HL 27: Quantum Dots and Wires: Optics II

Time: Wednesday 9:30–11:30 Location: EW 202

HL 27.1 Wed 9:30 EW 202

Single mode coupled emission of resonant and cw excited GaAs quantum dots — •Martin Kernbach[1], Sophia Fuchs[2], Julian Siller[2], and Andreas W. Schell[1] — [1]Johannes Kepler University Linz — [2]Leibniz University Hannover

Advanced quantum technologies like computing or sensing demand for deterministic bright sources of single indistinguishable photons. In order to provide quantum light of isolated systems properly usable for quantum applications, an efficient excitation and extensive collection in a single mode is required. Single molecules and cavity confined quantum dots are convenient sources. The coupling to the excited state is maximized on resonance, but challenges the usability of the emitter due to the effort for separation of the optical excitation mode from the mode of emission. A temporal, spacial, spectral, or combined method for separation is typically used.

Here we present a realization of a single emitter under resonant excitation in a confocal setup with a polarization filtered emission coupled into a single mode fiber. The optical path is free beam along a one meter long stick which dives the objective lens and scanning stage into a liquid helium reservoir. For resonant cw excitation of GaAs semiconductor quantum dots a SNR of polarization suppression up to 400 and count rates of 2 Mcps are archived by using a collecting lens with NA 0.68 only. Under this scheme further investigations regarding the blinking behavior are possible as well as probing alternative emitters like single molecules.

HL 27.2 Wed 9:45 EW 202

Diameter dependence of light absorption enhancement in GaAs nanowires evidenced by photoluminescence spectroscopy — •Francisca Marín, Ijaas Mohamed, Oliver Brandt, and Lutz Geelhaar — Paul-Drude-Institut für Festkörperelektronik, Leibniz-Institut im Forschungsverbund Berlin e. V., Hausvogteiplatz 5-7, 10117 Berlin, Germany

Semiconductor nanowires have attracted increasing interest for photovoltaic applications, among other reasons because the absorption of light can be enhanced compared to planar layers by the appropriate geometric design of nanowire arrays. This benefit is due to the more complex coupling of light with nanowires whose dimensions are of similar scale as the light wavelength. In fact, light absorption in nanowire arrays depends sensitively on the combination of wavelength and nanowire diameter, spacing, as well as length. This phenomenon has been extensively investigated by simulations, but experimentally it is challenging to probe light absorption in nanowires, in particular in single nanowires. Here, we use photoluminescence spectroscopy to study the effect of the diameter of highly phase-pure GaAs nanowires on light absorption. Our key idea is that the nature of carrier recombination depends on carrier density, which in turn is affected by the absorption of the exciting laser light. We investigated nanowires with diameters in the range 60-160 nm and find a clear absorption enhancement with a maximum for a diameter of 80 nm.

HL 27.3 Wed 10:00 EW 202

Improving the Positioning Accuracy of Quantum Dots in Circular Bragg Grating Resonators Using Hyperspectral Imaging — •Constantin Krause, Quirin Buchinger, Aileen Zhang, Giora Peniakov, Andreas Pfenning, Tobias Huber-Loyola, and Sven Höfling — Julius-Maximilians-Universität Würzburg, Lehrstuhl für Technische Physik, Würzburg, Deutschland

Self-assembled semiconductor quantum dots (QDs) are a well-studied source of single or entangled photons. To enhance their emission properties, QDs can be embedded in micro resonators, e.g. circular Bragg grating resonators (CBGs). To select QDs with the desired wavelength and determine their position, we use hyperspectral imaging. With this method the QDs are first mapped and subsequently the CBGs are defined via E-beam lithography.

To increase our measurement efficiency, we developed a fully automated measurement routine that allows us to measure twice the area in the same amount of time. We reduced the image distortion by modifying our setup and we investigated various designs of markers that we use to span a reference coordinate system. These improvements have increased the positioning accuracy of the QDs, enabling us to observe systematic errors in the position determination. We compensated for these errors using post-processing image correction algorithms. This further increased the positioning accuracy of the CBGs around the QDs to around 20 nm. We demonstrate the increased accuracy with measurements on InGaAs QDs embedded in a GaAs membrane.

HL 27.4 Wed 10:15 EW 202

Investigation of Purcell Enhancement of Telecom-Wavelength Semiconductor Quantum Dots in Open Cavities — •Nam Tran[1], Julian Maisch[1], Jonas Grammel[2], Julia Wecker[1], Thomas Herzog[1], Robert Sittig[1], Ponraj Vijayan[1], Michael Jetter[1], Simone Luca Portalupi[1], David Hunger[2], and Peter Michler[1] — [1]Institut für Halbleiteroptik und Funktionelle Grenzflächen, Center for Integrated Quantum Science and Technology (IQ^{ST}) and SCoPE, University of Stuttgart, — [2]Physikalisches Institut, Karlsruher Institut für Technologie (KIT), Karlsruhe,

Single photon sources operating at telecom wavelength play a central role in quantum information, in particular when long-distance implementations are targeted. Highly promising candidates are semiconductor quantum dots (QD). Cavity quantum electrodynamics is often used to tailor the emission properties and, in case of photon sources, enhance their performances. However, limiting factors like spatial and spectral mismatch can be detrimental to the cavity-emitter interaction. Using open, tunable fiber cavities one can overcome these limitations. Here, we made a thorough investigation on how the ratio between the cavity and emitter linewidth, and unwanted mechanical vibrations can affect the achievable Purcell factor in open fiber/ semiconductor cavities embedding semiconductor QDs emitting in the telecom O- and C-band. Moreover, deterministic positioning of individual QDs enables the direct comparison of the optical properties within and outside the cavity.

15 min. break

HL 27.5 Wed 10:45 EW 202

Quantum dot single-photon source in the telecom C-band with high brightness and indistinguishability — •Wolfgang Fischer, Raphael Joos, Stephanie Bauer, Christian Rupp, Ponraj Vijayan, Michael Jetter, Simone L. Portalupi, and Peter Michler — Institut für Halbleiteroptik und Funktionelle Grenzflächen (IHFG), Center for Integrated Quantum Science and Technology (IQST) and SCoPE, Universität Stuttgart, Allmandring 3, 70569 Stuttgart, Germany

High efficiency sources of non-classical light in the telecom C-band represent a key building block in long-distance, fiber-based, quantum technology implementations, as quantum information and cryptography. Bright emission of pure single photons, with high coherence represent properties generally required in those quantum applications. In this work, we present a telecom C-band single-photon source consisting of an InGaAs quantum dot (QD) coupled to a circular Bragg grating (CBG). Under coherent excitation via the SUPER scheme as well as under incoherent, phonon-assisted excitation a high single photon purity as well as an excellent brightness is achieved. Simultaneously, a high indistinguishability is shown, supported by the CBG causing a Purcell enhancement. In order to further boost the indistinguishability, we implement a sub-GHz etalon filter representing the line width of the filtered source. Consequently, a further improvement of the indistinguishability as well as single photon purity is observed combined with still high brightness [1]. [1] Joos, R., arXiv:2310.20647v1, 2023

HL 27.6 Wed 11:00 EW 202

Sending polarization-entangled photon pairs from semiconductor quantum dots through telecommunication fiber networks — •Stefan Kazmaier[1], Tim Strobel[1], Tobias Bauer[2], Marlon Schäfer[2], Ankita Choudhary[3], Nand Lal Sharma[3], Raphael Joos[1], Cornelius Nawrath[1], Weijie Nie[3], Ghata Bhayani[3], Andre Bisquerra[1], Caspar Hopfmann[3], Simone L. Portalupi[1], Christoph Becher[2], and Peter Michler[1] — [1]Institut für Halbleiteroptik und Funktionelle Grenzflächen, Center for Integrated Science and Technology (IQ^{ST}) and SCoPE, University of Stuttgart, Allmandring 3, 70569 Stuttgart, Germany — [2]Fachrichtung Physik, Universität des Saarlandes, Campus E2.6, 66123 Saarbrücken, Germany — [3]Institute for Integrative Nanosciences, Leibniz IFW

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Enabling fiber-based distribution of entangled single photons is crucial for advancing quantum repeater-based quantum communication. Semiconductor quantum dots (QDs) offer on-demand polarization-entangled photon pairs, but their near-infrared emission hinders telecommunication network compatibility. Here, compatibility is achieved by employing quantum frequency conversion (QFC). We show the conservation of polarization entanglement after QFC of the biexciton emission, making it compatible to telecommunication networks. This is utilized to prove high entanglement fidelity after propagation through a 35 km urban fiber network. Also, entanglement conservation is cofirmed after back conversion in a second QFC to 780 nm preparing an interface for a Rb-based quantum memory.

HL 27.7 Wed 11:15 EW 202

Progress in Telecom C Band Single Photons from Semiconductor Quantum Dots — •Daniel Vajner[1], Paweł Holewa[2,3], Emilia Zieba-Ostój[2], Maja Wasiluk[2], Martin van Helversen[1], Lucas Rickert[1], Aurimas Sakanas[4], Alexander Huck[3], Kresten Yvind[3], Niels Gregersen[3], Anna Musiał[2], Paweł Mrowinski[2], Marcin Syperek[2], Elizaveta Semenova[1,3], and Tobias Heindel[1] — [1]Institute of Solid State Physics, Technical University of Berlin, 10623 Berlin, Germany — [2]Wrocław University of Science and Technology, Wyb. Wyspiańskiego 27, 50-370 Wrocław, Poland — [3]Technical University of Denmark, Kongens Lyngby 2800, Denmark — [4]Quantum Foundry Copenhagen

We report progress towards high quality semiconductor quantum dot single photons at Telecom C-band wavelengths. This includes recent work demonstrating the coherent on-demand generation of indistinguishable photons from single QD devices consisting of InAs/InP QD-mesa structures heterogeneously integrated with a metallic reflector on a silicon wafer [1]. Furthermore, we show new experimental results which extend the employed two-photon-resonant excitation by using chirped excitation laser pulses as well as by adding a stimulation laser pulse resonant with the biexciton.

[1] Vajner, Daniel A., et al. arXiv preprint arXiv:2306.08668 (2023).