control the position and size of the hexagonal pyramids a Focused Ion Beam-deposited etch mask was used and regular array of pyramidal structures were formed. While the QD thickness and indium contents are given by the QW structure,an optimization of the etching process to control the pyramid size is required to enable the control of the QD lateral extension.

HL 8.22 Tue 10:00 P

Kondo effect in a few-electron quantum dot — •Olfa Dani[1], Johannes C. Bayer[1], Timo Wagner[1], Gertrud Zwicknagl[2], and Rolf J. Haug[1] — [1]Institut für Festkörperphysik, Leibniz Universität Hannover, Germany — [2]Institut für Mathematische Physik, Technische Universität Braunschweig, Germany

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

The investigated quantum dot device is based on a flat two-dimensional electron gas (2DEG) formed in a GaAs/AlGaAs heterostructure. A single quantum dot is formed in this 2DEG using top-gates and a quantum point contact (QPC) is operated as sensitive charge detector, allowing the real-time detection of electrons tunneling through the system [1].

The Kondo effect dominates at a strong coupling between dot and leads. It gives rise to a finite conductance in the otherwise Coulomb-blockaded regime, and has a characteristic temperature dependence. Here we study the Kondo effect as a function of the tunnel coupling and its symmetry. For small number of electrons, we see that the shell structure[2] of the electronic states in the quantum dot influence the Kondo effect.

[1] T. Wagner, et. al., Nat. Nanotech. 12, 218-222 (2017).
[2] L. P. Kouwenhoven, Rep. Prog. Phys. 64, 701-736 (2001).

HL 8.23 Tue 10:00 P

Theoretical description of higher excited quantum dot states in an external magnetic field — •Jan Kaspari, Matthias Holtkemper, Tilmann Kuhn, and Doris Reiter — Institut für Festkörpertheorie, WWU Münster, Wilhelm-Klemm-Straße 10, 48149 Münster, Germany

The influence of a magnetic field on the quantum dot states is usually reduced to the interaction of the external magnetic field with the spins of electrons and holes. Based on the envelope function approximation and minimal coupling we derive additional interaction terms of the magnetic field with the envelope functions and treat the magnetic field interaction, direct and short-range exchange Coulomb interactions as well as the four-band Luttinger theory within a configuration interaction approach. The quantum dot confinement is approximated by an anisotropic harmonic potential. We show that the magnetic field interaction with the envelope functions crucially depends both on the geometry of the quantum dot as well as on the orientation of the magnetic field. In the case of a magnetic field in the growth direction of a cylindrically symmetric quantum dot we find that the interaction with the envelopes results in the mixing of states of the same type which leads to a partial splitting of higher excited energy levels, while for a broken cylindrical symmetry an additional mixing with other orbital states and further energy shifts can be noted. We discuss in detail the observed dependencies on geometric parameters and analyze whether the common approximation to describe the interaction of the external magnetic field solely with spins is applicable for higher excited states.

HL 8.24 Tue 10:00 P

Ultra-high quality factor Ta2O5-on-insulator microring res-

onators with cryogenic temperature stability — •Julian Rasmus Bankwitz, Martin A. Wolff, Adrian Abazi, Alexander Eich, and Carsten Schuck — Institute of Physics University of Münster, Germany

Tantalum pentoxide (Ta2O5) on insulator is an emerging nanophotonic material system that benefits applications in nonlinear and quantum technology due to its outstanding optical properties [1]. As many implementations of quantum technology require cryogenic environments a need for low loss photonic integrated circuits with high temperature stability has arisen. Here we demonstrate ultra-high quality factor Ta2O5-on-insulator microring resonators with minimal temperature-dependent wavelength shift (TDWS). Through careful tuning of design and nanofabrication parameters, we achieve critically coupled devices with loaded quality factors of up to 1.8 Mio., observed over the entire range from room to cryogenic temperatures. The TDWS of ring resonances is as low as 237 pm from 1.74 K to 286 K and, remarkably, vanishes in the 110 K to 140 K range as it changes sign. Our Ta2O5-on-SiO2 devices will thus enable athermal operation of ultra-stable resonators as desired for wavelength division multiplexing, on-chip frequency stabilization and low-noise optical frequency combs.

[1] G. Moody et al. "Roadmap on Integrated Quantum Photonics," arXiv preprint arXiv:2102.03323, 2021.

HL 8.25 Tue 10:00 P

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

A quantum dot (QD) is an ideal system to study electron-electron interaction in a confined nanostructure [1]. The Auger recombination is a special case, where the recombination energy is transferred to third charge carrier that leaves the dot or is excited to an higher energy level. Therefore the Auger effect destroys the radiative trion transition - an effect, which should be minimized for future applications of QDs using the spin states as stationary qubit that should be transferred to a photon via this trion transition.
In this work, we investigate how the Auger rate is affected by an external magnetic field, applied along the growth direction of the sample. In the magnetic field, the trion state of a QD is no longer spin degenerate and splits up. We use two-color, time-resolved resonance fluorescence spectroscopy to investigate the quenching of the trion recombination by the Auger effect. Two-color excitation allows us to symmetrically excite both trion resonances and thus neglect spin relaxation as well as spin-flip Raman scattering. We observe a suppression of the Auger recombination by almost a factor of three, when increasing the field up to B = 10T. **[1] A. Kurzmann et al., Nano Lett. **16, 3367-3372 (2016)

HL 8.26 Tue 10:00 P

Halogen vacancy migration at a surface of CsPbBr3: Insights from Density Functional Theory — •Raisa-Ioana Biega[1] and Linn Leppert[1,2] — [1]Institute of Physics, University of Bayreuth, Bayreuth 95440, Germany — [2]MESA+ Institute for Nanotechnology, University of Twente, 7500 AE Enschede, The Netherlands

Migration of mobile halogen ions is ubiquitous in lead-halide perovskites, and has been studied in detail experimentally and with computational modelling techniques. However, the question whether and how surfaces affect ion migration in these materials is still debated. Here we contribute to this debate by using density functional theory to compute bromine vacancy migration in the bulk and at the (001) surface of cubic CsPbBr3. We find that the migration barrier at the surface is approximately half of that in the bulk due to larger structural distortions at the surface. The targeted choice of an alkali-halide passivation layer can suppress this undesirable effect and leads to an increase of migration barrier to almost the bulk value.

HL 8.27 Tue 10:00 P

Polarons and Dynamic Disorder in Halide Perovskites: a Tight Binding Approach — •Maximilian. J. Schilcher[1], Matthew. Z. Mayers[2], Paul. J. Robinson[2], David. J. Abramovitch[3], Liang. Z. Tan[4], Andrew. M. Rappe[5], David. R. Reichman[2], and David. A. Egger[1] — [1]Technical University of Munich, Germany — [2]Columbia University, USA — [3]University of California Berkeley, USA — [4]Lawrence Berkeley National Laboratory, USA — [5]University of Pennsylvania, USA

Unusual experimental observations of halide perovskites (HaPs) are often explained by polaronic effects. However, the standard polaron picture in its simplest form cannot properly rationalize some of the key carrier-transport features of HaPs. We propose to augment it by a complementary concept based on dynamic disorder [1], taking into account the slow, anharmonic lattice dynamics and incoherent nature of carrier relaxation in HaPs. This approach can be tackled computationally in the framework of a tight-binding (TB) model [2], allowing for modeling large-scale system sizes and temperature-dependent optoelectronic properties. We demonstrate that in this way, we can, e.g., elucidate on the influence of dynamic disorder around room temperature on the band gaps in a variety of HaPs.

[1] M. J. Schilcher et al., ACS Energy Lett. 6, 2162-2173 (2021).
[2] M. Z. Mayers et al., Nano Lett. 18, 8041-8046 (2018).

HL 8.28 Tue 10:00 P

Disorder in halide perovskites: anharmonicity and dynamically shortened correlations — •Christian Gehrmann and David A. Egger — Technical University Munich, Germany

Small Urbach energies, important for an effective collection of sunlight in photovoltaic devices, imply a short range correlated disorder potential [1]. Halide perovskites (HaPs), however, are discussed to show a long-range bonding mechanism, anharmonic nuclear dynamics, disorder, and small Urbach energies all at the same time. We show that correlations in the disorder potential for electronic states, calculated using density functional theory (DFT) and DFT-based molecular dynamics simulations, are dynamically shortened in HaPs [2]. This dynamic shortening of the disorder correlation, which we attribute to the motion of A-site and, in particular, X-site ions, results in narrow band-edge energy distributions as we show explicitly. Our findings about correlations in the disorder potential due to nuclear motion is complemented by data showing considerable anharmonicity in the lattice dynamics of $CsPbBr_3$. With this, we conclude that besides showing complex nuclear dynamics, a mechanism of dynamic shortening of the disorder potential promotes a sharp optical absorption edge in HaPs.

[1] C. W. Greeff & H. R. Glyde, Phys. Rev. B 51, 1778-1783 (1995).
[2] C. Gehrmann & D. A. Egger, Nat. Commun. 10, 3141 (2019).