HL 42: Quantum Dots and Wires: Optics I

Time: Wednesday 16:45–18:30 Location: H17

Invited Talk HL 42.1 Wed 16:45 H17

Quantum key distribution with single photons from quantum dots — Joscha Hanel[1], •Jingzhong Yang[1], Jipeng Wang[1], Vincent Rehlinger[1], Zenghui Jiang[1], Frederik Benthin[1], Tom Fandrich[1], Jialiang Wang[1], Fabian Klingmann[2], Raphael Joos[3], Stephanie Bauer[3], Sascha Kolatschek[3], Ali Hreibi[4], Eddy. Patrick Rugeramigabo[1], Michael Jetter[3], Simone. Luca Portalupi[3], Michael Zopf[1,5], Peter Michler[3], Stefan Kueck[4], and Fei Ding[1,5] — [1]Leibniz Universität Hannover, Hannover, Germany — [2]Fraunhofer-Institut für Photonische Mikrosysteme, Dresden, Germany — [3]Institut für Halbleiteroptik und Funktionelle Grenzflächen, Center for Integrated Quantum Science and Technology (IQST) and SCoPE, University of Stuttgart, Stuttgart, Germany — [4]Physikalisch-Technische Bundesanstalt, Braunschweig, Germany — [5]Laboratorium für Nano-und Quantenengineering, Hannover, Germany

Quantum key distribution (QKD) ensures secure communication against eavesdroppers. On-demand quantum light sources, such as semiconductor quantum dots (QDs), enhance QKD security and loss tolerance due to their deterministic single-photon emission with high brightness and low multiphoton rates. Here, we demonstrate high-speed modulation of telecom C-band single photons emitted from a QD embedded in a circular Bragg grating. Using a phase-modulator in a Sagnac-loop interferometer, a 16-bit pseudo-random sequence is encoded into polarisation states in real time at a 76 MHz clock rate, achieving an ultra-low quantum bit error rate of ~1%.

HL 42.2 Wed 17:15 H17

Development and deterministic fabrication of electrically controlled quantum dot molecule bullseye resonators — •Setthanat Wijitpatima[1], Normen Auler[2], Binamra Shrestha[2], Sven Rodt[1], Arne Ludwig[3], Dirk Reuter[2], and Stephan Reitzenstein[1] — [1]Institute of Solid-State Physics, Technische Universität Berlin, D-10623 Berlin, Germany — [2]Department of Physics, Universität Paderborn, Warburger Str. 100, 33098 Paderborn, Germany — [3]Lehrstuhl für Angewandte Festkörperphysik, Ruhr-Universität Bochum, Universitätsstraße 150, 44780 Bochum, Germany

Quantum information can be encoded in the polarization states of photons as flying qubits and decoded in the spin states of solid-state systems as stationary qubits, providing robust platforms for quantum information processing. Quantum dot molecules (QDMs) are particularly promising for this purpose, as their singlet-triplet qubits are immune to spin dephasing, enabling temporally stable spin-photon interfaces. Toward real-world applications, QDM devices with high photon extraction efficiency (PEE) are required, motivating the integration of QDMs into nanophotonic structures, such as circular Bragg gratings (CBGs) which yield broadband enhancement of PEE and moderate Purcell enhancement. However, applying the CBG concept to QDMs has been challenging since precise electrical control is crucially needed to operate QDMs properly. In this work, we demonstrate the fabrication of QDM-CBG devices, providing a crucial step toward scalable and efficient quantum technologies.

HL 42.3 Wed 17:30 H17

Magnetic field dependence of the Auger recombination rate in a single quantum dot — •Nico Schwarz[1], Fabio Rimek[1], Hendrik Mannel[1], Marcel Zöllner[1], Britta Maib[1], Arne Ludwig[2], Andreas D. Wieck[2], Axel Lorke[1], and Martin Geller[1] — [1]Faculty of Physics and CENIDE, University Duisburg-Essen, Germany — [2]Chair of Applied Solid State Physics, Ruhr-University Bochum, Germany

In solid state physics, the quantum dot (QD) as a single photon emitter is an ideal system to study the Auger effect in a confined nanostructure. The Auger effect is an electron-electron scattering effect in which the energy of the electron-hole recombination is transferred to a third carrier, leading to a non- radiative recombination of, e.g., the trion [1]. This Auger recombination should be suppressed in high-photon-yield, low-dephasing single-photon emitters. We used two-color, time resolved resonance fluorescence spectroscopy with a high spectral resolution on a single quantum dot to differentiate between the differ- ent recombination paths: Auger, spin-flip and spin-flip Raman recombination [2]. We observe an unexpected behaviour of the Auger recombination rate, which shows a decrease from B = 0 to 2 T, followed by an increase to 4 T , before decreasing again by a factor of approx. three up to 8 T. These new findings may be the starting point for further theoretical and experimental studies to unterstand or even supress this scattering effect, in which the environment seems to play an important role. [1] P. Lochner et al., Nano Lett. **20**, 1631-1636 (2020). [2] H. Mannel et al., JAP **134**, 154304 (2023).

HL 42.4 Wed 17:45 H17

Studying the optical properties of AgInS2-based quanutm dots — •Yizhuo Xi, Julian Mann, Jochen Feldmann, and Sushant Ghimire — Chair for photonics and optoelectronics, Nano-institute Munich and department of physics, Ludwig-Maximilians-University, Königstr.10, 80539 Munich, Germany

I-III-VI quantum dots have attracted considerable interest for their non-toxic nature, tunable bandgap, and excellent stability. However, these quantum dots contain intrinsic sub-gap defects, which can act as donor-acceptor pairs. In this work, we synthesize AgInS2 quantum dots showing a dual emission spectrum. A narrow but weak free-exciton emission is observed near the band edge, while a broad and intense emission, associated with donor-acceptor-type defects, appears in the lower energy region. After coating the core particles with a gallium sulfide shell, the free-exciton luminescence is strongly improved, and the recombination at donor-acceptor pairs is suppressed. This demonstrates the successful elimination of defects in AgInS2/GaSx core/shell quantum dots, which is further evidenced in the absorption spectrum by the removal of a defect-related Urbach tail. In essence, we find that the donor-acceptor pair defects in these AgInS2 quantum dots are mainly located on the surface, and the excitonic character emerges upon their elimination through the growth of a gallium sulfide shell.

HL 42.5 Wed 18:00 H17

Deoxidization induced InAs(P) single photon emitter formation on InP substrate — •Yiteng Zhang[1], Xin Cao[1], Doaa Abdelbarey[1], Zenghui Jiang[1], Markus Etzkorn[2], Chenxi Ma[1], Tom Fandrich[1], Arijit Chakraborty[1], Tom Rakow[1], Eddy Rugeramigabo[1], Michael Zopf[1,3], and Fei Ding[1,3] — [1]Institut für Festkörperphysik, Leibniz Universität Hannover, Appelstraße 2, 30167, Hannover, Germany — [2]Technische Universität Braunschweig,LENA, Institut für Angewandte Physik, Universitätsplatz 2, 38106 Braunschweig — [3]Laboratorium für Nano- und Quantenengineering, Leibniz Universität Hannover, Schneiderberg 39, 30167, Hannover, Germany

Efficient quantum light sources at telecom O-band and C-band are essential for long-haul quantum communication to minimize photon dispersion and loss. While semiconductor quantum dots (QDs) grown by Stranski-Krastanov and droplet epitaxy methods show promise, their reproducibility is hindered by complex growth parameters. Here, we present a straightforward method to fabricate self-assembled InAs(P) QDs emitting single photons at telecom O-band using molecular beam epitaxy. By deoxidizing and annealing InP(001) substrates in an arsenic atmosphere, QDs form naturally without additional metal deposition. Statistical analysis reveals size distribution and density comparable to QDs from conventional methods. Cryogenic photoluminescence confirms single-photon emission. This approach offers a reproducible and efficient pathway to telecom-wavelength single-photon sources, advancing quantum information technologies.

HL 42.6 Wed 18:15 H17

Excitonic structure of G center computed by unfolded tight-binding model — •Jakub Valdhans[1] and Petr Klenovský[1,2] — [1]Masaryk University, Brno, Czech Republic — [2]Czech Metrology Institute, Brno, Czech Republic

We have studied the carbon G center in bulk silicon and germanium using the empirical tight-binding (ETB) model for calculating unfolded band structures with configuration interaction (CI) correction for an exciton. The G center in B configuration (emissive) being a candidate for a telecom single photon source has two substitutional carbons and one interstitial atom embedded in the bulk for 6 possible configurations. Using advantage of low computation effort of ETB, it is possible to calculate and analyze behavior of electronic transitions with respect to a variation of bond distance between substitutional carbons and interstitial atom, and with using band offset as external tuning parameter.