HL 26: Poster II

Time: Wednesday 9:30–11:30 Location: P1

HL 26.1 Wed 9:30 P1

Quantum Dots in Nonlinear Mechanical Resonators — •Jona Richter, Noah Spitzner, Emeline Nysten, Matthias Weiss, and Hubert Krenner — Universität Münster, Münster, Germany

Surface acoustic waves are employed in a broad range of technologies, including radio-frequency filters in wireless communication systems and life-science applications. In the presented work, SAWs are utilized to drive mechanical modes in a quantum-dot membrane patterned into rings on a lithium niobate substrate. Generation of the SAWs is achieved by fabricating a comb-shaped interdigital transducer on the substrate. When an RF signal is applied, the piezoelectric response of the lithium niobate converts the electrical excitation into coherent acoustic waves propagating on the surface of the substrate. The propagating SAW induces a periodic modulation of the QD lattice constant, resulting in a corresponding modulation of the emission energy at the driving frequency. This mechanism enables the use of individual QDs as point-like nanoscale sensors, which can be probed through photoluminescence spectroscopy using ultrafast optical detection. When sweeping the RF frequency over a range of 200-900 MHz, pronounced resonances in the emission-energy modulation are observed, but only for QDs located within the ring structures. Both time-integrated as well as time-resolved measurements exhibit clear signatures of nonlinear mechanical behavior for example a hysteresis.

HL 26.2 Wed 9:30 P1

Gallium Nitride arrays for proton imaging — •Nico Frédéric Brosda[1], Matilde Siviero[2], Maxime Hugues[2], Stéphane Higueret[3], Nicolas Arbor[3], Andreas Wieck[1], and Jean-Yves Duboz[2] — [1]Ruhr University Bochum, Faculty of Physics and Astronomy, Experimental Physics VI, D-44780 Bochum, Germany — [2]Université Côte d'Azur, CNRS, CRHEA, 06560, Valbonne, France — [3]Université de Strasbourg, CNRS, IPHC UMR 7178, F-67000 Strasbourg, France

The MATRIX project is advancing proton therapy for cancer treatment by developing novel, highly durable detectors designed to improve real-time control of irradiation doses. Proton detection is performed by measuring the charge generated within the active regions of PIN GaN diodes. These GaN-based devices are fabricated as linear arrays containing 128 diode elements, as well as two-dimensional imaging arrays with up to 11×11 elements, covering an area of 1 cm^2 and achieving spatial resolutions of up to 500 μm. Owing to microelectronic fabrication techniques, even higher resolutions can be realized when required. The spatial performance of these detectors was validated through proton radiography of test objects using a 24 MeV beam, benchmarked against non-pixelated Gafchromic film. Measurements with phantoms of varying thickness further demonstrated the detector's capability for energy-resolved proton imaging. With achieved frame times of 1 ms, the MATRIX detector also provides a first proof of concept for real-time proton beam monitoring.

HL 26.3 Wed 9:30 P1

Impact of Ge-doping on the photoelectrochemical response of cubic (Ga,In)N photoelectrodes — •Sundas Hamid[1,2], Marius Wasem[1,2], Mario F. Zscherp[1,2], Silas A. Jentsch[1,2], Jörg Schörmann[1,2], Sangam Chatterjee[1,2], and Matthias T. Elm[1,2] — [1]Center for Materials Research, Heinrich-Buff-Ring 16, 35392 Giessen — [2]Institute of Experimental Physics I, Heinrich-Buff-Ring 16, 35392 Giessen

(Ga,In)N is a promising electrode material for electrochemical water splitting as the amount of indium determines the band gap of the semiconductor alloy. In this study we focus on the influence of germanium doping on the photoelectrochemical response of cubic (In,Ga)N photoanodes, which were grown by molecular beam epitaxy (MBE). Different methods like open circuit potential, cyclic voltammetry and electrochemical impedance spectroscopy were used to analyse charge carrier transport and the properties of the electrode electrolyte interface, such as flat band potential. The non-intentionally doped samples show a high photocurrent, indicating less recombination and efficient charge separation, while doping decreases the photoelectrochemical response. Despite the lower photocurrent, the doped samples show higher electrochemical stability displaying structural strength and chemical resistance at the interface. The results show that a trade-off between stability and activity needs to be achieved by controlling doping and indium concentration to develop durable and efficient III-nitride photoanodes for solar water splitting.

HL 26.4 Wed 9:30 P1

First Principle Calculations of Scandium-Aluminium-Nitrides — Max Grossmann, Malte Grunert, and •Wichard Beenken — Technische Universität Ilmenau, Institut für Physik, Theoretische Physik I, Ilmenau, Germany

We have calculated the crystal structures and optical spectra of $Sc_xAl_{1-x}N$ compounds in trigonal/hexagonal and tetragonal/cubic lattices. For increasing Scandium content, we could confirm the experimentally found first order phase transition from Wurtzit to Rock-Salt structure. Furthermore we found a second order phase transition to the theoretically predicted metastable hexagonal-MgO-structure. Thereby, we studied various possible superstructures for rational Scandium to Aluminium proportions in detail. Using LDA, *GW*, and BSE methods, we calculated band structures and optical dielectric functions for selected $Sc_xAl_{1-x}N$ compounds with high precision.

HL 26.5 Wed 9:30 P1

Tracing Charge Carrier Transport in Freestanding Core-Shell GaN Nanowires on n-Si(111) Substrates — •Juliane Koch[1], Patrick Häuser[2], Peter Kleinschmidt[1], Lisa Liborius[2], Nils Weimann[2], and Thomas Hannappel[1] — [1]Technische Universität Ilmenau, Fundamentals of Energy Materials, Ilmenau, Germany — [2]University of Duisburg-Essen, Components for High Frequency Electronics (BHE) and CENIDE, Duisburg, Germany

Precisely engineered heterojunctions are essential for advancing nanoscale systems with superior electrical performance. The structure and electrical behavior of nanostructured devices must be examined with high spatial resolution. This study investigates the charge carrier transport in freestanding core-shell GaN nanowires (NW) grown via polarity- and site-controlled metal-organic vapor phase epitaxy with a site-dependent AlN interlayer on pre-structured n-type Si(111) substrates. Multi-tip scanning tunnelling microscopy and electron beam-induced current mapping were utilized to probe local transport phenomena with high precision. Transport pathways of charge carriers within the NWs and across key interfaces were resolved. Distinct I-V characteristics appeared for different facets, while scanning transmission electron microscopy revealed no direct shell-core contact. Consequently, current transport is governed by three serially connected diodes: shell-shell, shell-core, and NW-substrate junctions. These results reveal mechanisms shaped by geometry and interfaces, advancing understanding of charge carrier dynamics in III-N nanostructures.

HL 26.6 Wed 9:30 P1

Optical loss characterization in UV multimode AlGaN waveguides with and without a backside absorbing layer — •leonardo wildenburg[1], verena kowallik[1], tim wernicke[1], and michael kneissl[1,2] — [1]Technische Universität Berlin, Berlin, Germany — [2]Ferdinand-Braun-Institut (FBH), Berlin, Germany

Photonic integrated circuits (PICs) in the UV range enable complex optical functions on a chip-scale platform, e.g. for the detection of gases and biomolecules by absorption or Raman spectroscopy. The implementation of UV PICs requires wide-bandgap materials to ensure optical transparency. Among the available material systems, one promising candidate is AlGaN due to its application in UV-LEDs and laser diodes. In this work, the optical losses near 265 nm of n-$Al_{0.76}Ga_{0.24}N$ waveguides with a width of 200 μm are investigated using a monolithically integrated UV-LED and UV-photodetector. The influence of straylight from the substrate backside was investigated with and without an absorbing 200 nm thin SiN layer. When operating the LEDs at a constant output power of 0.2 mW, the photocurrent decreases exponentially with increasing waveguide length according to Beer-Lambert-law. The reduction of scattered light was confirmed by measurements of photodetectors of the same wafer, but not connected to the emitting LED by a waveguide. Thus, optical losses of (40 ± 5) cm^{-1} with an absorbing layer and (33 ± 5) cm^{-1} without were measured for the n-$Al_{0.76}Ga_{0.24}N$ waveguides. It was also determined that the optical losses strongly depend on the amount of scattered light from the UV-LED signal.

HL 26.7 Wed 9:30 P1

Optimization of etching processes for quantum well structures to enhance IR emission — •Daniel Janzen[1], Peter Zajac[1], Sascha R. Valentin[2], Arne Ludwig[1], and Andreas D. Wieck[1] — [1]Ruhr-Universität Bochum, Bochum, Germany — [2]Gesellschaft für Gerätebau mbH, Klönnestr. 99, 44143 Dortmund

The precise control of etching processes is crucial for the properties of quantum well structures, especially in terms of IR emitter efficiency. This study examines how different etching techniques affect surface quality, defect formation, and electrical properties of the epitaxially grown GaSb layers. A critical aspect is the formation of oxides and metallic antimony, which can lead to leakage currents and short circuits. Through Atomic Force Microscopy (AFM) the influence of etching parameters are investigated. Reducing defect states and optimizing material passivation could contribute to the long-term improvement of emission efficiency. This research bridges materials science and semiconductor physics by discussing strategies to optimize surface states for IR emitters. The findings are relevant not only for quantum optics but also for sensor applications and industrial semiconductor fabrication.

HL 26.8 Wed 9:30 P1

Hydrogen Annealing of Silicon Micro- and Nanostructures through Rapid Thermal Processing — •Kyra Malcherek, Thomas Grap, and Markus Kaiser — Helmholtz Nano Facility, Forschungszentrum Jülich, Germany

As semiconductor devices continue to scale into the lower nanometer range, achieving smooth surfaces becomes increasingly important for device performance. In particular, silicon nanowires used in Gate-All-Around Metal-Oxide-Semiconductor Field-Effect Transistors (GAA-MOSFETs) require these characteristics to ensure uniform electrostatic control over the channel. Therefore, Hydrogen Annealing of silicon is a promising process to enable shape transformation and surface smoothing.

In this study, we characterized the effects of Hydrogen Annealing. Silicon microstructures showed a significant reduction in surface roughness and rounded corners after the process. In addition, stable crystal facets were formed and identified as (111) and (113) planes. The influence of the relevant process parameters - temperature, annealing time, hydrogen flow and pressure - were investigated. The radius of curvature increases with both temperature and annealing time, whereas hydrogen flow and pressure show no significant influence.

The process was further applied to silicon-on-insulator nanostructures, creating free-floating silicon nanowires after oxide etching. Subsequent hydrogen annealing effectively smoothed and rounded the structures, demonstrating its potential for the fabrication of GAA-MOSFETs.

HL 26.9 Wed 9:30 P1

Processing and Characterization of Mid Infrared Emitters from III-V Epitaxy — •Peter Zajac[1], Sascha R. Valentin[1], Timo A. Kurschat[1], Rainer Krage[1], Arne Ludwig[2], and Andreas D. Wieck[3] — [1]Gesellschaft für Gerätebau mbH, Klönnestr. 99, 44143 Dortmund, Germany — [2]Arbeitsbereich Epitaxie, Experimentalphysik VI, Ruhr-Universität Bochum, 44801 Bochum, Germany — [3]ehem. Lehrstuhl für Angewandte Festköperphysik, Ruhr-Universität Bochum, 44801 Bochum, Germany

A layer structure optimized for mid-infrared emission, containing W-type quantum wells has been realized with III-V epitaxy on GaSb. The processing workflow presented here, from the MBE-grown wafer sample to an emitting device, includes mesa etching, photolithography and electrical contacting. The contribution outlines the challenges faced in progressing towards the first prototype, including the optimization of the wet-etching process with respect to the observed trench formation and surface roughness. The electrical characterization includes contact resistance and I-V measurements. Electroluminescence spectroscopy is performed for optical characterization.

HL 26.10 Wed 9:30 P1

GaAs nanowire networks by electrochemical etching as a universal platform for oxide and nitride architectures — •Eduard Monaico[1], Sebastian Lehmann[2], Elena Monaico[1], Xinzhi Li[2], Veaceslav Ursaki[1], Ion Tiginyanu[1], and Kornelius Nielsch[2] — [1]Technical University of Moldova, Chisinau, Moldova — [2]Leibniz Institute of Solid State and Materials Research, Dresden, Germany

GaAs nanowire networks obtained by electrochemical etching provide a versatile platform for semiconductor-oxide-nitride architectures with controlled geometry and crystallinity. Depending on the orientation of the GaAs substrate ((100), (111)B, (001)), the resulting nanowires can be tilted, vertical, or oriented parallel to the surface. Formed by selective electrochemical dissolution rather than epitaxial growth, they retain the structural quality of the bulk crystal, offering a low-defect scaffold suitable for subsequent transformations.

In this work, we explore their conversion into oxides and nitrides. Thermal treatment in argon with 3% oxygen led to selective formation of Ga2O3 on the nanowires while preserving the GaAs substrate, confirmed by SEM, EDX, XRD, and Raman analysis. Preliminary nitridation tests also show the feasibility of forming GaN-based architectures. These findings highlight the potential of electrochemically derived GaAs nanowire networks as a universal platform for oxide and nitride structures relevant to optoelectronics, photonics, and sensing technologies.

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HL 26.11 Wed 9:30 P1

Influence of AlInP(100) Surface Reconstruction on TiO_2/III–V Interface Chemistry and Band Alignment — Mohammad Amin Zare Pour[1,2], Christian Höhn[3], Negin Mogharehabed[1], Roel van de Krol[3], Thomas Hannappel[2], and •Agnieszka Paszuk[1] — [1]BMFTR Junior Research Group PARASOL, Technische Universität Ilmenau, Germany — [2]Fundamentals of Energy Materials, Technische Universität Ilmenau, Germany — [3]Institute for Solar Fuels, Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Germany

TiO_2/III–V heterointerfaces are crucial for photoelectrochemical devices, as their chemistry and band alignment govern photogenerated charge-carrier transfer. The TiO_2/InP(100) heterointerface was recently studied using XPS/UPS and *ab initio* molecular dynamics simulations [Adv. Funct. Mater. 2025, 2506105]. ALD-grown TiO_2 on phosphorus-terminated (P-rich) InP(100) shows strong interface-induced band bending, $InPO_x$ formation related to the P-rich surface, and Cl incorporation from $TiCl_4$, reflecting precursor-dependent chemistry. Here, we relate these findings to AlInP(100) surfaces prepared with either P-rich or indium-rich termination, as well as with a thin oxide layer. By comparing oxide states and valence-band positions with those of InP, we analyze how surface reconstruction governs the formation and energetic alignment of TiO_2/III–V heterointerfaces. These insights highlight how AlInP surface preparation controls the formation and electronic structure of TiO_2/III–V interfaces.

HL 26.12 Wed 9:30 P1

Measuring the Temperature Distribution of GaSb Wafers during MBE Growth — •Timo A. Kurschat[1], Sascha R. Valentin[1], Peter Zajac[1], Rainer Krage[1], Arne Ludwig[2], and Andreas D. Wieck[3] — [1]Gesellschaft für Gerätebau mbH, Klönnestr. 99, 44143 Dortmund — [2]Arbeitsbereich Epitaxie, Experimentalphysik VI, Ruhr-Universität Bochum, 44801 Bochum — [3]ehem. Lehrstuhl für Angewandte Festkörperphysik, Ruhr-Universität Bochum, 44801 Bochum

During epitaxial growth the substrate temperature is one of the essential parameters. To obtain high-resolution temperature maps we use a single-lens reflex (SLR) camera with the infrared filter removed. The sensor is sensitive up to a wavelength of about 1 μm and can therefore be used as a pyrometer. With wafer rotation disabled, temperatures down to $T_S = 400\,^\circ$C can be measured. With rotation and a reduced exposure time of 0.25 s images can still be obtained at the growth temperature of $T_S = 680\,^\circ$C.

To optimize the temperature distribution, so called washers are used during growth that cover parts of the wafer. With the original washers, the center of our quarter 2" wafers is more than 20 K hotter than the corners. Without a washer the profile inverts. Therefore we designed a new washer which greatly improves the homogeneity.

On the other hand an inhomogeneous temperature profile can be used to optimize growth parameters, which we show with photoluminescence measurements of quantum wells and atomic force microscope images.

HL 26.13 Wed 9:30 P1

Impact of Al containing nucleation layers on Si(100)/GaP heterointerface — •Kai Daniel Hanke[1], Angieszka Paszuk[1,2], Peter Kleinschmidt[1], and Thomas Hannappel[1] — [1]Technische Universität Ilmenau, Fundamentals of Energy Materials, Ilmenau, Germany — [2]Technische Universität Ilmenau, BMFTR Junior Research

Group PARASOL, Ilmenau, Germany

Monolithically grown III-V-on-silicon (100) tandem solar cells show great promise for applications such as direct solar water splitting. A critical interface in these devices is the Si/GaP heterointerface, at which defects originate and subsequently propagate through the entire III-V epitaxial stack. Minimizing defect formation at this initial interface is therefore essential for achieving high-efficiency water-splitting performance. The use of TMAl during the pulsed nucleation of the GaP layer has previously been shown to lower defect densities, particularly stacking faults, stacking-fault pyramids (SF/SFP), and threading dislocations (TDs). In this study, we investigate the effect of TMAl on the formation of SF/SFP and on the density of TDs. We further analyze how TMAl modifies the interfacial energetic band alignment using X-ray photoelectron spectroscopy, and study its impact on surface anisotropy and interface-related optical transitions by low-temperature reflection anisotropy spectroscopy. Defect densities are quantified by electron channeling contrast imaging, a scanning electron microscopy technique that exploits electron channeling at an acceleration voltage of 30 kV.

HL 26.14 Wed 9:30 P1

Enhanced Field Emission Current Density in Chemically Engineered Multiwall Carbon Nanotube Neodymium Oxide Heterostructures — •Anima Mahajan[1], Menaka Jha[2], and Santanu Ghosh[1] — [1]Department of Physics, Indian Institute of Technology, Hauz Khas, New Delhi -110016, India. — [2]Institute of Nano Science & Technology, Knowledge City, Sector-81, Mohali, Punjab-160062, India.

The MWCNT, neodymium oxide (Nd*O*), and MWCNT-Nd*O* heterostructure were successfully fabricated through a facile three-step synthesis process: the synthesis of MWCNT rods by the chemical vapor deposition technique, the synthesis of the Nd*O* nanoparticles by using the micellar-assisted solid-state route, and the fabrication of the MWCNT-Nd*O* heterostructure. Moreover, the MWCNT-Nd*O* heterostructure exhibits enhanced field emission properties, with a lower turn-on field of 2.4 V/*m compared to pure MWCNT and Nd*O*, which have turn-on fields of 3.6 and 3.8 V/*m, respectively. The MWCNT*Nd*O* heterostructure exhibits an enhancement in current density of approximately 6365% compared to pure Nd*O* and around 172% relative to pristine MWCNT. The emission current stability at a preset value of 6 V/*m over an 8-hour duration is found to be fairly good, characterized by current fluctuations within * 3% of the average value. The enhanced field emission (FE) performance of the MWCNT-Nd*O* heterostructure is attributed to its high enhancement factor (β) of ˜3.3*10*.

HL 26.15 Wed 9:30 P1

Low temperature photoluminescence excitation spectroscopy on thin film zinc phthalocyanine — •Josephine Braun, Sebastian Hammer, and Jens Pflaum — Experimental Physics 6, University of Würzburg, 97074 Würzburg, Germany

The optical properties of molecular semiconductors are determined by the electronic properties of the molecular constituents and their respective inter-molecular (IM) interaction [1]. To disclose the IM interaction, polymorphic materials like Zinc-phthalocyanine (ZnPc) provide perfect prototypical systems [2]. Its luminescence in the α-phase is dominated by excimer emission [3], wheras the β-phase luminescence is governed by a highly temperature sensitive Frenkel exciton emission. While temperature dependent luminescence studies provide insight into the IM interaction potential, the excitation spectrum does the same without being prone to effects of excitonic relaxation. In this contribution we investigate the excitonic system of ZnPc thin films in the α- and β-phase via temperature dependent photoluminescence excitation (PLE) and photoluminescence (PL) spectroscopy between 4 K and 300 K. We show, that while the PL spectra exhibits strong variability with temperature, the PLE spectra show only minor changes. This suggests that rather than a large modulation of the IM interaction with temperature, exitonic relaxation processes are at the heart of ZnPc's pronounced spectral luminescence changes.

[1] Hestand and Spano, *Chem. Rev.* **118** (2018), p. 7069–7163
[2] Hammer et al., *Appl. Phys. Lett.* **115** (2019), p. 263303
[3] Hammer et al., *Mater. Horiz.* **10** (2023), p. 221–234

HL 26.16 Wed 9:30 P1

Host-Emitter Interactions in Single-Gaussian Deep-Blue Europium(II) OLED Emitters — •Mahmoud Soleimani[1,2], Paulius Imbrasas[2], Jan-Michael Mewes[2], Felix Kaden[2], Sebastian Schellhammer[1], Toni Bärschneider[2], Carsten Rothe[2], and Sebastian Reineke[1] — [1]Institute of Applied Physics (IAP), Technische Universität Dresden, Germany — [2]beeOLED GmbH, Dresden, Germany

Lanthanide-based emitters offer a promising approach to stable and efficient deep-blue organic light-emitting diodes (OLEDs). While divalent europium [Eu(II)] and trivalent cerium [Ce(III)] can provide ideal emission colors with near-unity exciton utilization, their integration into thin-film architectures remains insufficiently understood. In particular, the compatibility of lanthanide complexes with organic host materials and possible lanthanide-specific interactions are open questions. To shed light on and gain a deeper understanding of these aspects, we combine photoluminescence spectroscopy and density functional theory to evaluate the behavior of a literature-reported Eu(II) emitter and to introduce two new carborate-based Eu(II) complexes. These novel materials exhibit deep-blue single-Gaussian 4f-5d emission. Our experimental and theoretical analysis provides a framework for understanding electron confinement and shielding in Eu-based emitters, establishing design principles for a new class of stable, efficient deep-blue OLED materials.

HL 26.17 Wed 9:30 P1

Flexible OLED-OPD System in a Rolled Geometry for Angle-Resolved Optical Sensing — •Shujun Pei, Jan Schardt, Markus Köpke, and Martina Gerken — Chair for Integrated Systems and Photonics, Faculty of Engineering, Kiel University, Kiel, Germany

We investigate an integrated sensing platform combining an organic light-emitting diode (OLED) and multiple organic photodetector (OPD) pixels fabricated on a single flexible PET substrate. After fabrication, the substrate is rolled manually such that the OLED and OPDs face each other across the inner circumference of a cylindrical channel. This geometry enables angle-dependent optical paths through fluids flowing inside the tube, providing a basis for reconstructing absorption and scattering profiles relevant for chemical and biomedical sensing.

To independently assess OLED-OPD performance, devices were characterized on separate flat substrates. OPD responsivity was quantified using a calibrated LED solar simulator and direct OLED illumination. Distance-dependent photocurrent measurements reveal the expected decay consistent with Lambertian emission and simple geometric coupling between the OLED and OPD pixels. Numerical modeling, including finite emitter and detector areas as well as realistic alignment offsets, closely reproduces the measured photocurrent trends.

These results demonstrate the feasibility of compact, flexible OLED-OPD assemblies for multi-angle optical sensing and provide a foundation for future device refinement.

HL 26.18 Wed 9:30 P1

Organic Narrowband Near-infrared Photodiodes for Breath Monitoring — •Sudhi Mahadevan[1,2], Siddhartha Saggar[1,2], Rabiul Islam[1,2], and Caroline Murawski[1,2] — [1]Institute of Solid-State Electronics, Technische Universität Dresden, 01062 Dresden, Germany — [2]Kurt Schwabe Institute for Sensor Technologies, Kurt-Schwabe-Straße 4, 04736 Waldheim, Germany

For clinical diagnosis of various diseases, breath analysis has become a powerful non-invasive tool, which demands the development of reliable and efficient sensing technologies. However, conventional respiratory monitors hinder users' mobility, provide discomfort, and affect natural breathing patterns. Recent progress in organic and wearable optoelectronics presents an opportunity to develop thin, flexible, and imperceptible sensors. In this work, we report high-performance near-infrared (NIR) organic photodiodes (OPD), using a PM6:Y6 blend combining a polymer donor with an NIR-absorbing small molecule processed from the green solvent o-xylene. In this simplified device architecture, the hole-blocking functionality is incorporated directly into the active layer, reducing fabrication complexity and enabling cost-effective production. A narrow-band optical response at 800 nm is achieved via an organic photo-filtering layer that allows only long-wavelength photons into the active layer. The optical breath sensor will integrate organic light-emitting diodes (OLEDs) to emit light onto the chest, while an OPD will capture changes in diffusely scattered light from the skin during breathing. This work aims to advance organic electronic devices into the NIR spectrum for non-invasive medical diagnosis applications.

HL 26.19 Wed 9:30 P1

Wavelength-selective, ultraviolet (Mg,Zn)O photodiodes —

•Jonas Elz, Holger von Wenckstern, and Marius Grundmann — Leipzig University, Felix Bloch Institute for Solid State Physics, Semiconductor Physics Group, Leipzig, Germany

Ninety-five percent of the UV radiation that reaches the Earth's surface is in the UVA band (315-400 nm). In order to assess the potential harmful effects of UVA radiation on the human epidermis with compact, wearable devices, semiconductor technology can be used. Magnesium zinc oxide is a suitable material for detectors in such devices because it exhibits a bandgap between 3.3 and 4.8 eV. One photodiode design uses a filter and an active layer with different material compositions to achieve sensitivity in different optical bands [2].

In this study, we use combinatorial pulsed laser deposition to fabricate metal-semiconductor-metal photodiodes that are sensitive to different wavelength ranges. With the same mask system and similar targets as in [3], we achieve multiple compositions of filter and active layers on a single substrate.

[1] von Wenkstern et al. "The (Mg, Zn)O Alloy" in "Handbook of zinc oxide and related materials" pp 257-320
[2] Zhang et al. Appl. Phys. Lett. 108, 243503 (2016)
[3] Thyen et al. J. Vac. Sci. Technol. A 41, 020801 (2023)

HL 26.20 Wed 9:30 P1

Determination of activation energies in vertical co-doped κ-Ga_2O_3 Schottky barrier diodes — •Elise Morawe, Sofie Vogt, Holger von Wenckstern, and Marius Grundmann — Universität Leipzig, Felix-Bloch-Institut für Festkörperphysik Halbleiterphysik, Leipzig, Germany

The predicted spontaneous polarization of κ-Ga_2O_3 renders this polymorph of Ga_2O_3 highly interesting for, e.g., high electron mobility transistor devices [1]. As shown by Kneiß et al., vertical Schottky barrier diodes can be realized on pulsed laser deposition (PLD) grown κ-Ga_2O_3 thin films [2]. For that, the addition of tin in the process is mandatory to induce the surfactant-mediated growth of the κ phase [3]. We present κ-Ga_2O_3 thin films grown by PLD on indium tin oxide (ITO) layer on different substrates: c-sapphire and yttria-stabilized zirconia (YSZ). We discuss the influence of co-doping of the κ-Ga_2O_3 thin films with ZrO_2 or SiO_2 in addition to SnO_2 on the performance of Schottky barrier diodes. Furthermore, the activation energies of Sn, Zr and Si in the κ-Ga_2O_3 are determined by thermal admittance spectroscopy.

[1] Juyeong Kim et al, Appl. Phys. Express, 11, 061101 (2018)
[2] M. Kneiß et al, J. Appl. Phys. 130, 084502 (2021)
[3] M. Kneiß et al, APL Mater. 7, 022516 (2019)

HL 26.21 Wed 9:30 P1

How To Tame Your Iodine in Reactive Sputtering and Similar UHV Thin Film Deposition Processes — •Christiane Dethloff, Sebastian Köpp, Sofie Vogt, Lukas Trefflich, Holger von Wenckstern, and Marius Grundmann — Felix-Bloch-Institute for Solid State Physics, Universität Leipzig, Germany

Sputtering in reactive atmospheres involves several challenging conditions, like target poisoning, or a hysteresis of the reactive gas partial pressure, leading to an unstable operation regime [1]. In order to investigate and control these process conditions, and therefore tune the properties of the resulting thin film, a controlled flux of the reactive species is crucial. Commonly, this is achieved by mass flow controllers, when O and N are the reactive gases [2]. However, in the case of an iodine enriched atmosphere this is hardly feasible, due to the corrosive effect and low inlet pressures.

We present an optical measurement setup, enabling real-time measurements of the iodine content in an iodine enriched Ar flow from an iodine vaporizer into a deposition chamber. Our investigations comprise the growth and characterization of functional p-type copper iodide (CuI) thin films by reactive magnetron sputtering under a well defined iodine flux.

[1] D. Güttler *et al.*, Applied Physics Letters 85.25 (2004): 6134 – 6136 DOI:10.1063/1.1835002.
[2] A. Welk, M. Grundmann *et al.*, Physical Review Applied 17.2 (2022): 024007 DOI: 10.1103/PhysRevApplied.17.024007

HL 26.22 Wed 9:30 P1

Investigation of vertical α-Ga_2O_3/$(Al_xGa_{1-x})_2O_3$ diodes grown by pulsed laser deposition — •Veronika Lunova, Sofie Vogt, Paul Bokemeyer, Holger von Wenckstern, and Marius Grundmann — Universität Leipzig, Felix Bloch Institute for Solid State Physics, Semiconductor Physics Group, Leipzig, Germany

With a bandgap of 5.3 eV and a dielectric breakdown field of 10 MV/cm, α-phase gallium oxide is a promising ultra-wide bandgap semiconductor for high-power electronics [1]. Furthermore, alloying with isostructural α-Al_2O_3 is possible without a miscibility gap and allows for even higher band gaps and electrical breakdown fields [2]. In this work, we present a systematic investigation of vertical Schottky diode structures based on α-$(Al_xGa_{1-x})_2O_3$ thin films grown by pulsed laser deposition (PLD). The heterostructures consist of an undoped α-Ga_2O_3 buffer layer, highly doped intermediate layers, and an $(Al_xGa_{1-x})_2O_3$ layer. Achieving sufficient conductivity in $(Al_xGa_{1-x})_2O_3$ remains a major challenge; thus, we investigate donor activation as a function of aluminum content [3]. The structural quality and electrical properties of the resulting heterostructures were investigated, with focus on the influence of Al incorporation on crystal structure, carrier activation, and vertical transport behavior.

[1] Higashiwaki *et al.*, Appl. Phys. Lett. **100**, 013504 (2012).
[2] Hassa *et al.*, J. Phys. D: Appl. Phys. **54** 223001 (2021).
[3] Varley *et al.*, Appl. Phys. Lett. **120**, 262104 (2022).

HL 26.23 Wed 9:30 P1

Titania-based aerodynamic nanomaterials produced by atomic layer deposition — •Tudor Braniste[1], Vladimir Ciobanu[1], Sebastian Lehmann[2], Phil Goldberg[2], Kornelius Nielsch[2], Niklas Wolff[3], Lorenz Kienle[3], Rainer Adelung[3], and Ion Tiginyanu[1] — [1]Technical University of Moldova, Chisinau, Moldova — [2]Leibniz Institute for Solid State and Materials Research, Dresden — [3]Institute for Materials Science, Kiel University, Germany

In this work, we report on a technology for the production of TiO2, Zn2TiO4, and Mg2TiO4 aero-nanomaterials. Titanium and magnesium oxides were deposited using atomic layer deposition (ALD) onto a sacrificial network of ZnO microtetrapods. After deposition, the sacrificial ZnO layer was removed using two different technological routes. The first route involves removing the zinc oxide in a citric acid solution at room temperature, followed by critical-point drying of the titania-based material. The second route consists of removing the ZnO substrate in a hydrogen atmosphere at high temperature. At temperatures as high as 850 °C in an atmosphere of H2 + Ar (2% + 98%), the ZnO core decomposes, and the resulting aero-nanomaterial consists of hollow microtetrapods with porous microtubular arms composed of Zn2TiO4 or (ZnMg)TiO2. Scanning and transmission electron microscopy, as well as X-ray analysis, were used to elucidate the morphology, composition, and crystal structure of the produced aeromaterials. The investigations revealed the influence of annealing temperature and the sequence of technological steps on the morphology and properties of the resulting materials.

HL 26.24 Wed 9:30 P1

Band-Gap Trends in Halide Double Perovskites from Quasiparticle Self-Consistent GW — •Louis Meier[1], Timur Biktagirov[1], Volodymyr Vasylkovskyi[2], Anastasiia Kultaeva[2], and Wolf Gero Schmidt[1] — [1]Physics Department, Paderborn University, 33098 Paderborn, Germany — [2]Experimental Physics 6, University of Würzburg, 97074 Würzburg, Germany

Halide double perovskites represent a chemically versatile class of optoelectronic materials with tunable band gaps dependent on their cation and halide composition. Their diversity requires a first-principles framework that can predict these trends consistently. Semilocal density functional theory (DFT) underestimates band gaps, while many-body GW results depend sensitively on the DFT starting point. In this contribution, we assess the quasiparticle self-consistent GW (QSGW) method as a unified, starting-point-independent approach for predicting the electronic structure of the $Cs_2MM'X_6$ family (M = Bi, Tl; M' = Ag, Cu; X = Cl, Br), focusing on trends with composition and spin-orbit coupling.

HL 26.25 Wed 9:30 P1

Atomistic Modeling of A- and X-Site Mixing in Halide Perovskites using Cluster Expansion — •Hilde Bellersen[1], Ana M. Valencia[2], and Caterina Cocchi[1] — [1]Friedrich-Schiller-Universität Jena, Germany — [2]Carl von Ossietzky Universität Oldenburg, Germany

Designing stable and efficient halide perovskites involves navigating a vast space of possible chemical substitutions. To address this challenge, we combine density-functional theory calculations with a machine-learning-based cluster expansion framework [1] to efficiently explore multi-component perovskite alloys. Our training structures systematically sample A-site mixing (FA, MA, Cs), X-site mixing (I, Br, Cl),

as well as simultaneous A- and X-site co-mixing, with the lattice parameters adjusted according to Vegard's law. These configurations provide the basis for constructing cluster expansion models capable of capturing key energetic trends across the full compositional space. Such models can be used to identify stability landscapes and quantify the influence of configurational effects. We present the methodology, dataset construction, and first insights from the ongoing model development, highlighting the importance appropriate settings to ensure model accuracy, as well as the potential of this approach to guide the design of complex halide perovskite alloys.

[1] M. Ångqvist et al., Advcd Theory and Sims 2, (2019).

HL 26.26 Wed 9:30 P1

Cavity-enhanced microscopy: absorption measurements of single perovskite nanocubes and photo-switchable lipids — •Ayesha Khan[1], Ines Amersdorffer[1,2], David Hunger[3], and Thomas Hümmer[1,2] — [1]Qlibri GmbH, Munich, Germany — [2]Ludwig Maximilian University of Munich, Munich, Germany — [3]Karlsruhe Institute of Technology, Karlsruhe, Germany

Optical studies of nano-scale systems through spectroscopy and imaging can reveal intrinsic optical properties of materials including resolving the exitonic fine structure of systems. However, due to diminutive absorption of nano-scale systems, it is challenging to perform absorption spectroscopy.

For a nano-scale system placed inside an optical resonator, the light passes through the sample thousands of times, enhancing the absorption and thus, allowing measurements.

Here we demonstrate the use of a fiber-based, open-access microcavity to perform direct measurements of the absorption of single perovskite nanocubes. We further image and obtain hyperspectral maps of perovskite nanocubes.

We also present the use of the cavity microscope to image label-free Azo-PC phospholipid bilayers in both cis and trans state and show the diffusion of the two states.

The successful measurements of different nano-scale systems promise that fiber-based microcavities can become standard tools for absorption measurements of these systems.

HL 26.27 Wed 9:30 P1

Excitonic Reststrahlen Effect in $(PEA)_2PbI_4$ — •Michael Pfeufer, Patrick Grenzer, Friedrich Schöppler, and Tobias Hertel — Institute of Physical and Theoretical Chemistry, Julius-Maximilains-University Würzburg, Germany

Layered Ruddlesden-Popper perovskites with their natural quantum well structure allow for strongly confined excitons with very high oscillator strengths. In this work, evidence of an excitonic Reststrahlen effect, a phenomenon in which strong exciton resonances push the real permittivity below zero, was identified and characterized in phenethylammonium lead iodide $(PEA)_2PbI_4$. Transfer-matrix method simulations of the thin film were employed to fit temperature-dependent transmission measurements to an isotropic Lorentz oscillator model and to extract the dielectric function of the material. Additionally, we show that the behaviour of the Reststrahlen band in thickness-dependent transmission spectra is consistent with that found in other materials featuring a Reststrahlen-like response. Electric field calculations inside the material slab suggest natural exciton-polaritonic formation in the material, as well as longitudinal modes near the zero crossing of the real permittivity.

HL 26.28 Wed 9:30 P1

Optical Composition-Property Relationships in a Lead-Free Isostructural 2D Hybrid Metal-Halide Series — •Nils Kasten[1], Jan-H. Littmann[1], Meng Yang[2], Natalie Dehnhardt-Fehst[2], Lukas Gümbel[1], Ralph Kusche[2,3], Markus Stein[1], Johanna Heine[2,3], and Sangam Chatterjee[1] — [1]Institute of Experimental Physics I and Center for Materials Research (ZfM), Justus Liebig University Giessen, Heinrich-Buff-Ring 16, 35392 Giessen, Germany. — [2]Department of Chemistry and Material Sciences Center, Philipps-Universität Marburg, Hans-Meerwein-Straße, 35043 Marburg, Germany. — [3]Insitute of Chemistry, Carl von Ossietzky Universität Oldenburg, Ammerländer Heerstraße 114-118, 26129 Oldenburg, Germany.

Organic–inorganic metal halides have achieved notable success in photovoltaics. Among these, metal-halide perovskites represent a versatile class of compounds, exhibiting diverse optoelectronic behaviour, ranging from narrow-band emission to broadband white-light photoluminescence (PL), typically arising from self-trapped excitons (STEs). These characteristics render them relevant for optoelectronic applications. In this study, we investigate a lead-free isostructural series of two-dimensional hybrid metal halides, $[(R)\text{-1-(4-F)PEA}]_4\,[E_2X_{10}]$; (R)-1-(4-F)PEA = (R)-1-(4-fluoro) phenylethylammonium, where E = Sb, Bi and X = Cl, Br, I. All compounds share a common structural framework, which allows us to isolate the effects of metal-cation and halide-anion substitution on the optical response. We employ PL and Raman spectroscopy to characterize these compounds.

HL 26.29 Wed 9:30 P1

Stokes, Anti-Stokes and selective excitation of Si-vacancies in SiC — •Emilian Eisermann, Vladimir Dyakonov, and Andreas Sperlich — Experimental Physics 6, University of Würzburg, 97074 Würzburg, Germany

Our group has demonstrated a room temperature continuous-wave maser that uses the silicon vacancy (V2) in silicon carbide (4H-SiC) (arXiv:2312.08251). Stimulated emission arises from an optically pumped population inversion in these spin defects. However, only a low output power could be achieved and laser heating caused instabilities. To enhance the maser characteristics, we investigate the fundamental pumping behavior of V2 (zero phonon line at 916.2 nm). Hereby, we distinguish between common Stokes excitation (CSE) (<916.2 nm), Anti-Stokes excitation (ASE) (>916.2 nm) and selective excitation (=916.2 nm). Using electron paramagnetic resonance spectroscopy, we resolve microwave absorption and emission signals due to the optical polarization of Zeeman split states. By analyzing these features, we calculate the population inversion and hence the pump efficiency. At low temperatures selective excitation is particular efficient and CSE outcompetes ASE, which requires thermally driven phonons. At room temperature, the increased phonon activity and the shortened T_1 lifetime cause ASE (λ=950 nm) to have an efficiency of around 50 % compared to CSE. ASE however allows for a very targeted excitation of V2 and we identify an optical pumping sweet spot that is promising for future maser implementations.

HL 26.30 Wed 9:30 P1

Double Gaussian Defect Cavity Design for Semiconductor Based Entangled Photon Sources — •Xian Zheng, Fei Ding, and MIchael Zopf — Institute of Solid State Physics, Leibniz University of Hannover, Appelstr. 2, 30167 Hannover, Germany

Polarization-entangled photon pairs are essential resources for quantum communication and quantum networks, enabling protocols such as quantum key distribution, teleportation, and entanglement swapping. However, simultaneously controlling cavity spectrum, field profile, and balanced coupling to multiple radiative transitions in a solid-state emitter remains challenging. In this work, we design a double-Gaussian defect cavity as a flexible platform to engineer semiconductor quantum-dot entangled photon sources. Two Gaussian-shaped, microsphere-like thickness modulations are embedded inside a DBR cavity and sculpt the axial and lateral field distributions, providing independent knobs, such as cavity height and defect width, to simultaneously tune the cavity resonance close to emission lines, such as biexciton and exciton emission and optimize the emission wavelength. Using FDTD simulations and time-domain exponential decay fitting, we extract the quality factor, mode volume, and Purcell enhancement, and quantify their dependence on the geometric parameters. The resulting design framework provides practical guidelines for tailoring cavity*quantum-dot coupling in double-Gaussian defect geometries and supports the development of bright, on-demand entangled photon sources suitable for future integrated quantum-network architectures.

HL 26.31 Wed 9:30 P1

Low-density InAs quantum dots for telecom O-band single-photon emission — •Elias Kersting, Nikolai Spitzer, Hans Georg Babin, Severin Krüger, Phil Julien Badura, and Arne Ludwig — Ruhr-Universität Bochum, EP6 , Bochum, Germany

InAs quantum dots (QDs) grown by molecular beam epitaxy (MBE) are promising candidates for single-photon sources (SPS), particularly for quantum communication. Emission in the telecom O-band (1260 - 1360 nm) is especially desirable due to the low transmission loss in optical fibers. However, conventional Stranski-Krastanov (SK) InAs QDs face challenges in achieving low and well-controlled densities in the range of 0.1- 10 QDs/um^2, as well as in precisely tuning the emission wavelength. We present an alternative approach to address this issue based on local droplet etching (LDE), in which nanoholes in a GaAs matrix are filled with InAs to form QDs. The quantum dot density is defined by the nanohole pattern, enabling precise and scalable

control. A strain-reducing layer (SRL) shifts the emission wavelength into the telecom O-band. Homogeneous low-density (~2 QDs/um^2) growth is achieved through shutter-synchronized deposition, making this approach well suited for scalable SPS fabrication. We detail the fabrication method and present structural and optical characterization results.

HL 26.32 Wed 9:30 P1

Effect of TiO_2 thin films on shallow NV centers in co-doped diamond. — •Arthur Witte, Dominic Reinhardt, Peter Schlupp, Holger von Wenckstern, Jan Meijer, and Marius Grundmann — Universität Leipzig, Felix-Bloch Institute for Solid State Physics, Germany

The nitrogen vacancy (NV) center is a color center in diamond, that was proposed as a platform for solid state quantum computing. Essential for this idea is the spin-dependent photoluminescence of the negatively charged NV center, through which an optical spin polarization can be achieved and its relatively long spin coherence time at room temperature. Much research has been done in this direction: to engineer the required negative charge of the NV centers, co-doping of the diamond with donors was developed [1]. Shallow NV centers are subject to surface effects that cause charge instabilities, as well as magnetic and electronic noise. Various surface treatments have been explored to mitigate these effects, including the deposition of a passivation layer on the diamond surface. We combine surface engineering and charge engineering by co-doping and study the effects of these methods on the charge state and T_2 time of shallow NV centers. This is done by sputtering transparent titanium dioxide layers of varying thickness onto a diamond with shallow NV centers in differently co-doped environments. Additionally, effects of annealing of the layer on both the layer itself and the NV properties are discussed.

[1] T. Lühmann, et al. *Phys. Status Solidi a* **8**(1), 1671-1703. (2021)

HL 26.33 Wed 9:30 P1

High-Resolution Lift-Off Process for Sub-100-nm Metal Features using a PMMA Bilayer Stack — •Melina Sporkett[1], Lina Trippelsdorf[1,2], Thomas Grap[1], Florian Lentz[1], and Markus Kaiser[1] — [1]Helmholtz Nano Facility, Forschungszentrum Jülich, Germany — [2]Peter Grünberg Institute, Forschungszentrum Jülich, Germany

A reliable and reproducible lift-off process is essential for the fabrication of high-resolution metal structures in micro- and nanotechnology. This has become increasingly important due to recent advances in quantum computing. In quantum devices, these nanoscale electrodes and interconnects are needed to realize the electrical connections to qubits.

In this study, we present a PMMA bilayer lift-off process that enables the reliable fabrication of structures below 100 nm, including fine lines and spaces. The resist stack consists of a copolymer bottom layer that creates a defined undercut and a thin PMMA/CSAR top layer. Through specifically optimized electron-beam lithography and development using a methoxypropanol-based developer, a clearly defined resist profile was achieved. Subsequent metal deposition using Ti/Au electron beam evaporation enabled the fabrication of lines with a width of only 30 nm.

These results demonstrate a robust and practical process for fabricating ultra-fine metallic interconnects for nanoelectronic applications.

HL 26.34 Wed 9:30 P1

Diamond devices for high contrast electrical readout of NV centers — •Melina F. V. Pees[1], Lina M. Todenhagen[1], Joachim P. Leibold[2], Dominik B. Bucher[2], and Martin S. Brandt[1] — [1]Walter Schottky Institut, TU Munich, Am Coulombwall 4, 85748 Garching — [2]Department of Chemistry, TU Munich, Lichtenbergstr. 4, 85748 Garching

Nitrogen-vacancy (NV^-) centers in diamond enable optically and electrically detected magnetic resonance (ODMR and EDMR/PDMR, respectively) and are a promising semiconductor platform for spin-based sensing. Metal contacts often influence the NV^- charge state, change current flow near the surface and worsen the spin contrast in resonance measurements. In this work we investigate shallow, implanted NV ensembles under Ti/Pt/Au contacts using combined photoluminescence, photocurrent and ODMR/EDMR measurements as a function of applied bias voltage, nitrogen implantation depth and position relative to the metallized surface. We have recently shown that Pt, just as other metals, strongly influences the charge state of the NV centers underneath the contacts, leading to mostly neutral or positively charged centers. Here, we show that via application of bias voltages, the negative charge state can be partially recovered, leading to an increase in the spin contrast. This approach allows to stabilize the NV^- charge state and improves the suitability of such diamond devices for quantum sensing applications.

HL 26.35 Wed 9:30 P1

Fabrication of SNSPDs on TF-LNoI for measurement device independent QKD — •Simon Palitza[1,2,3], Bilal Malik[1,2,3], and Carsten Schuck[1,2,3] — [1]Department for Quantum Technology, University of Münster — [2]Center for NanoTechnology - CeNTech, Münster — [3]Center for Soft Nanoscience - SoN, Münster

Thin-Film Lithium Niobate on Insulator (TF-LNoI) has been recognized as a promising platform for realizing low-loss propagation and high-speed modulation of optical signals in photonic integrated circuits. However, quantum technology applications, such as quantum key distribution (QKD) also require integrating single photon detection capabilities with nanophotonic functionalities. Here we show how crucial optical circuit components of a QKD-receiver can be co-integrated with Nb-based Superconducting Nanowire Single Photon Detectors (SNSPDs) on the TF-LNoI-platform. We specifically assess the influence of ubiquitous lithium diffusion on SNSPD performance and explore mitigation strategies in the design and nanofabrication process flow, such as introducing diffusion barrier layers. Combining efficient measurement capabilities with the stability and low loss routing of optical signals in monolithic LNoI-circuits provides a viable way towards realizing quantum communication protocols, such as measurement device independent QKD.

HL 26.36 Wed 9:30 P1

Role of a Quarter-Wave Plate in Resonant Laser Spectroscopy: Signature of Spin-Orbit Interactions of Light — •Wenze Lan, Anton Lögl, and Bernhard Urbaszek — Institute for Condensed Matter Physics, Technische Universität Darmstadt, 64289 Darmstadt, Germany

Resonant laser spectroscopy is a powerful technique for probing the intrinsic optical transitions, coherence properties, and spin dynamics of single quantum emitters. Although polarization-based dark-field confocal microscopy enables nearly background-free detection of resonant fluorescence [1], the role of an additional quarter-wave plate in further improving extinction has remained unclear. Here, we elucidate the mechanism by which a commercial quarter-wave plate enhances polarization extinction in a simple confocal geometry. Under cross-polarization conditions, the transmitted beam exhibits a robust first-order Hermite-Gaussian mode, which explains the improved background suppression and we identify it as a direct signature of spin-orbit interactions of light [2-3]. Our findings inspire applications in polarization optics, nanophotonics, and quantum photonics. [1] Rev. Sci. Instrum. 84, 073905 (2013); [2] J. Opt. 15, 014001 (2013); [3] Nat. Photon. 9, 796-808 (2015).

HL 26.37 Wed 9:30 P1

Phonon-Polaritons in MOVPE-grown hexagonal Boron Nitride — •Oskar Schröer[1], Maximilian Scharpey[1], Lena Miler[2], Johannes Binder[2], Andrzej Wysmołek[2], Daniel Wigger[3], and Iris Niehues[1] — [1]Institute of Physics, University of Münster, Germany — [2]Faculty of Physics, University of Warsaw, Poland — [3]Department of Physics, University of Münster, Germany

Two-dimensional materials composed of atomically thin layers have attracted great interest due to their unique optical and electronic properties. Using a scattering-type scanning near-field optical microscope (s-SNOM), surface phonon polaritons (SPhPs) are observable in the insulating polar van-der-Waals material hexagonal boron nitride (hBN) [1]. While most works focus on exfoliated single-crystalline layers of hBN, we show that SPhPs can also be excited in hBN grown by metalorganic vapor phase epitaxy (MOVPE). Here, grain boundaries and defects play a major role for the propagation properties of the polaritons. By evaluating the real-space interference patterns, we extract dispersion relations and compare propagation characteristics for the two sample types. The results contribute to a deeper understanding of light-matter interactions in polar van der Waals materials and may pave the way towards improved control and manipulation of light-matter excitations on the nanometer scale.

[1] Caldwell et al., Nat. Commun. **5**, 5221 (2014).

HL 26.38 Wed 9:30 P1

Predicting nonlinear optical properties from the linear response: Generalized Miller Formulae — •Maximilian Tim Meyer and Arno Schindlmayr — Universität Paderborn, Department Physik, 33095 Paderborn, Germany

Predicting the nonlinear optical response of real materials from first principles remains a major challenge, since quantitative calculations require strong simplifications and large computational resources. As a shortcut, Miller's rule provides an empirical relation between the linear and second-harmonic coefficients. It can be extended to higher-order nonlinearities and is now accepted as a useful tool for guiding experiments and computational materials discovery. However, its theoretical foundation had long been limited to a simple derivation for the classical Lorentz model with a weak anharmonic perturbation, whose properties differ from those of real quantum-mechanical electrons. We have developed a mathematical framework which enabled us to prove that Miller's rule is nevertheless equally valid for weakly anharmonic quantum-mechanical oscillators [1]. For three-dimensional anharmonic oscillators, we further derived generalized Miller formulae that express all orders of the nonlinear response to an arbitrary multi-frequency field exactly in terms of the linear optical susceptibility [2]. These generalized formulae are applicable to a much broader range of nonlinear optical processes and systems. The practical implementation is illustrated by means of a numerical example. [1] Meyer and Schindlmayr, J. Phys. B **57**, 095001 (2024). [2] Meyer and Schindlmayr, Dynamics **5**, 34 (2025).

HL 26.39 Wed 9:30 P1

Revisiting Cross-Polarized Resonant Excitation: Spin-Orbit Interaction in Confocal Dark-Field Microscopy — •Anton Lögl, Wenze Lan, and Bernhard Urbaszek — Institute for Condensed Matter Physics, Technische Universität Darmstadt, 64289 Darmstadt, Germany

Resonant excitation is a key experiment for accessing and probing the optical properties of semiconductor quantum emitters. The typical epi-fluorescence geometry of the cryostat environment presents an experimental challenge: separating the much weaker emission of the sample from the much stronger excitation, typically addressed using a cross-polarization scheme [1]. It is well known that confocal microscopy in combination with a dark-field technique can surpass the intrinsic extinction limit of commercial polarizers [1, 2]. In this work, we investigate the spin-orbit interaction of light observed when a polarized Gaussian beam is reflected from a mirror surface within such a microscope arrangement. We revisit the model from [2] and demonstrate that slight modifications allow us to phenomenologically model all of our results within the linear and circular polarization basis. Our results pave the way for improved characterization and optimization of optical setups used to measure the optical properties of various quantum emitters. Simultaneously, our results highlight how poorly understood the physical principles of one of the most common characterization techniques in resonant spectroscopy are.

[1] A. V. Kuhlmann, et al. Rev. Sci. Instrum. 84, 073905 (2013)
[2] Benelajla, M. et al. Phys. Rev. X 11, 021007 (2021)

HL 26.40 Wed 9:30 P1

Optical properties of $(Ti_xGa_{1-x})_2O_3$ — •Leonard Käferstein, Clemens Petersen, Daniel Splith, Holger von Wenckstern, Chris Sturm, and Marius Grundmann — Felix Bloch Institute for Solid State Physics, Leipzig University, Leipzig, Germany

The high bandgap energy in the order of 5.3 eV and its high predicted electrical breakdown field of about 10 MV cm^{-1} make α-Ga_2O_3 a quite promising material for transparent electronic devices and high power applications [1]. Alloying αGa_2O_3 with Ti leads to a decrease of the band gap. Here we report on the optical properties, especially the dielectric function, of $(Ti_xGa_{1-x})_2O_3$ determined by spectroscopic ellipsometry as a function of the cation composition.

A $(Ti_xGa_{1-x})_2O_3$ thin film with a lateral composition gradient was deposited by combinatorial pulsed laser deposition [2]. X-ray diffraction indicates a transformation from the tetragonal rutile phase for large Ti concentration ($x > 0.55$) toward a rhombohedral phase for $x < 0.4$. As $(Ti_xGa_{1-x})_2O_3$ is optically uniaxial and the optic axis is within the surface plane, generalized spectroscopic ellipsometry was applied. In the transparent spectral range, we determined a decrease from positive birefringence for high x towards negative birefringence for $x \approx 0$. As expected, we observe a redshift of the bandgap energy with increasing Ti-content from 5.1 eV for $x \approx 0$ down to 4.3 eV for $x \approx 0.85$.

[1] M. Higashiwaki *et al.*, Appl. Phys. Lett. **100**, 013504 (2012).
[2] H. v. Wenckstern *et al.*, Ph. Status Solidi B **257**, 1900626 (2020).

HL 26.41 Wed 9:30 P1

In situ investigation of PEC devices by time-resolved photoluminescence — •Peter Kleinschmidt, Ali Omar, Sahar Shekarabi, David Ostheimer, and Thomas Hannappel — TU Ilmenau, Institute of Physics, Fundamentals of Energy Materials, 98693 Ilmenau

Direct, unassisted photoelectrochemical (PEC) water splitting is a promising approach for the generation of solar hydrogen. At present, PEC devices still suffer from rapid degradation during operation in the electrolyte. In PEC devices, the control of the dynamics of minority charge carriers is crucial for efficient operation. *In situ* time-resolved photoluminescence (TRPL) measurement provides a direct access to charge carrier lifetimes in the PEC environment. We demonstrate that *in situ* TRPL reveals early-stage, localized degradation in PEC devices under operating conditions long before any decline in conventional performance metrics, such as a reduction in hydrogen evolution current density, becomes detectable. With this method, we investigate the effect of different surface treatments of dual junction PEC devices, in particular the functionalization with passivation layers and catalysts, on the stability and overall performance.

HL 26.42 Wed 9:30 P1

Propagation of Bloch surface polaritons in ZnO — Sebastian Henn, •Dmitry Sayenko, Marius Grundmann, and Chris Sturm — Felix Bloch Institute for Solid State Physics, Leipzig University, Leipzig, Germany

Here we present the long-range propagation of Bloch surface polaritons (BSP) in ZnO, which are formed through the strong interaction between light and excitons. Of special interest are BSP particles as they are bosonic quasi-particles and inherit the long-range propagating properties of the involved photons. In contrast to typically used microcavities, BSPs are formed at the surface of a photonic crystal, and thus the fabrication of these structures requires less technical effort and the properties of the BSP are surface-sensitive. In our studies, we realized BSPs in a photonic crystal made of distributed Bragg reflector made of yttria-stabilized zirconia (YSZ) and Al_2O_3. As an active medium, we used a ZnO surface layer, allowing strong coupling up to 430 K [1]. For the coupling of the BSPs to the vacuum modes, a 1D grating was etched onto the surface. By employing non-resonant excitation and varying the distance of the excitation with respect to the grating, the propagation length of BSPs was determined. We found that the propagation length of the BSP is about five times larger than would be expected for a pure photonic mode traveling through the ZnO layer [2]. We attribute this enhancement of the propagation lenght to the extended field distribution within the structure.

[1] S. Henn *et al.*, New J. Phys. **23**, 093031 (2021).
[2] S. Henn *et al.*, Appl. Phys. Lett. **125**, 211104 (2024).

HL 26.43 Wed 9:30 P1

Comparative *ab initio* characterization of $LiNbO_3$, Li_3NbO_4 and $LiNb_3O_8$ — •Frederik Schmidt and Arno Schindlmayr — Universität Paderborn, Department Physik, 33095 Paderborn, Germany

Ferroelectric lithium niobate ($LiNbO_3$) is an important material for nonlinear optical technologies. It is part of the Li_2O–Nb_2O_5 system, whose two components can not only form $LiNbO_3$ but also other phases with different Li:Nb ratios, such as Li_3NbO_4 or $LiNb_3O_8$. Both are studied as possible materials for lithium-ion batteries on their own, but they may also occur as unwanted secondary phases during the growth of lithium niobate crystals when pure $LiNbO_3$ is preferred. As a consequence, it is important to detect and identify the different phases. In this work, we employ *ab initio* methods including density-functional theory, the *GW* approximation and the Bethe-Salpeter equation in order to characterize the three compounds with identical computational techniques and convergence parameters. In particular, we compare the density of states, electronic band structure and optical absorption spectrum of Li_3NbO_4 and $LiNb_3O_8$ to $LiNbO_3$. Despite qualitative similarities, our results reveal quantitative differences in the electronic and optical properties that should be clearly measurable in experiments. Compared to $LiNbO_3$, the electronic band gap of Li_3NbO_4 is 1.0 eV larger and that of $LiNb_3O_8$ is 0.4 eV smaller. The optical absorption edges also vary correspondingly.

HL 26.44 Wed 9:30 P1

Improving the optical readout of NV-centers in diamond by

oxide surface coating — •Klemens Wurl, Michael Bar, Holger von Wenchstern, and Marius Grundmann — Universität Leipzig, Felix-Bloch Institute, Germany

Successful quantum computing has many advantages compared to regular computing, especially in simulations. It is proposed that nitrogen-vacancy (NV) centers in diamond could be used as qubits at room temperature, which would make everyday applications of quantum computing easier compared to solutions that rely on superconductivity.[1] The quantum states of the NV-centers can be controlled by optical excitation via laser and spin-state manipulation by microwave radiation.[2] The main objective of this research is to improve the optical readout of the NV-center by the use of solid immersion lenses (SIL). For this purpose, transition metal oxides are used, which are optically transparent and do not exhibit photoluminescence for the given wavelength. PLD is used for the surface coating, but the optical properties are limited by particle density. Therefore, peripheral target ablation was used to decrease the particle density as it allows for higher control of the plasma plume deflection. The influence of O_2 partial pressure and fluence will be investigated in order to record the corresponding growth window for decreased particle expulsion as well as increased optical transparency and refractive index.

[1] S.Pezzagna *et al.*, Appl. Phys. Rev. **8**(1), 011308, (2021).
[2] F. Jelezko *et al.*, Phys. Stat. Sol.(a) , **203**(13), 3207-3225, (2006).

HL 26.45 Wed 9:30 P1

Two-color sensitive II-VI wide-bandgap diodes with PbTe quantum dots for visible and infrared detection and emission — •Jakub Gluch[1], Sergij Chusnutdinow[1], Michal Szot[1,2], Piotr Wojnar[1], and Grzegorz Karczewski[1] — [1]Institute of Physics, Polish Academy of Sciences, 02-668 Warsaw, Poland — [2]International Research Center MagTop, 02-668 Warszawa, Poland

We present the results of research on p-n diode working as two-color photodetector, made from combined narrow- and wide-bandgap semiconductors. With the use of molecular beam epitaxy (MBE) we managed to create diode structures (p-ZnTe/(Active Layers - AL)/n-CdTe) with lead telluride (PbTe, 0.32 eV in 300K) quantum dots embedded in cadmium telluride matrix (CdTe, 1.49 eV in 300K). To create quantum dots we first grown 20 alternating layers of PbTe and CdTe on top of p-type layer, which followed by thermal annealing which break down PbTe layers in to dots. We performed current-voltage measurements for the basic characteristics followed by an optical measurements to obtain diode spectral response curves with respect to different temperatures in the visible and infrared ranges (350 - 3500nm in 300K). In photoluminescence measurement we observe emission from PbTe quantum dots. We confirmed junction formation in the diode by electron beam induced current (EBIC) measurements. On cross sections of this structures, we observed formation of double p-n junction at the interface of p-type layer and AL, and AL and n-type layer. Measurements show promising possibilities for creating infrared LED and at the same time photodetector with wide spectrum of detectivity.

HL 26.46 Wed 9:30 P1

Microscopic reverse-bias electroluminescence spectra and spectral images of 850 nm oxide-confined VCSELs during burn-in — •Arndt Jaeger[1], Nikolay Ledentsov Jr.[2], Sebastian Haberkern[1], Helmut Meinert[1], Alexander Moll[1], Dominik Ölke[1], Ilya E. Titkov[2], Oleg Yu. Makarov[2], and Nikolay Ledentsov[2] — [1]Esslingen University of Applied Sciences, Flandernstrasse 101, 73732 Esslingen, Germany — [2]VI Systems GmbH, Hardenbergstrasse 7, 10623 Berlin, Germany

850 nm vertical-cavity surface-emitting lasers (VCSELs) are studied during high-current burn-in operation utilizing both reverse-bias electroluminescence (ReBEL) spectra and spectral images. High-resolution spectral images are generated by means of a confocal scanning optical microscope using interference filters whereas microscopic spectra are obtained with a fiber-coupled sensitive USB spectrometer. Recently unfiltered ReBEL images have proven to be sensitive to operation-induced changes of VCSELs because defect states evolved during high-current stress trigger avalanche breakdown and give rise to ReBEL emission. In particular, local current crowding during high current burn-in leads to spatial distributions of ReBEL emission being characteristic to the aging status and contain spectral portions due to quantum well as well as AlGaAs barrier emissions. In contrast, electroluminescence spectra measured under near flatband conditions exhibit only quantum well emission at 848 nm.

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Optical Properties of a Transition-metal Dichalcogenide - ZnO Nanowire Field-effect Transistor — •Yashvi Bulsara[1], Maximilian Tomoscheit[1], Omid Ghaebi[1], Edwin Eobaldt[1], Carsten Ronning[1], and Giancarlo Soavi[1,2] — [1]Institute of Solid State Physics, University of Jena — [2]Abbe Center of Photonics, University of Jena

Transition-metal dichalcogenide (TMD) monolayers combined with zinc-oxide (ZnO) nanowires (NW) represent a promising platform for electrically tunable nanophotonic devices. ZnO NWs are naturally nanoscale lasers, supporting waveguiding, field amplification and being the gain medium at the same time. A further major step towards the success and broad applicability of NW lasers is the possibility to actively tune their laser properties via external stimuli, such as the piezo-electric effect[2]. Recently, we have demonstrated that coupling of ZnO NWs to monolayer TMDs leads to an increase of the lasing intensity threshold[3]. Building on this approach. in this poster I will propose a device where the laser emission of a ZnO NW can be electrically tuned by coupling it to a TMD based field-effect transistor. Besides the main idea and device architecture, I will present preliminary results of device fabrication and characterization. [1] M. Zapf, Nano Lett., 2017, 17 (11), 6637-6643 [2] E. Eobaldt, Nanoscale, 2022,14, 6822-6829.

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PT-Symmetry in Excitonic Spectra of TMDC Monolayers under Influence of Magnetic Fields — •Michiel Snoeken, Andreas Knorr, and Henry Mittenzwey — Nichtlineare Optik und Quantenelektronik, Institut für Physik und Astronomie (IFPA), Technische Universität Berlin, D-10623 Berlin, Germany

Excitons in TMDC monolayers under the influence of an in-plane magnetic field are theoretically studied. We demonstrate that in-plane magnetic fields induce a hybridization between spin-bright and spin-dark exciton transitions, resulting in a brightening of spin-dark excitons in optical experiments. We provide a thorough analytical characterization of the spectrum and demonstrate that, upon including dissipation, such a system can be interpreted as a gain-loss system as described in PT-symmetric quantum mechanics.

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Calculation of thermodynamic potentials and heat capacities of ScN , YN and Au_2InYb — •Clemens Vogel and Jens Kortus — TU Bergakademie Freiberg, Institut für Theoretische Physik

ScN and YN can be incorporated in AlN to improve piezoelectric properties and electromechanical coupling. The Heusler phase Au_2InYb is of interest due to its potential for thermoelectric properties. In this work we computed the thermodynamic potentials, the entropy, the specific heat capacities C_p and C_V, and the thermal expansion coefficient. The calculations were performed using DFT/DFPT in Quantum ESPRESSO (PBE-XC) using the quasi-harmonic approximation for phonons. C_p and C_V were determined over the range of 3-600 K, as well as entropy and thermal expansion coefficient; C_p exceeds the Dulong-Petit limit. For Au_2InYb, the projected density of states was also calculated, which reveals a strong $4f$ density of states near the Fermi level and indicating valence fluctuation (in agreement with experimental findings); the calculated heat capacities agree very well with the experimental measurements.

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Super-Resolution Terahertz Spectroscopy via Near-Field Electro-Optic Sampling — •Kevin Berwagner, Moritz Heindl, Fabian Brütting, and Georg Herink — Universität Bayreuth

Electro-optic sampling of THz radiation transmitted through a specimen provides a non-invasive way to analyze materials, however, the spatial resolution is typically constrained by the diffraction limit of the THz beam to a few hundred microns.

In this contribution, we will present our progress in developing a novel method for sampling pulsed terahertz fields with potentially submicron spatial resolution. Specifically, the approach is based on local imaging of THz nearfields via an electro-optic material in close contact with the specimen. In contrast to established near-field approaches, the method does not require the scanning of local probes such as SNOM or micro-antennas. We analyze phase-matching conditions and effective resolutions, and we demonstrate the super-resolution capabilities.

HL 26.51 Wed 9:30 P1

Highspeed ultrafast spectroscopy via active synchronization

of dual-comb lasers — •Simeon Schmitt, Julia Lang, and Georg Herink — University of Bayreuth, Germany

Dual-comb lasers enable ultrafast spectroscopic measurements at high speeds by generating optical delays without the motion of mechanical elements. According to the asynchronous optical sampling (ASOPS) scheme, pulses from two mode-locked lasers with detuned repetition rates are combined to automatically scan relative delays throughout the pulse period. In contrast, here, we present a novel approach which features flexible active synchronization of both lasers: Employing precisely timed electrical signals and fast electro-optical modulators, we achieve full control over the overall scanning process. This concentrates the scanning range to the region of interest by limiting it to several picoseconds, resulting in record fast scanning rates. Furthermore, the scanning resolution can be arbitrarily adjusted up to tens of THz by varying the repetition rate difference. We adopt this process to realize ultrafast acquisition speeds for rapid THz time domain spectroscopy and present first measurements.

HL 26.52 Wed 9:30 P1

Ultrafast negative thermal expansion in NbO_2 — •Florian Baltrusch[1], Marc Herzog[1], Florin Boariu[2], Matthias Rössle[2], Jutta Schwarzkopf[3], and Matias Bargheer[1,2] — [1]Institut für Physik und Astronomie, Universität Potsdam, Potsdam, Germany — [2]Helmholtz-Zentrum Berlin, Berlin, Germany — [3]Leibniz-Institut für Kristallzüchtung, Berlin, Germany

Niobium dioxide (NbO_2) exhibits negative thermal expansion (NTE), meaning it contracts upon heating rather than expanding like most materials. Below 200 K, bulk NbO_2 shows a monotonic contraction of the tetragonal c-axis, while the a/b-axes expand. This behaviour not only enables zero-expansion composites but also provides an unconventional elastic driving mechanism for magneto-elastic materials on picosecond timescales.

In epitaxial thin films, however, the lattice response is modified by substrate constraints via the Poisson effect. Temperature-dependent XRD measurements show that the film response depends strongly on the thermal-expansion mismatch between film and substrate during equilibrium heating.

Using ultrafast X-ray diffraction (UXRD), we directly observe ultrafast NTE in NbO_2 thin films. On picosecond timescales, the substrate remains effectively "frozen", allowing us to isolate the intrinsic response of the NbO_2 layer. This enables us to determine the timescale of contraction, which provides crucial insights about its driving mechanism.

HL 26.53 Wed 9:30 P1

Development of single-shot spectral referencing to increase signal-to-noise ratio in broadband 2D electronic spectroscopy — •Lotte Polling, Anton Trenczek, Pavel Trofimov, Trideep Kawde, and Hélène Seiler — FU Berlin

Two-dimensional optical spectroscopy is a powerful technique for resolving couplings between electronic states. Its implementation relies on the availability of a broadband light source in the visible range, typically generated using non-collinear optical parametric amplifiers or gas-filled hollow-core fibers. These sources exhibit shot-to-shot spectral fluctuations which can be as high as 10-15% depending on the laser source. Here, we introduce a setup for single-shot spectral referencing with the end goal of significantly increasing the signal-to-noise ratio in broadband 2D electronic spectroscopy measurements.

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Ultrafast Lattice Dynamics in Gold Beyond the Kinematic Approximation — •Helena Hollstein[1,2], Sebastian Hammer[2], and Heinrich Schwoerer[1] — [1]Max-Planck-Institut für Struktur und Dynamik der Materie, 22761 Hamburg, Germany — [2]Experimental Physics 6, University of Würzburg, 97074 Würzburg, Germany

In the interpretation of electron diffraction experiments, the kinematic scattering approximation and simple phonon models are often used to reduce computational cost when modeling structural dynamics [1]. However, even for well-studied benchmark systems such as polycrystalline gold thin films, it often remains unquestioned how reliably these assumptions hold under strong nonequilibrium excitation [2].

In this work, we investigate a 20 nm gold thin film under optical excitation using ultrafast electron diffraction (UED) and static temperature dependent electron diffraction to extract transient atomic displacements and determine phonon excitation by analyzing the Debye-Waller effect. We compare our experimental findings of lattice heating dynamics with simulated diffraction patterns that rely on kinematic scattering and harmonic phonon models. We hereby assess to what extent the commonly used theoretical frameworks cease to describe the structural response accurately. Our findings demonstrate that neglecting possible anharmonic potentials, phonon-phonon coupling and multiple scattering-effects can lead to systematic misinterpretations of ultrafast lattice dynamics and thermophysical material properties.

[1] Schäfer et al. *Chem. Phys. Lett.* **515** (2011)
[2] Durham et al. *Struct. Dyn.* **9** 064302 (2022)

HL 26.55 Wed 9:30 P1

Ultrafast dynamics of exciton–exciton interaction in monolayer MoS_2 investigated by high-order pump–probe microspectroscopy — •Ruidan Zhu, Patrick Grenzer, Simon Büttner, Matthias Hensen, Tobias Hertel, and Tobias Brixner — Institut für Physikalische und Theoretische Chemie, Universität Würzburg, Am Hubland, 97074 Würzburg, Germany

Exciton–exciton interaction (EEI), as a many-body effect, sets a fundamental limit to optimizing the photoluminescence efficiency of light-emitting devices based on 2D materials under high exciton densities [1]. A detailed understanding of the underlying EEI mechanisms provides crucial insight for the optimization of the device performance. However, EEI dynamics are challenging to probe directly as their signatures are mixed with the dominant single-exciton background in conventional ultrafast measurements. Here, we apply our recently developed high-order pump–probe spectroscopy [2] in a cryo-microscope to study exciton interaction in freestanding and supported MoS_2 monolayers. We aim to separate different EEI-related processes (fifth and higher orders of the system's nonlinear response) from the single-exciton dynamics (third order) and further investigate how the dielectric environment influences EEI dynamics. We present our current progress toward isolating EEI dynamics.

[1] Y. Yu et al., Phys. Rev. B 2016, 93, 201111.
[2] P. Malý et al., Nature 2023, 616, 280.

HL 26.56 Wed 9:30 P1

Impulsive Stimulated Raman Scattering: Highspeed Detection Strategies — •Laura Hüllmandel, Julia A. Lang, and Georg Herink — Universität Bayreuth

Pulse interaction of femtosecond pulses inside Ti:Sapphire lasers is mediated by Raman-active modes with terahertz beats causing bound states of solitons at fixed time delays [1]. In this contribution, we employ extra-cavity impulsive stimulated Raman scattering (ISRS) to quantitatively determine the phase-shifts involved to further our understanding of the intra-cavity formation of so-called “soliton molecules". We compare spectral-shift and interferometric methods for phase-sensitive detection and achieve efficient noise reduction of multiplicative $1/f$ noise sources – where lock-in amplification is ineffective – through rapid scan-averaging and balanced detection.

[1] A. Völkel et al., “Intracavity Raman Scattering Couples Soliton Molecules with Terahertz Phonons.“, Nature Communications 13.1 (2022).