HL 97: Quantum Dots and Wires: Optical Properties IV (mainly Nitrides)

Time: Friday 10:00–11:30 Location: ER 270

HL 97.1 Fri 10:00 ER 270

Exciton-Phonon coupling in single GaN quantum dots — •Juri Brunnmeier[1], Gordon Callsen[1], Andrei Schliwa[1], Johannes Settke[1], Christian Kindel[1], Erik Stock[1], Satoshi Kako[2], Yasuhiko Arakawa[2], and Axel Hoffmann[1] — [1]Institut für Festkörperphysik, Technische Universität Berlin, Germany — [2]Institute of Industrial Science, University of Tokyo, Japan

Recently, single photon emission of MOCVD grown GaN quantum dots embedded in an AlN matrix was observed at elevated temperatures ($>$ 200 K) which represents a strong technological advantage in comparison to the well established system of arsenide quantum dots. However, to this day single photon emission of GaN quantum dots at room temperature seems to be hindered by a combination of various effects as the excitonic interaction with defects situated in the vicinity of the GaN quantum dot and a comparably strong exciton-phonon interaction. As a measure of the exciton-LO-phonon coupling strength we determine Huang-Rhys factors between 0.02 and 0.3, scaling with the size of the individual quantum dot, it's emission energy and the related dipole-moment, which is up to 3 orders of magnitude larger than in the arsenide quantum dot system. Furthermore, we compare measured values for the Huang-Rhys factor for a statistically valid ($>$ 100) number of single GaN quantum dots with eight-band k·p model based calculations. As a result we gain detailed insight into the strong piezo- and pyroelectrical fields which are characteristic for wurzite GaN/AlN quantum dots.

HL 97.2 Fri 10:15 ER 270

Modeling polar exciton-LO-phonon interaction in GaN/AlN quantum dots — •Johannes Settke, Andrei Schliwa, Gordon Callsen, Juri Brunnmeier, Axel Hoffmann, and Christian Thomsen — Institut für Festkörperphysik, Technische Universität Berlin, Germany

Recently, strong exciton-LO-phonon interaction for epitaxial GaN/AlN quantum dots (QD) was observed experimentally by analyzing the LO-phonon sidebands of single-QD excitonic peaks. Depending on the exciton energy, ranging from 3 eV to 4.5 eV, values of the Huang-Rhys parameter S between 0.3 and 0.02 were deduced. Since the polar coupling strength (described by S) for an exciton is proportional to the squared absolute value of the Fourier transformed difference of the probability densities of the electron and hole, S provides a measure for the electron-hole separation.

GaN/AlN QDs are well known for their strong intrinsic piezo- and pyroelectrical fields along the c-axis, giving rise to excitonic charge separation analogous the quantum confined Stark effect. As this charge separation is known to be dependent on the QD height, it should be mirrored by a variation of the parameter S.

Here, we calculate the Huang-Rhys parameter for the ground-state exciton as function of size and composition using a strain dependent 3D implementation of the eight-band **k·p** model taking into account piezo- and pyroelectric effects in the adiabatic approximation. We discuss the interrelation of QD size, built-in fields, exciton energy, dipole-moment and Huang-Rhys parameter S.

HL 97.3 Fri 10:30 ER 270

Strong dipole coupling in nonpolar nitride quantum dots due to Coulomb effects — •Kolja Schuh[1], Steffan Barthel[1], Oliver Marquardt[2], Gerd Czycholl[1], and Frank Jahnke[1] — [1]Institute for Theoretical Physics, University of Bremen, Germany — [2]Tyndall National Institute, Lee Maltings, Cork, Ireland

Due to their wide-range of emission frequencies nitride-based optoelectronic devices are of current interest. However, a major drawback in nitrides is that the optical recombination is hindered by strong intrinsic fields that causes a separation of electrons and holes. In quantum wells, this effect can be avoided by enforcing a nonpolar growth direction, which ensures the absence of fields in the confined direction. However, since quantum-dot states are confined in all directions, there is always a separation of electrons and holes.

We show that in nonpolar nitride quantum dots the dipole transition between the single-particle ground states is only of minor importance for optical spectra. This spectra are dominated by many higher excited single-particle states which contribute to the ground-state transition when taking into account the Coulomb interaction. This finding may resolve existing discrepancies between theory and experiment, as theoretically only a weak ground state transition was obtained because of the spatial seperation of electron and hole ground state due to intrinsic fields, whereas experimentally fast recombinations were observed. Our treatment combines a continuum elasticity approach for the polarization potential, a microscopic tight-binding model for the electronic properties, and a many-body theory for the optical properties.

HL 97.4 Fri 10:45 ER 270

Photoluminescence response of Si doped GaN nanowires to pH variations — •Jens Wallys[1], Florian Furtmayr[1,2], Sebastian Koslowski[1], Jörg Schörmann[1], Jörg Teubert[1], and Martin Eickhoff[1] — [1]I. Physikalisches Institut, Justus-Liebig-Universität Gießen, — [2]Walter Schottky Institut, Technische Universität München

GaN nanowires (NWs) feature a low density of structural defects, a high surface to volume ratio and an excellent electrochemical stability. Due to these properties they appear as promising candidates for photo electrochemical water splitting and electrochemical sensing.

In this contribution we present photoluminescence (PL) measurements performed on Si-doped GaN NW ensembles in contact with a physiological electrolyte solution of different pH. We demonstrate that the PL response to the ion concentration can be controlled by application of an external bias in a three electrode setup. A systematic investigation reveals a correlation of the pH-response with the Si-doping concentration and the average NW diameter.

The related response mechanism will be discussed in terms of surface band bending, NW diameter, external bias and non-radiative processes.

HL 97.5 Fri 11:00 ER 270

Luminescence properties of InGaN quantum dots embedded in GaN nanowires — •Pascal Becker[1], Max Kracht[1], Florian Furtmayr[1,2], Sangam Chatterjee[3], Alexej Chernikov[3], Philomela Komninou[4], Thomas Kehagias[4], and Martin Eickhoff[1] — [1]I. Physikalisches Institut, Justus-Liebig-Universität Gießen — [2]Walter Schottky Institut, Technische Universität München — [3]Fachbereich Physik, Philipps-Universität Marburg — [4]Physics Department, Aristotle University of Thessaloniki

III-N nanowires (NWs) have attracted a lot of attention in recent years due to their high crystalline quality compared to III-N thin films. The realization of InGaN/GaN heterostructures embedded in GaN-NWs allows one to shift the photoluminescence emission energy into the visible spectral range and to improve its temperature stability. We report on the emission properties of InGaN quantum dots (QDs) embedded in GaN NWs grown by plasma assisted molecular beam epitaxy on n-type Si(111) substrates. A series of samples with varied QD-thickness was investigated by low temperature photoluminescence (PL), single wire micro-PL, and time-resolved PL measurements. Emission bands at 3.48 eV, around 2.5 eV and at approximately 3.15 eV are attributed to the GaN band gap, the QD emission, and interfacial defects, respectively. High resolution transmission electron microscopy analysis was performed on selected samples for structural characterization.

HL 97.6 Fri 11:15 ER 270

μ-Photoluminescence of GaN nanowires with different diameters and pitches grown by selective-area epitaxy on Si substrates — •Christian Hauswald[1], Tobias Gotschke[1], Oliver Brandt[1], Namil Koo[2], Jung Wuk Kim[2], Raffaella Calarco[1], Lutz Geelhaar[1], and Henning Riechert[1] — [1]Paul-Drude-Institut für Festkörperelektronik, Berlin — [2]AMO GmbH, Aachen

Selective-area growth (SAG) of nanowires (NWs) by molecular beam epitaxy constitutes an important step towards uniform III-V NW arrays on Si. A homogeneous size and a controlled position are desirable for processing NWs into optoelectronic devices with predictable characteristics. In this work, we study the influence of different diameters and pitches of selectively grown NWs on their optical properties.

We use μ-photoluminescence (μ-PL) to investigate GaN NWs grown in pre-patterned holes defined by electron beam lithography in a SiO_x-mask. The holes have various shapes (hexagons, triangles, and squares) with diameters and periods in the range of 30–300 nm and 0.3–3.0 μm, respectively. All investigated NW arrays have been grown side by side

on the same sample to ensure similar growth conditions. We compare the μ-PL spectra and integrated intensities of various NW diameter and pitch configurations and discuss the spatial homogeneity.

Finally, the coupling of light with GaN NWs fabricated using different mask geometries is simulated with a finite-element software to gain insight into the effects of the in-plane light propagation in SAG NW arrays. The potential of these ordered GaN NW arrays to form a photonic crystal is explored.