HL 13: Nitrides: Optical characterization

Time: Monday 11:15–12:45 Location: POT 251

HL 13.1 Mon 11:15 POT 251

Nano-scale characterization of InGaN/GaN core-shell micropillars using helium temperature STEM-CL — •Marcus Müller[1], Sebastian Metzner[1], Anja Dempewolf[1], Gordon Schmidt[1], Peter Veit[1], Frank Bertram[1], Jürgen Christen[1], Steven Albert[2], Ana María Bengoechea-Encabo[2], Miguel Ángel Sánchez-Garcia[2], and Enrique Calleja[2] — [1]Institute of Experimental Physics, OvGU Magdeburg, Germany — [2]ISOM and Departamento de Ingeniería Electrónica, UP Madrid, Spain

In this study we report on the approach of combining top-down and the bottom-up processes to fabricate ordered InGaN/GaN core-shell micropillars by plasma-assisted molecular beam epitaxy. Direct comparison of the cross-section scanning transmission electron microscopy image of a single InGaN/GaN core-shell micropillar with the simultaneously recorded panchromatic cathodoluminescence (CL) mapping at 15 K reveals the highest CL intensity from the thick InGaN cap region and from the InGaN side walls. The CL peak wavelength image exhibits a dominating emission from the GaN near band edge at 359 nm as well as the yellow band at 560 nm from the center of the micropillar. On the side facets we observe an InGaN CL peak at 407 nm. In contrast, the upper part of the micropillar emits a broad luminescence band between 510 nm and 640 nm which can be attributed to different In compositions and strain conditions compared to the side facets. Furthermore, a red shift of the InGaN luminescence in both InGaN regions is observed indicating a gradual increase of the In composition during the growth due to the lattice pulling effect.

HL 13.2 Mon 11:30 POT 251

Time-integrated and time-resolved luminescence studies of hybrid InGaN/GaN MQW microrod structures — •Angelina Vogt[1], Stephanie Bley[1], Jana Hartmann[2], Sebastian Resch[3], Xue Wang[2], Matin Sadat Mohajerani[2], Martin Mandl[4], Martin Strassburg[4], Siegfried Waldvogel[3], Andreas Waag[2], Jürgen Gutowski[1], and Tobias Voss[1] — [1]Institute of Solid State Physics, University of Bremen — [2]Institute of Semiconductor Technology, TU Braunschweig — [3]Institute of Organic Chemistry, Johannes Gutenberg University Mainz — [4]Osram Opto Semiconductors GmbH

Three-dimensional GaN-based microrods with embedded InGaN multi-quantum-well structures (MQW) are promising candidates for sensors and light-emitting diodes in the green-ultraviolet spectral region. In order to extend the available wavelength region or to achieve selectivity in sensing devices, coating of the microrod structures with specific organic compounds can be applied. Here, we study the luminescence properties of GaN-based microrod LED structures coated with a perylene bisimide derivative. The InGaN/GaN LED structures were grown by MOVPE. Prior to the dye-coating process, their luminescence properties were studied in order to investigate their homogeneity. The samples were afterwards wet chemically coated with the perylene dye. The energy transfer from the QWs to the dye layer was studied in time-integrated and time-resolved photoluminescence experiments. We compare and discuss the luminescence dynamics in the bare InGaN/GaN microrod LEDs and the hybrid systems and analyse the energy transfer from the inorganic to the organic part.

HL 13.3 Mon 11:45 POT 251

Optical characterization of quaternary AlInGaN SQW using cathodoluminescene spectroscopy — •Martin Müller[1], Christopher Karbaum[1], Gordon Schmidt[1], Frank Bertram[1], Jürgen Christen[1], Jan Wagner[2], Michael Jetter[2], and Peter Michler[2] — [1]Institute of Experimental Physics, OvGUniversity Magdeburg, Germany — [2]IHFG, Stuttgart University, Germany

The optical properties of quaternary AlInGaN SQW have been investigated using spectrally and time-resolved cathodoluminescence (CL) microscopy at liquid helium temperature. All samples of the set consist of an 1 μm thick optimized GaN buffer on a c-plane sapphire substrat. Subsequently, on top of this a quaternary SQW of varying thickness (2, 3, 6, 10 nm) was grown using pulsed MOVPE and finally capped by a high temperature GaN layer. At low temperatures the CL-spectra are dominated by a blue-shifted near band edge luminescence with respect to relaxed GaN and a broad quaternary SQW emission band at about 370 nm. A slight shift of the SQW emission band to longer wavelengths with increasing thickness possibly caused by the quantum confined Stark effect as a consequence of inherent electric fields could be clearly seen. Addionally, the initial lifetime of the SQW increases from 1.1 ns up to 1.5 ns with the thickness as a result of a decreased electron and hole wave function overlap. The temperature dependent shift of the FX^A and FX^B from the GaN buffer could be observed indicating a high optical quality. The non-Varshni-like shift of the quaternary SQW emission with temperature will be discussed.

HL 13.4 Mon 12:00 POT 251

Valence band order in c-oriented wurtzite AlGaN layers — •Benjamin Neuschl[1], Jeffrey Helbing[1], Manuel Knab[1], Hannah Lauer[1], Tobias Meisch[2], Kamran Forghani[2], Ferdinand Scholz[2], and Klaus Thonke[1] — [1]Institute of Quantum Matter / Semiconductor Physics Group, University of Ulm — [2]Institute of Optoelectronics, University of Ulm

Aluminum gallium nitride (AlGaN) is the key material system for semiconductor-based optical devices emitting in the ultraviolet spectral region of light. Until now, some fundamental properties such as the valence band structure are not safely explored yet for all compositions. Especially the symmetry of the topmost valence band has a major impact on the light extraction behavior of the device.

Different layers of c-oriented wurtzite AlGaN were grown by metalorganic vapor phase epitaxy, and investigated by means of temperature- and polarization-dependent photoluminescence and X-ray spectroscopy. Knowing the samples' strain situation, we derive the valence band order, as a function of the relative amount of Al for a unified strain state. Subsequently, $k \cdot p$ theory allows the simulation of the strain-dependent valence band crossing. These fundamental results allow to design optimal light emitters for different emission wavelengths.

HL 13.5 Mon 12:15 POT 251

Micro-photoluminescence and micro-Raman studies on strained polar GaN layers — •Sebastian Bauer[1], Matthias Hocker[1], Lisa Hiller[1], Frank Lipski[2], Ferdinand Scholz[2], and Klaus Thonke[1] — [1]Institute of Quantum Matter / Semiconductor Physics Group, Ulm University, 89081 Ulm, Germany — [2]Institute of Optoelectronics, Ulm University, 89081 Ulm, Germany

Heteroepitaxial growth of *c*-oriented gallium nitride (GaN) layers by hydride vapor phase epitaxy (HVPE) on sapphire substrates is always associated with specific strain states in the grown material. The efficiency of optoelectronic devices suffers from strain-induced piezoelectric effects as well as from structural defects caused by strain. Hence, the mechanism of strain relaxation with increasing layer thickness is of great interest.

We investigate a series of samples with different thicknesses grown by HVPE by spatially resolved low temperature microphotoluminescence and room temperature micro-Raman spectroscopy. The correlation between the layer thickness and the strain state of the material is analysed. These results suggest a minimum substrate layer thickness of GaN required for the realization of strain-free device material.

HL 13.6 Mon 12:30 POT 251

Photoluminescence of Zn and Mn doped thick GaN layers — •Friederike Zimmermann[1], Jan Beyer[1], Frank Habel[2], Gunnar Leibiger[2], Berndt Weinert[2], Martin Krupinski[3], Patrick Hofmann[3], and Johannes Heitmann[1] — [1]Institute of Applied Physics, TU Bergakademie Freiberg, Leipziger Str. 23, D-09599 Freiberg, Germany — [2]Freiberger Compound Materials GmbH, Am Junger-Löwe-Schacht 5, D-09599 Freiberg, Germany — [3]Namlab gGmbH, Nöthnitzer Straße 64, 01187 Dresden, Germany

Due to its superior electronic properties, GaN-based devices are suitable for high power, high frequency and high temperature applications. The direct and wide bandgap of GaN makes it an ideal material for bright UV and blue light emitting diodes and lasers. Electronic and optical properties can be tuned by doping with transition metal elements. We report on photoluminescence spectroscopy data of Zn and Mn doped samples grown by HVPE. Zn doped samples exhibit clear exitonic features including the exciton bound to the Zn acceptor. For samples of different Zn content four broad bands in the red, yellow, green and blue spectral region are found to vary in their relative intensities and temperature quenching. Mn doped samples show intense

peaks at 1.25 and 1.41 eV which are assigned to intra-d-shell transitions of the incorporated Mn-ions. Sharp features in the exitonic range at room temperature can be ascribed to Raman scattering of the laser. As transition metals are generally expected to suppress the PL Raman contribution cannot be ruled out in Zn doped samples neither.