HL 47 GaN: Devices II

Time: Thursday 15:15–16:30 Room: BEY 118

HL 47.1 Thu 15:15 BEY 118

MOVPE growth of nitride-based green LEDs — •D. Fuhrmann, T. Litte, C. Netzel, H. Bremers, U. Rossow, and A. Hangleiter — TU Braunschweig, Inst. f. Angewandte Physik, Mendelssohnstr. 2, 38106 Braunschweig, Germany

Despite the high efficiencies achieved for blue $Ga_{1-x}In_xN$ based light emitting diodes, a significant drop in efficiency occurs towards longer emission wavelengths. This behavior is commonly explained by the diminished crystalline quality of GaInN and increased piezoelectric field due to the higher In content x_{In} necessary for longer λ_{peak}. By optimizing the MOVPE growth conditions for the active region of green LEDs, we achieved thin quantum wells (QWs) of good material quality with x_{In} $\geq 25\%$. The In content was determined by XRD for thicker GaInN layers ($\approx$ 20nm) assuming that x_{In} is independent of layer thickness. The optical properties of our single QW samples were analyzed using temperature and excitation power dependent PL. It turns out that the PL linewidth, which is due to compositional fluctuations and fluctuations of the QW width, has a strong correlation with the quantum efficiency (QE). We obtained the highest values in terms of the internal QE for quantum wells showing a small PL linewidth. Hence, we find that a homogeneous In composition and smooth GaInN/GaN interfaces are of central importance for the device performance. We processed the QW structures into simple LEDs and performed "on wafer" measurements. Again, we find the highest optical output power for the structures grown under optimized growth conditions. The internal QE for QWs emitting around 525nm is only 40% lower compared to QWs emitting at 460nm

HL 47.2 Thu 15:30 BEY 118

Crack-free monolithic nitride vertical-cavity surface-emitting laser structures and pillar microcavities — •H. Lohmeyer[1], K. Sebald[1], C. Kruse[1], R. Kröger[1], J. Gutowski[1], D. Hommel[1], J. Wiersig[2], and F. Jahnke[2] — [1]Institute of Solid State Physics, University of Bremen, P.O.Box 330 440, 28359 Bremen, Germany — [2]Institute of Theoretical Physics, University of Bremen, P.O.Box 330 440, 28359 Bremen, Germany

The successful realization and optical characterization of fully epitaxially grown monolithic nitride vertical-cavity surface-emitting laser (VCSEL) structures and pillar microcavities (MCs) is presented. VCSEL structures made of InGaN/GaN λ-cavities and Bragg mirrors composed of GaN and AlN/(In)GaN superlattices have been fabricated by molecular-beam epitaxy. Airpost pillar MCs with diameters between 800 nm and 3 μm were realized by focused ion-beam etching.

The reflectivity data as well as the spontaneous emission spectra of the planar VCSEL structures show a pronounced influence of the optical-mode confinement by the cavity. The discrete mode spectrum of the pillars is studied by micro-photoluminescence measurements. The measured data for different pillar diameters show good agreement with calculations of the transmission spectra of the three-dimensional pillars based on a vectorial transfer-matrix method.

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HL 47.3 Thu 15:45 BEY 118

Study and comparison of efficiency and optical degradation of GaN/InGaN Light Emitting Diodes grown on SiC substrates — •Gianluca Tamiazzo, Ulrich Zehnder, Thomas Zahner, and Uwe Strauss — Wernerwerkstrasse 2, 93049 Regensburg

High reliability of GaN/InGaN based Light Emitting Diodes (LEDs) is of great interest. However, despite of high long-term stability, degradation mechanisms could potentially occur. In this work, we study GaN/InGaN LEDs structures for a further improvement of their reliability and lifetime. A comparison with other commercial devices coming from different competitors was performed as well. The samples were biased in identical conditions of temperature and injected current. Electroluminescence relative intensity of LEDs was monitored in dependence of time. Dynamics of optical degradation as well as forward voltage aging during the DC-bias stress were studied. Different aging phases correspondent to as many potential failure mechanisms were identified. A model able to interpret the devices degradation behaviour is proposed. In particular, a thermally activated process is found to be responsible for long-term DC aging.

HL 47.4 Thu 16:00 BEY 118

Inhomogeneous broadened gain spectra of InGaN/GaN laser diodes — •Ulrich Schwarz[1], Georg Feicht[1], Bernd Witzigmann[2], Valerio Laino[2], Mathieu Luisier[2], Alfred Lell[3], and Volker Härle[3] — [1]Institut für Experimentelle und Angewandte Physik, Universität Regensburg, 93040 Regensburg — [2]OSRAM Opto Semiconductors GmbH, Wernerwerkstr. 2, 93049 Regensburg — [3]Integrated Systems Laboratory, ETH Zürich, CH-8092 Zürich

For InGaN quantum wells (QW) indium and QW width fluctiations are a critical issue, as they cause carrier localization and affect the performance of InGaN LEDs and laser diodes (LD). We compare experimental gain spectra measured by the Hakki-Paoli mehotd with a microscopic theory including quantum-confined stark effect (QCSE) and many-body effects to analyse the contribution of homogeneous and inhomogeneous broadening to the QW gain. In particular we perform low-temperature gain spectroscopy of InGaN LDs which confirms the notion that inhomogeous broadening due to structual variations is a significant contribution to QW gain in InGaN LDs. From these measurements we can also give an estimate of the nonradiative recombination rate.

HL 47.5 Thu 16:15 BEY 118

Processing and Characterization of GaN homo-epitaxial Laser Diodes — •Jens Dennemarck, Stephan Figge, and Detlef Hommel — Institute of Solid State Physics, University of Bremen, Otto-Hahn-Allee NW1, D-28359 Bremen

The threshold of GaN-based laser diodes is mainly determined by the geometry of the ridge wave-guide and its processing. In this work we are investigating different ridge structures to lower the threshold current density. The emission wavelength of the laser diodes, grown homo-epitaxially on GaN substrates with dislocation densities in the range of $\approx 10^6 cm^{-2}$, is 395nm.

To improve the device performance, the stripe width of the devices was varied from $2-10\mu m$ and three different depths of the ridge were applied: a planar structure (no ridge), 600nm - starting at the upper wave-guide, and 900nm - penetrating the active region.

The largest impact on the threshold current density was found in the depth of the ridge, where the devices with the largest depth showed a reduction of a factor of 5 to $3kA/cm^2$ in comparison to the planar structures. Duty cycles up to 50% could be applied an these devices. The width of the ridge showed also a reduction of the threshold, but not as much as the depth.

Additional to this, a better optical confinement for the deepest ridge could be seen in the far field of the laser diode.