HL 37: Poster IV

Topics:
- Materials and devices for quantum technology
- Nitrides
- Semiconductor lasers
- Transport properties of semiconductors
- Ultra-fast phenomena

Time: Wednesday 18:00–20:30 Location: Poster F

HL 37.1 Wed 18:00 Poster F

SignalSnap and QuantumCatch: Python Libraries for Analyzing General Quantum Measurement Records — •Markus Sifft and Daniel Hägele — Ruhr Uni. Bochum, DE

Quantum measurement records exhibit diverse characteristics ranging from Gaussian noise to telegraph noise and even to clicks at random times. Traditional evaluation methods often cater to one of those noise characteristics, while general methods especially for intermediate regimes are missing. We close this gap by analyzing measurements in terms of their higher-order temporal correlations that are directly related to the Liouvillian of the measured quantum system.

This approach is made readily available by two Python libraries: SignalSnap [1] and QuantumCatch [2]. SignalSnap computes higher-order correlations of the detector output, while QuantumCatch relates them to the Liouvillian of the measured quantum system. Higher order correlations follow from the stochastic master equation covering coherent quantum dynamics, environmental damping, and measurement backaction at arbitrary measurement strength. Using SignalSnap and QuantumCatch quantum measurements were evaluated from the realms of conventional spin noise spectroscopy [3], quantum transport experiments [4], and ultra-weak measurements with stochastically arriving single photons [5,6].

[1] github.com/markussifft/signalsnap, [2] github.com/markussifft /quantumcatch, [3] Hägele PRB 98, 205143, [4] Sifft PRR 3, 033123, [5] Sifft PRA 107, 052203, [6] Sifft arXiv:2310.10464

HL 37.2 Wed 18:00 Poster F

Photoluminescence studies of erbium implanted GaAs nanostructures — •Nico Brosda[1], Christian Düputell[1], Natalie Jung[2], Lisa Kreuzer[2], Nils C. Gerhardt[2], Martin R. Hofmann[2], and Andreas D. Wieck[1] — [1]Lehrstuhl für angewandte Festkörperphysik, Ruhr-Universität-Bochum — [2]Lehrstuhl für Photonik und Terahertztechnologie, Ruhr-Universität Bochum

The rare earth element erbium emits light in the wavelength range of around 1.54 μm; this coincides with the absolute absorption minimum of optical fibres in the so-called C-band. Molecular beam epitaxial grown GaAs was used as a semiconductor matrix for erbium; the implantation was carried out with the help of a focused ion beam system at ion energies around 250 keV. Due to the damage to the crystal structure, thermal annealing is necessary. Utilizing photoluminescence (PL) measurements, statements about optimal parameters and dependencies can be made.

The recorded PL spectra at different implantation and annealing parameters were compared. A temperature range of 700 °C to 800 °C and implantation into 300 °C hot samples was particularly advantageous for maximum erbium luminescence. Furthermore, a temperature-induced quenching of erbium luminescence was observed with a simultaneous increase in peak widths. Implantation of Er_2O_3 significantly increased the total intensity. By correlating PL lines with optical transitions in different crystal field symmetries, it can be concluded that different erbium centres are present in various crystal field symmetries.

HL 37.3 Wed 18:00 Poster F

Real-Time Quantum Measurement Analysis with Polyspectra at up to 25 MHz Sampling Rates — •Armin Ghorbanietemad, Markus Sifft, and Daniel Hägele — Ruhr University Bochum, Faculty of Phyiscs adn Astronomy, Experimental Physics VI, Germany

Our research focuses on applying quantum polyspectra to analyze continuous quantum measurement records across weak, strong, and single photon regimes. We employ our Python library, SignalSnap [1], which leverages the ArrayFire library for accelerated computations using both CUDA and OpenCL backends, providing hardware flexibility. This acceleration enables us to develop a new library for real-time evaluation of measurements. To digitize the data, we utilize PicoScope, a brand of PC Oscilloscopes. By combining the capabilities of an Nvidia 4090 graphics card and PicoScope 4000 Series, we successfully implement our new library for measurements currently with 25 MHz sampling rates. Real-time evaluation of measurements provides several key advantages for experimentalists. It allows for the immediate identification and correction of obvious errors in the experiment, such as drift, misalignment, or unwanted external noise.

[1] https://github.com/MarkusSifft/SignalSnap

HL 37.4 Wed 18:00 Poster F

Semiconductor membrane transfer for circular bragg gratings fabrication — •Juan Nicolas Claro Rodriguez, Dennis Deutsch, Hermann Kahle, Klaus D Jons, and Dirk Reuter — PhoQS Institute, CeOPP, and Department of Physics, Paderborn University, Paderborn

Semiconductor quantum dots are promising candidates to fulfill the requirements on the emission properties. Newly developed InGaAs quantum dots grown on a InP substrate using MBE deposition [2] are interesting for long-distance communication as they emit in the telecom C-band, where standard optical fibers exhibit an absorption minimum. The lack of brightness can be tackled by embedding them into cavity structures, improving the indistinguishability of the photons and entanglement fidelity. Among the different cavity designs, hybrid circular Bragg gratings stand out for their high and broad-range photon collection efficiency together with their elevated Purcell factor. These characteristic features are achievable thanks to the addition of a backside mirror spaced by a transparent medium from the semiconductor membrane containing the quantum dot which allows the reflection of the backscattered photons to the collecting lens [3]. Here, we present a membrane transfer method, a crucial step for achieving the desired cavity configuration. It involves growing the backside mirror on top of the sample before transferring the layer structure onto a new carrier using a press-bonding device. Subsequently, the original InP substrate is removed by wet chemical etching with HCl to allow for posterior illumination of the quantum dots.

HL 37.5 Wed 18:00 Poster F

Towards deterministic color centers in graphene-covered hexagonal boron nitride — •Ataur Rahaman Bhuiyan, Hossein Ostovar, Robert Schmidt, Philipp Wiesener, Harry Mönig, Rudolf Bratschitsch, and Ursula Wurstbauer — University of Münster, Institute of Physics, Wilhelm-Klemm Str 10, 48149 Münster

Deterministic generation and control of single photon emitters are of importance for quantum information technology. Such single-photon emitters (SPEs) have recently been discovered in various two-dimensional materials. Their properties are strongly dependent on the host materials and differ e.g. between TMDCs or hBN but also if the emitters originate from defects, strain, or moiré-potentials in twisted structures [1]. In this work, we investigate the generation of defects in hexagonal boron nitride (hBN) covered by graphene with the vision to ion-implant color center functional at room temperature. In order to find a suitable parameter range during ion implantation, the sputtering yield in dependence on ion materials (i.e. argon and helium), acceleration voltage, target material combination, and thickness (depth profile) has been studied in details by thorough SRIM (Stopping and Range of Ions in Matter) simulations. Argon sputtering is guided by those simulations. Prior and after to sputtering the hetero stacks are characterized. In this poster we discussed the findings of our combined simulation and experimental work to implant color centers that are presumably carbon-based within couple of hBN layers [1]. [1] S. Michaelis de Vasconcellos et al. Physica status solidi b259, 2100566 (2022).

HL 37.6 Wed 18:00 Poster F

Optimization of the direct bonding process for the manufacturing of GaAs/Si template — •Micha Seidel[1], Ponraj Vijayan[1], Matthias Seibold[2], Jakob Hirlinger-Alexander[3], Michael Jetter[1], and Peter Michler[1] — [1]Universität Stuttgart, 70569 Stuttgart, Germany — [2]21S GmbH, 72654 Neckartenzlingen, Germany — [3]Universität Ulm, 89081 Ulm, Germany

Silicon photonics has gained increasing significance as it allows for high-density photonic integrated circuits (PICs). The limitation of silicon lies in its indirect band gap, leading to inefficient light sources. In contrast, III-V materials demonstrate exceptional light-emitting characteristics, making it promising to synergize the strengths of silicon and III-V materials. One way to integrate of III-V material onto silicon platform is to transfer a thin III-V membrane onto silicon through direct wafer bonding forming a III-V on silicon bonded template. The bonded template can then be used for the epitaxial regrowth of various III-V based optical structures. This integration approach overcomes the challenges of the conventional direct growth approach, such as the high-density threading dislocation and anti-phase domain which arises due to the large lattice mismatch and material polarity difference, respectively. In this contribution, we will report on the optimization of a direct bonding process for the fabrication of a GaAs/Si template. Different parameters including plasma treatment, chemical surface activation, cleaning procedure before bonding, annealing temperature after bonding, were investigated to analyze their influence on the robustness, particularly the thermal durability of the bonded template.

HL 37.7 Wed 18:00 Poster F

Deterministically fabricated wavelength-tunable quantum dot device for interfacing with atomic vapor-based quantum memory — •Avijit Barua[1], Ching-Wen Shih[1], Yuhui Yang[1], Chirag C. Palekar[1], Lucas Rickert[1], Benjamin Maass[2], Norman V. Ewald[2], Jin-Dong Song[3], Janik Wolters[2], and Stephan Reitzenstein[1] — [1]Technische Universität Berlin, Hardenbergstr. 36, Berlin, Germany — [2]German Aerospace Center (DLR), Rutherfordstr. 2, Berlin, Germany — [3]Korea Institute of Science and Technology, Seoul, Republic of Korea

Semiconductor quantum dots (QDs) are extensively investigated as single-photon sources for applications in photonic quantum technology. Here, we develop bright and strain-tunable semiconductor QD single-photon sources at the Cs-D1 transition wavelength (894.6 nm). The devices are designed and numerically optimized to maximize extraction efficiency using the finite element method. By considering circular Bragg resonators with integrated QDs and Au-backside mirror we theoretically expect a photon extraction efficiency over 90% and a Purcell factor of 0.07. In the device fabrication, we implement in-situ electron-beam lithography to integrate QDs with spatial precision as good as 20 nm to create bright single-photon sources. By means of photon autocorrelation measurements, we demonstrate single-photon purity up to 97%. Furthermore, we explore the prospects of interfacing the QD single photons with a room-temperature ladder-type atomic vapor-based memory that allows for low-noise storage and retrieval at high repetition rates.

HL 37.8 Wed 18:00 Poster F

Towards an Open-Tunable Fiber Cavity for Enhanced Directionality in Single Photon Emission — •Paul Steinmann[1], Stefan Linden[1], and Beata Kardynal[2] — [1]Physikalisches Institut, Universität Bonn, Nussallee 12, 53115 Bonn, Germany — [2]PGI-9, Forschungszentrum Jülich, Jülich, Germany

Advancements in quantum communication technologies demand the development of robust single photon sources. Indium-Arsenide quantum dots, which act akin to atomic systems, have been recognized as a bright source for single photons of high quality. These quantum dots, situated in high refractive index GaAs, typically exhibit non-directional photon emission, making their integration into optical fibers for practical applications challenging. We propose and implement an open-tunable fiber micro cavity as a solution to this challenge. Our approach involves the careful construction of a cryostat insert, ensuring mechanical stability under low-temperature conditions. This cavity enhances the rate and directionality of single photon emission, allowing for efficient photon generation and direct coupling into optical fibers. The design and construction of this fiber cavity are focused on stability and minimizing photon loss, thereby optimizing the efficiency of single photon sources for quantum technologies.

HL 37.9 Wed 18:00 Poster F

Simulation of statistical electric field fluctuations in 28-Si:P — •Finja Tadge, Nico Eggeling, Jens Hübner, and Michael Oestreich — Leibniz Universität Hannover, Germany

In this work, statistical electric field fluctuations are examined using the Monte-Carlo method to simulate the linewidth of the D^0X excitonic transition in ultra-pure isotopically enriched 28-Si:P. The electric field inside a solid-state matrix is modelled with the help of a random distribution of ionized donors and acceptors as it would occur at temperatures around 4K. Distribution functions describing both the radius between ionized donors and acceptors and the electric field can be deduced. Using the Thomas-Fermi-Approximation the electric field distribution influencing optically active centres can be calculated. Furthermore, it is shown, that the mean value of the electric field as well as its variance converge against a finite value for diverging system radii and donor ionization probabilities. The resulting electric field distribution shows an $E^{-5/2}$ dependency that is well supported by the theoretical model and is additionally in good agreement with the experimentally determined spectrum of the excitonic transition.

HL 37.10 Wed 18:00 Poster F

Characterizing broadening effects and hysteresis of donor-bound excitons in 28-Si:P — •Dolores García de Viedma[1], Nico Eggeling[1], Finja Tadge[1], N.V. Abrosimov[2], Jens Hübner[1], and Michael Oestreich[1] — [1]Leibniz Universität Hannover, Germany — [2]IKZ Berlin, Germany

Our current work emphasizes how different effects affect the broadening of excitonic transitions at phosphorous donors in ultrapure isotopically enriched 28-Si. One main contribution is given by statistical electric field fluctuations due to spontaneous ionization of donors. Another point of interest is the variation of sample temperature, resulting in a shift of the bandgap [1]. Measurements are performed by LockIn-Amplification of a transmitted probe-laser signal. Linewidth data at different temperatures and varying above bandgap excitation enable the resolution of their respective influence on the line broadening for donor-bound excitons. The results are compared to numerical and analytical calculations.

[1] Sauter, et al. Phys. Rev. Research. **5**, 013182, (2023).

HL 37.11 Wed 18:00 Poster F

Exploring locking techniques for sub-picometer-scale stabilization of open micro-cavities — •Ayesha Khan[1,2], Jonathan Noé[1,2], Michael Förg[1,2], Manuel Nutz[1,2], Sambit Mitra[1,2], and Thomas Hümmer[1,2,3] — [1]Fakultät für Physik, Ludwig-Maximilians-Universität München, Germany — [2]Qlibri GmbH, München, Germany — [3]Max-Planck-Institut für Quantenoptik, Garching, Germany

Fiber-based, open-access micro-cavities are a new technology allowing enhancement of light-matter interactions with stability at pico-meter scale. These cavities can be used for spectroscopy of nano-scale solid state systems, single photon sources, and quantum applications such as quantum computation and quantum repeaters. Reaching ultimate stability and performing controlled sweeps is only possible by implementation of active locking techniques which are needed alongside any measurement being performed. Here, we present two different side-of-fringe locking techniques: two stop band lock and higher order mode lock. These locking techniques allow complete decoupling of the locking laser and the excitation laser. The independent excitation laser then ensures that any noise induced by active locking is not translated into the measurements. These locking techniques can be implemented in measurements of solid-sate nano-systems such as quantum dots embedded in membranes to achieve Purcell enhancement for quantum technologies and high precision spectroscopy.

HL 37.12 Wed 18:00 Poster F

Quantum dot photon emitter for quantum network — •Xuelin Jin[1,2], Selma Delic[1,2], Zheng Zeng[1,2], Nils von den Driesch[1,3], Alexander Pawlis[1,3], Detlev Gruetzmacher[1,2,3], and Beata Kardynal[1,2] — [1]Peter Grünberg Institute 9, Forschungszentrum Jülich, 52425 Jülich, Germany — [2]Department of Physics, RWTH Aachen, 52074 Aachen, Germany — [3]Peter Grünberg Institute 10, Forschungszentrum Jülich, 52425 Jülich, Germany

Connecting different spin qubits using photonic qubits could facilitate building networks that would benefit from the inherent advantage of the individual subsystems. An efficient transfer of a qubit from a photon to the spin qubit requires matching of the energies and the bandwidths of the photon wave packet and the spin qubit optical transitions. While non-linear optical processes can be used for wavelength

conversion[1], there is no well-established methods of the photon bandwidth conversion. Here, we show the design of an epitaxial quantum dot device that aim to use electrostatic gates to manipulate the bandwidth of the photons emitted from InAs quantum dots to improve the match to the spin qubits realized in ions. We show that application of electrostatic fields can change the overlap of the electron and the hole wavefunctions, leading to different radiative recombination rates. We will discuss the conditions that the heterostructure has to fulfill for the device operation and will show the status of its fabrication, which has centered on optimizing the epitaxial growth of the material. [1] A. Hamer, D. Fricker, M. Hohn, P. Atkinson, M. Lepsa, S. Linden, F. Vewinger, B. Kardynal,S. Stellmer, Opti.Lett.47,1778-1781(2022)

HL 37.13 Wed 18:00 Poster F

Towards optical interfaces to spin qubits with epitaxial GaAs quantum dots — •Selma Delić[1,2], Xuelin Jin[1,2], Sebastian Kindel[2], Paola Atkinson[3], Natalia Demarina[4], Hendrik Bluhm[2], Hans-Georg Babin[5], Arne Ludwig[5], Nils von den Driesch[1,6], Alexander Pawlis[1,6], Detlev Grützmacher[1,2], and Beata Kardynał[1,2] — [1]Peter Grünberg Institut (PGI) 9, Forschungszentrum (FZ) Jülich, 52428 Jülich — [2]Department of Physics, RWTH, 52074 Aachen — [3]Institut des Nano Sciences de Paris, CNRS UMR 7588, Sorbonne Université, 75005 Paris — [4]PGI 2, FZ Jülich — [5]Lehrstuhl für angewandte Festkörperphysik, Ruhr-Universität Bochum, 44780 Bochum — [6]PGI 10, FZ Jülich

Singlet-triplet (S-T) qubits created in gate-defined quantum dots (GDQD) at the GaAs/AlGaAs interface are promising candidates in quantum information processing. Due to the absence of hole confinement, S-T qubits cannot be directly coupled coherently to photonic qubits, which can be information carriers in quantum networks. One solution to this problem is coupling a GDQD to an epitaxial QD.

In this contribution, we show the design of heterostructures to fabricate optical interfaces to spin qubits in GaAs. We present the status of the optical and electrical characteristics of heterostructure wafers and the status of the device fabrication, focusing on the progress in spatial alignment of the two types of QDs. Using atomic force microscopy imaging, we show that the alignment can be realised by identifying and locating defects on the heterostructure's surface, which originate from the growth of GaAs QDs through local droplet etching.

HL 37.14 Wed 18:00 Poster F

Characterisation of GaN/AlGaN-ISFET Wheatstone bridge pH-sensors — •Alexander Hinz[1], Stephan Figge[1], and Martin Eickhoff[1,2] — [1]Institute of Solid State Physics, University of Bremen, Otto-Hahn-Allee 1, 28359 Bremen, Germany — [2]MAPEX Center for Materials and Processes, University of Bremen, Bibliotheksstraße 1, 28359 Bremen, Germany

GaN/AlGaN-heterostructure field-effect transistors as pH-sensors were investigated. A Wheatstone bridge design is used to compensate environmental drift effects due to temperature and persistent photocurrent. In that line sputtered Al2O3 is used as a passivation layer for the reference transistors. In addition, the integration of an on-chip Pt counter electrode will be discussed. Furthermore, the impact of a a GaN cap compared to an AlGaN will be analysed. The stability and the evolution of the pH sensitivity with time were investigated.

HL 37.15 Wed 18:00 Poster F

Impact of stress current on electro-optical properties of the active cavity region in 850 nm oxide-confined vertical-cavity surface-emitting lasers (VCSEL) — •Arndt Jaeger[1], Nikolay Ledentsov Jr.[2], Helmut Meinert[1], Sebastian Haberkern[1], Kevin Ehling[1], Maximilian Stock[1], Ilya E. Titkov[2], Oleg Yu. Makarov[2], and Nikolay N. Ledentsov[2] — [1]Esslingen University of Applied Sciences, Flandernstrasse 101, 73732 Esslingen, Germany — [2]VI Systems GmbH, Hardenbergstrasse 7, 10623 Berlin, Germany

VCSELs are used as efficient light sources for high-speed datacom, sensor and free-space applications. Optimization of the device performance includes an understanding of their degradation behavior under high current stress. VCSELs employing different doping of the cavity region are studied utilizing reverse current-voltage (IV) characteristics as well as photocurrent spectroscopy (PCS). Reverse IV characteristics exhibits avalanche breakdown enabling an estimation of the electric field in the cavity region. PCS reveals quantum well transitions redshifting with reverse bias due to quantum-confined Stark effect. Whereas VCSELs with a controlled doping do not show any changes VCSELs without doping of the cavity region exhibit reduced breakdown voltages being accompanied by operation-induced redshifts of quantum well transitions. These results are discussed in terms of different processes occurring during high current operation.

HL 37.16 Wed 18:00 Poster F

High-β lasing in photonic-defect semiconductor-dielectric hybrid microresonators with embedded InGaAs quantum dots — •Kartik Gaur, Ching-Wen Shih, Imad Limame, Aris Koulas-Simos, Niels Heermeier, Chirag Palekar, Sarthak Tripathi, Sven Rodt, and Stephan Reitzenstein — Institut für Festkörperphysik, Technische Universität Berlin, D-10623 Berlin

InGaAs quantum dots embedded in microcavities based on highly reflective distributed Bragg reflectors (DBRs) allow for the development of high Q-factor, low mode volume microcavities that feature high light-matter interaction. However, epitaxially grown DBRs consisting of GaAs/AlAs layers suffer from relatively low refractive index contrast, and often high absorption of the laser light upon optical pumping. Here, we propose an easy-to-fabricate microcavity design to produce optically pumped high-β quantum dot microlasers. Our cavity concept is based on a buried photonic defect for tight lateral mode confinement in a quasi-planar microcavity system, which includes an upper dielectric DBR as a promising alternative to conventional III-V semiconductor DBRs. The cavities show distinct emission features with a characteristic photonic defect size-dependent mode separation and Q-factors up to 17000. Comprehensive investigations further reveal lasing operation with a systematic increase (decrease) of the β-factor (threshold pump power) with the number of mirror pairs in the upper dielectric DBR. Notably, due to the quasi-planar device geometry, the microlasers show high temperature stability.

HL 37.17 Wed 18:00 Poster F

Optical tuning of Perylene-hybridized nanowire lasers — •Leon Kross, Edwin Eobaldt, Jakob Wurschi, Aurelia Eberhard, Marco Grünewald, Daniel Costabel, Kalina Peneva, and Carsten Ronning — Friedrich-Schiller-Universität, Jena, Germany

Over the past decade, the exploration of the laser properties has been a focal point in semiconductor nanowire research. With the spectral and temporal characteristics well-established to date, the next step involves advancing towards their application as nano-scale coherent light sources by deliberately manipulating these properties. In this regard, the hybridization of nanowires with customized molecules might offer new knobs through efficient charge and energy transfer processes at the heterointerface. As a proof of concept, ZnO nanowires were hybridized with perylene-based dye molecules as they provide an extraordinary chemical and optical stability, and, especially, the advantage to easily tune their optical gap over a wide spectral range by chemical functionalization. In this study, we carried out comparative micro-photoluminescence measurements to examine the influence of the molecules on the nanowire lasing properties. In particular, we show how different chemical functionalization and the applied amount of dyes play a significant role for a wavelength tuning of the nanowire, which paves the way towards a highly controllable emission by tailoring the chemical structure of the dyes.

HL 37.18 Wed 18:00 Poster F

Monolithic 850 nm VCSEL Array for QKD via the decoy state protocol — •Katharina Dahler, Michael Zimmer, 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.

The need for secure data communication has increased in recent years. In contrast to classical key distribution, the use of quantum key distribution (QKD) offers fundamental advantages, such as complete secrecy. However, QKD poses numerous challenges with regard to the use of single photons. With this in mind, the decoy-state protocol offers the possibility of realizing QKD with classical light sources such as attenuated semiconductor lasers.

Here, we present the electro-optical characterization of an array of eight VCSELs emitting at 850 nm, capable to be used in a faint pulse source enabling QKD via the BB84 and decoy state protocol. The VCSEL structure was fabricated on a 4-inch GaAs wafer using metal-organic vapor-phase epitaxy (MOVPE), and the VCSELs are arranged in a coplanar contact design. Polarization control of the laser emission is achieved by monolithically integrated surface gratings in the light opening window of the VCSELs. Structures with surface grating reliefs were fabricated for additional modal control. The electro-optical device characteristics as well as a detailed investigation of the polarization states of the VCSELs realized with the aforementioned surface gratings are presented.

HL 37.19 Wed 18:00 Poster F

Ultrafast Femtosecond Laser Induced Dynamics of Black Silicon — •Christelle Ines Kana Mebou[1], Tobias Zier[2], and Martin. E. Garcia[1] — [1]Institut für Physik, Universität Kassel, Germany — [2]Department of Physics, University of California Merced

Modern materials science has made manipulating material properties at the nanoscale a major focus. Due to its potential to enable novel applications in optoelectronics, photonics, and nanotechnology, the interaction of strong femtosecond laser pulses with black silicon has drawn a lot of attention. In this theoretical investigation, we investigate the dynamical and structural alterations brought about by the laser irradiation as we examine the motion of Silicon doped with Sulfur under a femtosecond laser pulse. We use a variety of methods to clarify how varied sulphur atom concentrations affect the behaviour of the material. Starting from initially randomly distributed S atoms, we simulated the ultrashort time dynamics of the system after laser heating. This research sheds light on the intricate relationship between laser-induced dynamics and dopant concentration, providing a conceptual framework that may be used to direct the development of future optoelectronic devices.

HL 37.20 Wed 18:00 Poster F

MOVPE grown InGaAs/GaAs quantum dots as gain medium in semiconductor lasers for the telecom O-band — •Philipp Noack, Nathalie Benzler, Michael Jetter, and Peter Michler — Institut für Halbleiteroptik und Funktionelle Grenzflächen, Universität Stuttgart

Conventional quantum well gain media are essentially used in every commonly available laser diodes. These devices are easy to produce and are cheap in mass production. However, there are wavelength ranges, that can not be covered by quantum well gain media, due to the constraints in lattice-matched substrates and materials. Semiconductor quantum dots (QDs) as gain media are able to reach these wavelength ranges, while also providing lower threshold currents, higher temperature stability and fast gain recovery times.

To reach emission in the telecom O-band, we grow InGaAs QDs on a GaAs substrate. We achieve growth of uniform high density quantum dots in single and in up to ten vertically stacked layers by carefully controlling a variety of growth parameters, like temperature, V/III ratio and the stabilization of the surface during growth.

These quantum dot layers are incorporated into edge emitting lasers to investigate the performance as well as the temperature stability of these devices. In this way we can make sure, that vertically stacked quantum dot layers increase the modal gain without introducing defects that increase the intrinsic optical losses.

HL 37.21 Wed 18:00 Poster F

Towards novel red-emitting VECSELs with a grating waveguide structure — •Peter Gierss[1], Ana Ćutuk[1], Maxim Leyzner[2], Uwe Brauch[2], Marwan Abdou Ahmed[2], Michael Jetter[1], Thomas Graf[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, Allmandring 3, 70569 Stuttgart — [2]Institut für Strahlwerkzeuge, University of Stuttgart, Pfaffenwaldring 43, 70569 Stuttgart

Classical vertical external-cavity surface-emitting lasers (VECSELs) offer favorable properties in comparison to other laser systems like e.g. near-diffraction limited beam profiles, high possible output powers and due to their external cavity, the possibility to integrate further optical elements into the cavity. Limitations arise due to the incorporation of a thick distributed Bragg reflector (DBR), which restricts the available laser wavelength and also possesses poor thermal properties.

A new design for a VECSEL is based on the use of a grating-waveguide structure (GWS) over the active region. In combination with a low-refractive-index heat spreader, the leaky guided-mode resonances of the GWS lead to a broadband high reflectivity of the device, which is required for efficient laser operation.

In this contribution we present our recent progress in the development and fabrication of this device.

HL 37.22 Wed 18:00 Poster F

In-plane coupling between a WGM micro-ring and a ridge waveguide — •Léo J. Roche[1], Yuhui Yang[1], Fridtjof Betz[2], Ching-Wen Shih[1], Aris Koulas-Simos[1], Sven Burger[2], and Stephan Reitzenstein[1] — [1]Institut für Festkörperphysik (TUB), Berlin, Germany — [2]Zuse Institute Berlin, Berlin, Germany

Integrated quantum photonic circuits (IQPCs) are very promising candidates for scalable and flexible on-chip quantum computation and quantum communication hardware. One critical requirement for their realization is the scalable integration of on-demand indistinguishable single-photon emitters. This is potentially possible through the resonant excitation of an integrated QD in a waveguide by means of an on-chip integrated coherent light microlaser. Towards this goal, we investigate the coupling and lasing properties of coherent light laterally emitted from a whispering gallery mode (WGM) type micro-ring resonator evanescently coupled to a single mode ridge waveguide. Using finite element method (FEM) simulations, we investigate the optimal geometrical parameters maximising the coupling efficiency between the two structures. The III-V semiconductor type nanostructures composed of a GaAs cavity with InGaAs QDs, on top of a SiO2 layer are processed using high-resolution electron beam lithography. Various geometries of the micro-ring coupled to waveguide with grating outcoupler are processed and subsequently investigated via micro-photoluminescence spectroscopy to provide a systematic study.

HL 37.23 Wed 18:00 Poster F

Optically pumped micropillar lasers at room temperature for gas sensing around 960 nm — •Floriana Laudani, Sarthak Tripathi, Kartik Gaur, Aris Koulas-Simos, Sven Rodt, and Stephan Reitzenstein — Institute of Solid State Physics, Technische Universität Berlin, 10623 Berlin, Germany

Quantitative water vapor measurements are essential for industrial applications to ensure a qualitative processing and control chain and require gas sensors with short response times and narrow spectral bandwith in a broad wavelength range. In contrast to conventional edge-emitting lasers, compact surface-emitting lasers offer a cost-effective alternative, usable in a variety of gas-sensing systems, with respect to the emission wavelength.

We report on room temperature operation of optically pumped GaAs micropillar lasers with a set of $In_{0.33}Ga_{0.67}As$ quantum dot (QDs) layers as active gain medium embedded in an $Al_{0.2}Ga_{0.8}As/Al_{0.9}Ga_{0.1}As$ distributed Bragg reflector (DBR) microcavity structure, emitting at a target wavelength of around 960 nm. The fabrication process is based on high-resolution electron-beam lithography with subsequent suitable development steps. The micropillars are made by etching in an Inductively Coupled Plasma RIE (ICP-RIE) chamber using a $CL_2/BCL_3/Ar$ atmosphere.

HL 37.24 Wed 18:00 Poster F

Electrical and Magnetotransport of the correlated metal $CaVO_3$ — •Mahni Müller[1], Maria Espinosa[1], Tatiana Kuznetsova[2], Roman Engel-Herbert[2,3], and Saskia F. Fischer[1,4] — [1]Novel Materials Group, Humboldt Universität Berlin, 12489 Berlin, Germany — [2]Department of Materials Science and Engineering, The Pennsylvania State University, University Park, PA 16802, USA. — [3]Paul-Drude-Institut für Festkörperelektronik, 10117 Berlin, Germany — [4]Center of the Science of Materials Berlin, 12489 Berlin, Germany

High-performance and cost-effective transparent conductive materials are in great demand in the optoelectronic industry. Correlated metals offer an alternative strategy to design a material with both high-optical transparency and high-electrical conductivity. In order to test this, the transport phenomena in these materials must be studied [1].

We have recently studied the electric transport characteristics of thin $CaVO_3$ films, which exceeded a residual-resistivity ratio RRR of 90 [2]. In this work, we study the temperature-dependent resistivity, Hall- and magneto-resistance between 4.2 K and 300 K. Films with high RRR showed increasingly nonlinear Hall resistivities and linear magnetoresistance below 40 K. Deviations from the Fermi liquid T^2 dependence of the resistivity were also observed. These deviations are discussed together with a multi-carrier model and the influence of the complex Fermi surface of $CaVO_3$ on the transport properties.

[1] Zhang, Lei, *et al.*; Nature materials **15.2**, 204-210 (2016).
[2] Tatiana Kuznetsova, *et al.*; APL Mater. ; **11 (4)**: 041120 (2023).

HL 37.25 Wed 18:00 Poster F

Electronic band structure and thermoelectric properties of ternary SnSxSe2-x (x = 0,1,2) — Aliakbar Ghafari[1,2] and •Christoph Janowitz[3] — [1]Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Hahn-Meitner-Platz 1, 14109 Berlin, Germany — [2]Department of Inorganic Chemistry, Fritz-Haber-Institut der Max-Planck-Gesellschaft, Faradayweg 4-6, 14195 Berlin, Germany — [3]Humboldt Universität, Institut für Physik, Newtonstr. 15, 12489 Berlin, Germany

We present a theoretical investigation of the electronic structure of layered metal dichalcogenides ternary SnSxSe2-x, with x = 0, 1, and 2. (A. Ghafari, C. Janowitz, Materialstoday Comm. 38, 107483, (2024)). Calculations involved density functional theory (DFT), density functional perturbation theory (DFPT), and Boltzmann transport theory. It has been found that adding Sulfur to the structure leads to an increase in i) direct and indirect band gaps, ii) the Seebeck coefficient iii) the acoustic and optical branches iv) the power factor and v) the lattice thermal conductivity. The thermoelectric properties are studied from the first principle for the whole series of compositions at the highest achievable n- and p-doping levels.

HL 37.26 Wed 18:00 Poster F

Tuning the optical properties and transient dynamics of antimony through external fields — •Joel Billermann, Sebastian Walfort, Niklas Vollmar, and Martin Salinga — University of Münster, Institute of Materials Physics, Wilhelm-Klemm-Straße 10, 48149 Münster, Germany

The crystal structure of antimony is characterized by a Peierls distortion motif resulting from a subtle energy balance between the electronic and atomic subsystems [1]. Perturbing this energy balance through the impulsive excitation of a small fraction of valence electrons leads to large structural changes towards a more symmetric phase and the displacive excitation of coherent phonons [2]. The system then decays back to the distorted structure within picoseconds. In our present study, we explore schemes to permanently shift the potential energy landscape of antimony towards the symmetric phase by applying external electric and strain fields. We use steady-state- and femtosecond pump-probe spectroscopy to elucidate the influence of structural distortion on both the optical properties and the ultrafast photoinduced dynamics of antimony, e.g. the coupling of the electron system to the lattice.

[1] U. Argaman et al., J Phys Condens Matter 31, 465501 (2019)
[2] H. J. Zeiger et al., Phys. Rev. B 45, 768 (1992)

HL 37.27 Wed 18:00 Poster F

Tailored sample designs for ultrafast electron diffraction at high repetition rates — •Leonardo C. da Camara Silva[1,2], Till Domroese[1,2], and Claus Ropers[1,2] — [1]4th Physical Institute, University of Göttingen, Germany — [2]Max Planck Institute for Multidiscipinary Sciences, Göttingen, Germany

Ultrafast electron diffraction (UED) is a powerful technique to resolve structural dynamics in strongly-correlated materials on ultrafast timescales [1]. For these experiments, the high-coherence electron source of the Göttingen Ultrafast Transmission Electron Microscope (UTEM) [2] enables the formation of particularly narrow but highly collimated femtosecond electron pulses. The nanometric beam diameters give access to nanoscale heterogeneity that often decisively influences the dynamics [3]. Highest spatiotemporal resolution, however, is only achieved for low bunch charges, mitigating Coulomb-induced pulse broadening, such that diffraction signal critically depends on the available duty cycle of the experiment. Here, we characterize different sample designs tailored to confine the laser excitation volume and to efficiently dissipate the thermal load. This allows us to drastically enhance the available repetition rates in our UED measurements, investigating structural phase transitions in the charge-density wave material $1T$-$TaTe_2$ at rates up to 2 MHz.

[1] D. Filippetto et al., Rev. Mod. Phys. **94**, 045004 (2022)
[2] A. Feist et al., Ultramicroscopy **176**, 63-73 (2017)
[3] T. Domröse et al., Nat. Mater. **22**, 1345-1351 (2023)

HL 37.28 Wed 18:00 Poster F

Probing the ultrafast dynamics of photonic devices based on phase change materials — •Nils Weber, Sebastian Walfort, Niklas Vollmar, and Martin Salinga — University of Münster, Institute of Materials Physics, Wilhelm-Klemm-Str. 10, 48149 Münster

Phase change materials (PCMs) are compounds typically composed of germanium, tellurium and antimony. They are characterized by a strong contrast in electrical and optical properties between crystalline and glassy states. Combined with the ability to switch rapidly between crystal and glass, this contrast makes them an interesting material system for non-volatile memory elements in electronic and photonic circuits. By using photons instead of electrons as signal carriers, photonic circuits are free from the bandwidth constraints associated with electrical circuits and are therefore sensitive to material dynamics on picosecond timescales. The implications and potential new applications of operating the PCM-based memory elements at these bandwidths remain largely unexplored. Here we present the design and implementation of an experimental setup capable of resolving the ultrafast response of photonic devices. Our approach combines an amplified femtosecond free-space laser with fiber coupled ultrafast light sources in a setup with sufficient spatial resolution to address individual microscopic devices. We show first experimental results together with finite element simulations of the transient response of PCM-based optical weights as used in photonic integrated circuits for in-memory computing.

HL 37.29 Wed 18:00 Poster F

Measurement of ultrashort electron pulse durations using a transient electric field — •Lukas Nöding, Arne Ungeheuer, Ahmed Hassanien, Mashood Tariq Mir, Thomas Baumert, and Arne Senftleben — University of Kassel, Institute of Physics, Kassel, Germany

Ultrafast electron diffraction is a well-known method for conducting time-resolved measurements on molecules and condensed matter. In this approach, electron diffraction is performed with an electron pulse at a variable time after optical excitation of the sample. The duration of the electron pulse directly determines the temporal resolution. A streaking setup utilizing free electrons is implemented to measure the duration of the electron pulse. Therefore, a transient electron deflector, was designed. Its main feature is a metal surface parallel to the path of the electron pulse. A femtosecond laser pulse is focused from the side onto this metal surface. As the beam incides, electrons are released from the metal. Due to their momentum, they separate from the surface, create an electric field perpendicular to the surface and then recombine. The build-up and the subsequent fading of this transient electric field is used to streak the electron pulse, because different electrons in the pulse experience different field strengths. By that, the duration of the pulse is mapped into a spatial broadening of the pulse. The broadening is captured by the detector as a streak. We will show results measured with different numbers of electrons per pulse and compare them with simulations. Moreover, the evaluation process and the fitting algorithms for the electron streak will be explained.