Q 25: Solid State Quantum Optics

Time: Wednesday 11:00–13:00 Location: E001

Q 25.1 Wed 11:00 E001

Temperature annealing of hBN single-photon emitters in a nitrogen-rich atmosphere — •Nora Bahrami[1,2], Pablo Tieben[1,2], Janosch Stutenbaeumer[1], and Andreas W. Schell[1,2] — [1]Physikalisch-Technische Bundesanstalt, Braunschweig, Germany — [2]Gottfried Wilhelm Leibniz Universität, Hannover, Germany

Single-photon emitters (SPEs) are becoming increasingly important due to their diverse use in quantum photonics, such as quantum communication and metrology. Especially hexagonal boron nitride (hBN), a two-dimensional semiconductor material, has recently gained interest because of its remarkable optical properties, such as bright emission at room temperature across the visible and near infrared spectral range owing to the large bandgap of 6 eV. Nevertheless the nature of this emission, i.e., its atomic origin, is still undefined and fluorescence bleaching is an unfortunate occurrence for integrated applications, where stable emission is significant for further research. Therefore we evaluate a recipe to enhance the spectral characteristics in hBN flakes by high temperature annealing in a nitrogen-rich atmosphere. Individual emitters were characterized and compared on certain areas via photoluminescence mapping and by the analysis of g(2) -, saturation- and lifetime measurements as well as emission spectra before and after annealing. Our research opens up another step towards improving the optical properties of hBN.

Q 25.2 Wed 11:15 E001

Enhanced photon emission from hBN defects centers inside a tunable fiber-cavity — •Gregor Bayer[1], Florian Feuchtmayr[1], Stefan Häussler[1,2], Richard Waltrich[1], Noah Mendelson[3], Chi Li[3], David Hunger[4], Igor Aharonovich[3,5], and Alexander Kubanek[1,2] — [1]Inst. f. Quantenoptik, Uni Ulm, D — [2]Center f. Integ. Q. Science and Techn. (IQst), D — [3]School of Math./ Phys. Sciences, Univ. of Tech. Sydney, AUS — [4]Phys. Institut, Karlsruhe Inst. of Tech., D — [5]ARC Centre of Exc. f. Transf. Meta-Optical Systems, Univ. of Tech. Sydney, AUS

Coupling single quantum emitters to the mode of optical resonators is essential for the realization of quantum photonic devices. We present a hybrid system consisting of defect centers in a few-layer hexagonal boron nitride (hBN) sheet and a fiber-based Fabry-Pérot cavity. The smooth surface of the chemical vapor deposition grown hBN layers enables efficient integration into the cavity. This hybrid platform is operated over a broad spectral range of more than 30 nm. Owing to cavity funneling, large cavity-assisted signal enhancement up to 50-fold and strongly narrowed linewidths are demonstrated, a record for hBN-cavity systems. On top, we implement an excitation and readout scheme for resonant excitation, allowing to establish cavity-assisted photoluminescence excitation spectroscopy. In total, we reach a milestone for the deployment of 2D materials to fiber-based cavities in practical quantum technologies.

Q 25.3 Wed 11:30 E001

Mechanically Isolated Quantum Emitters in Hexagonal Boron Nitride. — •Patrick Maier[1], Andreas Tangemann[1], Michael Koch[1], Michael Höse[1], Igor Aharonovich[2], T.T. Tran[2], Niklas Lettner[1], Lukas Antoniuk[1], and Alexander Kubanek[1] — [1]University of Ulm, Germany — [2]University of Technology Sydney

Single Photon emitters are a crucial resource for novel photonic quantum technologies. Quantum emitters hosted in two-dimensional hexagonal Boron Nitride (hBN) are a promising candidate for the integration into hybrid quantum systems. One type of emitters hosted in hBN has shown the remarkable property of Fourier limited linewidths from cryogenic up to room temperatures. This property can be attributed to mechanically isolated orbitals of the defect centers, which do not couple to in-plane phonon modes. Here, we present our recent results towards identifying the origin of this mechanical decoupling, which could be caused by out-of-plane emitters. We also present quantum random number generations using the symmetric dipole emission profile of these emitters.

Q 25.4 Wed 11:45 E001

Super-Poissonian Light Statistics from Individual Silicon Vacancy Centers Coupled to a Laser-Written Diamond Waveguide — •Michael K. Koch[1,2], Michael Hoese[1], Vibhav Bharadwaj[1,3], Johannes Lang[1], John P. Hadden[4], Roberta Ramponi[3], Fedor Jelezko[1,2], Shane M. Eaton[3], and Alexander Kubanek[1,2] — [1]Ulm University, D-89081 Ulm, Germany — [2]IQst, Ulm University, D-89081 Ulm, Germany — [3]Institute for Photonics and Nanotechnologies (IFN) - CNR, Milano 20133, Italy — [4]School of Physics and Astronomy, Cardiff University, Cardiff CF24 3AA, United Kingdom

Light field engineering on the single photon level is a key challenge for future quantum technology. Ideally, it will be realized with integrated quantum photonics to ensure robustness and scalability. Here we present a system that combines single silicon vacancy centers (SiVs) with laser-written type II waveguides [1] in diamond. Typically, these waveguides exhibit low cooperativity at the single photon level due to their large mode volume. To overcome this limitation, we use a novel operational technique of waveguide-assisted detection and high numerical aperture excitation of SiV centers to achieve a strong non-linearity at the single photon level. We demonstrate single-emitter extinction measurements with a cooperativity of 0.0050 and a relative beta factor of 13% [2].

[1] M. Hoese et al., Phys. Rev. Applied 15, 054059 (2021)
[2] M. K. Koch et al., ACS Photonics 9, 3366-3373 (2022)

Q 25.5 Wed 12:00 E001

Cavity-enhanced extinction measurements of nanoscale structures — •Ines Amersdorffer[2,1], Florian Sigger[3], Thomas Hümmer[2,1], Jonathan Noé[2,1], Alexander Högele[1], Christoph Kastl[3], and David Hunger[4] — [1]Faculty of Physics, Ludwig-Maximilians-Universität Munich, Germany — [2]Qlibri GmbH, Munich, Germany — [3]Walter Schottky Institute and Physics Department, Technical University of Munich, Germany — [4]Physikalisches Institut, Karlsruhe Institute of Technology, Germany

Measurements of the marginal absorption of nanomaterials are challenging. One way to address this issue is the use of an optical resonator in which the light passes the sample multiple times and thereby enhances the absorption of nanoscale objects to a measurable amount. We demonstrate how a high-finesse microcavity can be utilised in order to measure the extinction of defects in monolayer MoS_2. Such atomistic defects embedded in nanomaterials are a promising candidate for single-photon sources. However, to make them optically accessible, it is beneficial to know their absorption properties. To this end, we performed wavelength-dependent extinction measurements. The absolute values of extinction were recorded with a detection limit of down to 0.01 % and agree with theoretical predictions. Furthermore, we show first insights from applying this novel microscopy technique to perovskite nanocubes. Spectroscopy on single perovskite crystals helps to pick and engineer them for suitable applications, e.g. LEDs. The results show advances towards routine hyperspectral absorption measurements on the nanoscale.

Q 25.6 Wed 12:15 E001

Simulation of waveguide coupled single and double layer graphene electro-optic modulators — •Pawan Kumar Dubey[1], Ashraful Islam Raju[1], Rasuole Lukose[1], Christian Wenger[1,2], and Mindaugas Lukosius[1] — [1]IHP- Leibniz Institut für innovative Mikroelektronik, Im Technologiepark 25, 15236 Frankfurt (Oder), Germany — [2]BTU Cottbus Senftenberg, Platz der Deutschen Einheit 1, 03046 Cottbus, Germany

On-chip integrated, graphene-based optical modulator has the advantages of a small device footprint, low power consumption and low drive voltage, enabling it to be used in micrometer-scale optical interconnect. One of the very first single-layer graphene modulator was experimentally demonstrated in 2011 by Liu et al.[1], with a modulation depth of 0.1db/μm and a 3dB bandwidth of 1.2 GHz. Over the decade, there have been improvements in the performance with the double-layer design, in which a dielectric layer between the two successive graphene layers was introduced. It has the potential to significantly improve modulation depth, modulation efficiency and bandwidth of the operation. In this study, we present simulated results about, ridge and buried waveguide coupled double layer graphene modulators along with the effect of material and thickness of spacer layer between two graphene layers. Our simulation demonstrates a modulation depth of, 0.17db/μm, which is 70% higher than the single-layer design. We also demonstrate a 3dB bandwidth of 40 GHz and power consumption less than 1Pj/bit.

Q 25.7 Wed 12:30 E001

Contactless sheet resistance measurements of thin III-V semiconductors by far-field terahertz reflectometry — •Konstantin Wenzel, Steffen Breuer, Robert B. Kohlhaas, and Lars Liebermeister — Fraunhofer Institute for Telecommunications, Heinrich Hertz Institute, Einsteinufer 37, 10587 Berlin, Germany

Measuring the electrical properties of thin semiconductor layers is crucial for the development of semiconductor devices. 4-point measurements, such as van-der-Pauw and Hall, determine these properties very accurately. However, since this method requires electrical contacts, the measurement location becomes unusable for further processing. At the same time, areas of the sample used for processing are not measured. Here, we present far-field terahertz (THz) reflectometry measurements as a contactless alternative for determining the sheet resistance with spatial resolution. We investigate various doped indium gallium arsenide samples epitaxially grown on indium phosphide substrates using THz time-domain spectrometry. We compare these measurements to standard 4-point measurements and discuss the limitations of our technique. The presented THz reflectometry allows non-contact and spatially resolved characterization of a broad spectrum of thin semiconductors, paving the way towards a new measurement technique for full-wafer characterization.

Q 25.8 Wed 12:45 E001

Valley polarization in pristine graphene with linearly polarised laser pulses — •Arkajyoti Maity, Ulf Saalmann, and Jan M. Rost — Max Planck Institute for the Physics of Complex Systems, Nöthnitzer Straße 38,01187 Dresden

Information processing using preferential excitation of one of the two energy degenerate valleys in inversion symmetry broken graphene-like systems has been achieved by circularly polarized pulses. These pulses couple differentially to the valleys which have opposite orbital angular momentum, depending on their polarization[1]. Recent studies have, however, shown that linearly polarised light pulses can generate appreciable valley polarization, even in pristine graphene, without breaking inversion symmetry at the Hamiltonian level[2]. In our presentation, we will shed some light on the general mechanisms of this process of valley polarization with ultrashort laser pulses. We also show results for the terahertz regime, in which graphene shows strong non-linear behavior, and discuss the role of electronic decoherences for such longer pulses.

[1]Di Xiao, Wang Yao, and Qian Niu. Valley-contrasting physics in graphene:Magnetic moment and topological transport. Phys. Rev. Lett., 99:236809,Dec 2007 [2]Hamed Koochaki Kelardeh, Ulf Saalmann, and Jan M. Rost. Ultrashortlaser-driven dynamics of massless dirac electrons generating valley polarization in graphene. Phys.Rev.Research, 4:L022014, Apr 2022