HL 44: Quantum Dots: Optical Properties II

Time: Tuesday 14:45–16:00 Location: POT 81

HL 44.1 Tue 14:45 POT 81

Quantum Light Sources based on Quantum-Dot Biexcitons — •Dirk Heinze, Dominik Breddermann, Artur Zrenner, and Stefan Schumacher — Department of Physics and CeOPP, Warburger Strasse 100, Paderborn, Germany

Quantum dot biexcitons show great potential as sources of quantum light. In this work we study the possibilities of two photon emission from a biexciton to generate both polarization-entangled photon pairs and all optically controllable single photons. Using a high-Q cavity we show theoretically that biexcitons can decay by simultaneously emitting two degenerate and polarization-entangled photons. The degree of entanglement is insensitive to the fine-structure splitting of the excitons due to the nature of the two-photon decay of the biexciton[1]. We demonstrate that this process is robust against phonon-assisted cavity feeding at low temperatures[2]. A partly stimulated partly spontaneous two photon emission from the biexciton can further be used to generate single photons with all optically tailored properties, such as polarization, frequency and time of emission [3],[4]. Here, the first photon is stimulated by a classical light field which drives the system into an intermediate virtual state from which the second single photon is emitted as the system relaxes into its ground state. This scheme does not rely on cavity enhancement, however the probability of emitting the single photon can be enhanced if the photon is emitted into a cavity. [1] S. Schumacher et al., Opt. Express 20, 5335-5342 (2012). [2] D. Heinze et al., arXiv:1611.04328 (2016). [3] D. Heinze et al., Nat. Commun. 6,8473 (2015). [4] D. Breddermann et al., Phys. Rev. B 94, 165310 (2016).

HL 44.2 Tue 15:00 POT 81

Strain tuning of deterministic quantum dot devices — •Esra Burcu Yarar Tauscher, Sarah Fischbach, Alexander Schlehahn, Arsenty Kaganski, Sven Rodt, Tobias Heindel, and Stephan Reitzenstein — Institut für Festkörperphysik, Technische Universität Berlin, 10623 Berlin, Germany

Quantum light sources (QLSs) are building blocks for future quantum communication technologies. In recent years, significant progress has been achieved in this field, however, still most of the realized structures are based on spatially and spectrally random distributions of quantum emitters. In this regard, it is highly attractive to develop advanced technology platforms ensuring the precise control of the emitter's properties in deterministically fabricated devices. Self-assembled semiconductor quantum dots (QDs) integrated by in-situ electron-beam lithography into monolithic microstructures are very promising candidates to realize such high performance single photon sources. In this work we report on external strain tuning of deterministically fabricated single-QD devices. For this purpose, we apply voltage control to a ferroelectric material bonded to the single-QD microstructure via thermo-compression gold bonding. This allows us to reproducibly tune the optical properties of QDs, i.e. the emission and binding energies of excitonic complexes. Furthermore, we employ active electric feedback-control enabling long term stability of the emission energy of individual QDs. Our approach, which combines for the first time a deterministic device technology with piezo-tuning capabilities, offers high potential for the realization of bright QLSs with a complete control of their optical properties.

HL 44.3 Tue 15:15 POT 81

Wigner time delay — •Max Strauss[1], Christian Schneider[2], Martin Kamp[2], Sven Höfling[2,3], Janik Wolters[4], and Stephan Reitzenstein[1] — [1]TU Berlin — [2]Universität Würzburg — [3]University of St Andrews — [4]Universität Basel

The Heitler regime of resonance fluorescence, i.e. the low power regime of optical excitation of a two-level system (TLS), has recently been an active field of research because it offers single photons with intriguing properties. Here, we report on the first experimental study of the Wigner time delay on a semiconductor quantum dot, a solid state TLS. We show experimentally that in the Heitler regime, pulses long compared to T_1, the lifetime of the emitter, are scattered almost undistortedly while being delayed in time with respect to the exciting pulse. This time delay, also called the Wigner time delay, can reach a maximum value of T_2, the dephasing time of the quantum emitter, and is closely connected to the phase lag induced by the TLS.

HL 44.4 Tue 15:30 POT 81

Light-trapping and Waveguide Characteristics of Selective Area Grown GaN Nanowires on Transparent Substrates — •Richard Hudeczek, Julia Winnerl, and Martin Stutzmann — Walter Schottky Institut, Garching bei München, Germany

During the last decade group-III-nitride nanowires (NWs) have attracted increasing interest for device fabrication due to their high crystalline quality, e.g. for optoelectronic devices. Their large surface-to-volume ratio is advantageous for sensing or catalysis applications. Another interesting aspect is that NWs constitute intrinsic waveguides because of their one-dimensional geometry. The control of the NW density and diameter is essential for the reproducible fabrication of NW-based devices. The position-controlled growth of GaN NWs by molecular beam epitaxy can be achieved by using a patterned Ti mask as already reported by several groups [1,2].

Here, we present optical measurements of selective area grown GaN NWs on transparent substrates, e.g. c-plane sapphire and GaN based light emitting diode substrates. This allows backside illumination of as-grown NW arrays through the growth substrate. In particular, the dependence of the light trapping on the NW diameter (ranging from 70 to 220 nm), NW period which is varied between 300 and 2000 nm and the illumination wavelength (in the range of 400 to 620 nm) is investigated. Moreover, the experimental findings are compared to numerical simulations.

[1] K. Kishino, et al., J. Crystal Growth 311, 2063 (2009)
[2] F. Schuster, et al., Nano Lett. 15, 1773 (2015)

HL 44.5 Tue 15:45 POT 81

Ion-induced interdiffusion in self-assembled surface GaN quantum dots — •Charlotte Rothfuchs[1], Fabrice Semond[2], Marc Portail[2], Olivier Tottereau[2], Aimeric Courville[2], Andreas D. Wieck[1], and Arne Ludwig[1] — [1]Angewandte Festkörperphysik, Ruhr-Universität Bochum, D-44780 Bochum — [2]CNRS-CRHEA, F-06560 Valbonne

In the growing field of quantum communication, there is a great demand for spin qubits and single photon sources, for which single electrically and optically active quantum dots (QDs) are prospering candidates. Providing high stability and room-temperature operation, GaN self-assembled QDs have a great appeal for these quantum technology applications. One possible pathway towards the realization of single QDs could be a top-down process using focused ion beam (FIB) implantation to post-select self-assembled molecular beam epitaxy-grown QDs. It is based on the disabling of all QDs around an intentional one by a creation of non-radiative defects. Further, magnetic impurities could be incorporated by FIB with low fluences in the non-disabled QDs for spin control. Here, we present a study on hexagonal surface GaN QDs subjected to a 100 keV gallium and a 210 keV erbium ion beam. The QDs morphology is analyzed by atomic force and scanning electron microscopy concerning their size and density. Strong diffusion processes upon ion impact at the interfaces are observed and described by a fluence-dependent model. Besides, cathodoluminescence measurements are discussed in order to investigate the ion impact on the optical properties of the QDs, influenced by the quantum confined Stark effect.