TT 64: Quantum Dots: Optical Properties I (organized by HL)

Time: Wednesday 9:30–11:15 Location: POT 251

TT 64.1 Wed 9:30 POT 251

Single line emission of InGaN quantum dots grown on AlGaN templates — •Elahe Zakizadeh, Carsten Laurus, Stephan Figge, Timo Aschenbrenner, Kathrin Sebald, Jürgen Gutowski, and Detlef Hommel — Institute of Solid State Physics, University of Bremen, Germany

InGaN quantum dots (QDs) are a good candidates for realizing single-photon emission in the blue to green spectral region at elevated temperatures, because of the large bandgap and high exciton binding energies of the nitrides. Up to now, temperature dependent measurements demonstrate thermal stability up to 150 K of the emission of a single InGaN quantum dot grown on GaN template.

In order to achieve single-line emission at even higher temperatures, an enhancement of the carrier confinement in the quantum dots is needed. This can be realized by growing InGaN quantum dots on AlGaN templates by metal organic vaper phase epitaxy.

In this contribution we present the optical properties of single InGaN quantum dots achieved by the micro-photoluminescence measurements. The thermal stability of the emission lines and their dependance on the excitation density will be discussed.

TT 64.2 Wed 9:45 POT 251

Electronic coupling and luminescence dynamics of hybrid inorganic core/organic shell nanostructures — •Stephanie Bley, Michael Diez, Angelina Vogt, Jürgen Gutowski, and Tobias Voss — Institute of Solid State Physics, Semiconductor Optics, University of Bremen, 28359 Bremen, Germany

Hybrid core/shell nanostructures allow for spectral tuning of light emission and absorption processes what is of substantial interest for light-sensing and energy harvesting applications. Here, we study the luminescence decay dynamics of colloidal CdSe quantum dots (QDs) in different solvents and on different semiconducting and insulating surfaces. The QDs are optically excited with light from an optical parametric amplifier pumped by a Ti:Sapphire laser system. The time resolved luminescence signal is detected using a streak camera. The radiative recombination processes in the quantum dots attached to different three-dimensional nanostructure surfaces can be strongly influenced by different electron tunneling processes from excited states of the quantum dots into the conduction band of the nanostructures. In this context the experimental results show that different solvents and materials significantly change the decay process of the QDs. Possible reasons for decay time variations, including different polarities of solvents and dielectric constants of the solids, will be discussed.

TT 64.3 Wed 10:00 POT 251

Cubic GaN/AlN quantum dots - Characterization of individual emission lines — •Dmitrij Bostanjoglo[1], Gordon Callsen[1], Stefan Kalinowski[1], Gerald Hönig[1], Matthias Bürger[2], Donat As[2], Toni Markurt[3], Martin Albrecht[3], Andrei Schliwa[1], Stephan Reitzenstein[1], and Axel Hoffmann[1] — [1]TU Berlin, Germany — [2]Universität Paderborn, Germany — [3]Leibniz Institut für Kristallzüchtung, Germany

Group III-nitride quantum dots (QDs) with a wurtzite crystal structure (WZ) are plagued by a large spatial electron-hole separation, due to built-in pyro- and piezoelectric fields. As a consequence, one observes large excitonic lifetimes from the ns- up to the us-range in such QDs accompanied by a strong reduction of the overall light output. As most natural alternative to the WZ QDs one can examine their zincblende (ZB) counterparts. By growing nitride QDs onto ZB substrates such as 3C-SiC, the metastable ZB structure can be stabilized leading to the absence of spontaneous and a reduced piezoelectric polarization. Hence, a drastic reduction of the excitonic lifetime down to the 100 ps regime is observed. However, prior studies lack an interpretation of the physical origin of the observed emission lines. We examined the ZB GaN/AlN QDs in a time-resolved microphotoluminescence setup. The measured decay times of all occurring excitonic complexes yield values from 100 ps up to 5 ns. This observation clearly demonstrates an enhanced charge carrier overlap. Our conclusive identification of the emission lines is supported by an analysis of the power- and polarization-dependence of all occurring emission lines.

TT 64.4 Wed 10:15 POT 251

Observation of carrier relaxation dynamics in Quantum Dot Excited State Laser — Holger Schmeckebier[1], Dejan Arsenijevic[1], Dieter Bimberg[1], •Bastian Herzog[2], Yücel Kaptan[2], Nina Owschimikow[2], Ulrike Woggon[2], Vissarion Mikhelashvili[3], and Gadi Eisenstein[3] — [1]Institute of Solid-State Physics, Technical University Berlin, Germany — [2]Institute of Optics and Atomic Physics, Technical University Berlin, Germany — [3]Electrical Engineering Dept. Technion - Israel Institute of Technology, Haifa, Israel

Single- and two-color Heterodyne pump-probe measurements were used to investigate the carrier dynamics of an InAs/InGaAs quantum dot based excited state laser at room temperature. Our main attention has been attracted by the excitonic ground state relaxation dynamics before and after the onset of excited state lasing, giving information about possible carrier relaxation paths. We found an ultrafast recovery with higher device currents, showing no change at and above the excited state lasing threshold. This could be an indication for a decoupling of the ground state gain recovery from the excited state gain dynamics. Two-color pump-probe experiments were performed to identify the excited state and ground state sub-ensemble belonging to the equal dot sub-ensemble.

TT 64.5 Wed 10:30 POT 251

Deterministic fabrication of quantum-dot microlenses for enhanced photon extraction efficiencies — •Manuel Gschrey, Marc Seifried, Luzy Krüger, Jan-Hindrik Schulze, Tobias Heindel, Sven Rodt, André Strittmatter, and Stephan Reitzenstein — Institut für Festkörperphysik, Technische Universität Berlin, Hardenbergstraße 36, D-10623, Germany

The realization of building blocks for long-distance quantum communication is a major driving force for the development of advanced nanophotonic devices, like efficient quantum-dot-based single-photon sources. One major challenge of a deterministic device fabrication using self-assembled quantum dots (QDs) results from their random growth, which reduces the yield of usable nanophotonic devices. Another issue is the low extraction efficiency (EE), due to the high refractive index of the surrounding semiconductor material, where total internal reflection at the surface occurs already for very small angles. To overcome these obstacles we apply a recently developed cathodoluminescence (CL) lithography technique [1] to fabricate and position microlenses on top of preselected single InGaAs QDs. This in-situ lithography technique is based on low-temperature CL spectroscopy, to identify the spectral features and spatial positions of the statistically grown QDs, prior to the lithography step. To obtain optimum EE, the position and shape of the lens is directly taylored in the CL-system by means of 3D electron-beam lithography. By using this technique we fabricated microlenses that allow for a sixfold increase in EE as compared to plain surfaces - [1] M. Gschrey et al., APL 102, 251113 (2013).

TT 64.6 Wed 10:45 POT 251

Non-resonant and resonant optical spectroscopy of single self-assembled quantum dots, weakly coupled to a two dimensional electron gas — •Annika Kurzmann[1], Benjamin Merkel[1], Arne Ludwig[2], Andreas Wieck[2], Axel Lorke[1], and Martin Geller[1] — [1]Faculty of Physics and CeNIDE, University of Duisburg-Essen, Lotharstr. 1, 47057 Duisburg, Germany — [2]Chair of Applied Solid State Physics, Ruhr-Universitaet Bochum, Universitaetsstr. 150, 44780 Bochum, Germany

Self-assembled quantum dots (QDs) are promising candidates for single-photon sources and as hosts for spin qubits. For such applications, the QDs are often embedded in a diode structure which allows controlled charging by tunneling of electrons from a 3D, n-doped reservoir, with fast tunneling times in the order of nanoseconds. Here we show results from photoluminescence, differential reflection, resonant fluorescence, and correlation measurements on a single InAs QD, coupled weakly (tunneling times in the order of milliseconds) to a two-dimensional electron gas (2DEG).

By tuning the electrical field, we are able to occupy the QDs with single charge resolution and observe different excitonic emission lines simultaneously over a large voltage range under non-resonant excitation.

This unusual behavior can be explained by auto- and cross-correlation measurements of the exciton and trion recombination line and resonant optical measurements, which give in sight into the capture rates of electrons and holes into the dot states.

TT 64.7 Wed 11:00 POT 251

Charge noise and spin noise in a semiconductor quantum device — •Andreas Kuhlmann[1], Jonathan Prechtel[1], Julien Houel[1], Arne Ludwig[1,2], Dirk Reuter[2], Andreas Wieck[2], Martino Poggio[1], and Richard Warburton[1] — [1]University of Basel, Switzerland — [2]Ruhr-Universität Bochum, Germany

Self-assembled QDs are potentially excellent single-photon sources. The linewidths are in the best case a factor of two larger than the transform-limit. Optimizing performance demands an understanding of noise and a strategy to circumvent its deleterious effects.

There are two sources of noise inherent to the semiconductor: charge noise and spin noise[1]. We present an investigation of noise in an ultra-clean semiconductor quantum device, using a minimally-invasive, ultra-sensitive, local probe: resonance fluorescence from a single QD. We present noise spectra with 6 decades of resolution in the noise power over 6 decades of frequency, from 0.1 Hz to 100 kHz. Significantly, we have discovered a spectroscopic way to distinguish charge noise from spin noise. We present a dynamic feedback technique to remove charge noise from the device[2]. We show that nuclear spin noise is the dominant dephasing mechanism that limits performance as a single-photon source. For the charged exciton, we demonstrate a significant decrease in the spin noise with resonant laser excitation. This noise reduction for the charged exciton is exploited to demonstrate transform-limited optical linewidths even when the measurement is performed very slowly.

[1] A. V. Kuhlmann et al., Nature Phys. 9, 570 (2013). [2] J. H. Prechtel et al., Phys. Rev. X 3, 041006 (2013).