Dynamics of (Al,In)GaN-based laser diodes — Christian Hornuss, Wolfgang G. Scheibenzuber, Ulrich T. Schwarz, and Joachim Wagner — Fraunhofer-Institut für Angewandte Festkörperphysik, Tullastrasse 72, D-79108 Freiburg

Understanding the dynamics of (Al,In)GaN-based laser diodes is essential for realizing ultra-short pulse lasers for biomedical imaging. We investigate the dynamic behavior of violet laser diodes above and below laser threshold. Relaxation dynamics above threshold are analyzed with high temporal and spectral resolution, as well as electroluminescence decay below threshold to determine the charge carrier lifetime. The experimental results are compared with rate equation simulations. By comparison of experimental and theoretical findings we derive the carrier lifetime at threshold and the differential gain.

The loss mechanisms in green-emitting laser diodes — Andreas Kruse1, Moritz Brendel1, Uwe Rossow2, Hyunjoon Chauveauc2, Jean-Yves Duboc2, and Andreas Hangleiter1 — 1Institut für Angewandte Physik, TU Braunschweig — 2CHRHEA-CNRS, Valbonne, France

While GaN violet-blue laser diodes with high output power and long lifetimes are already commercially available, strong decrease in power performance occurs when the emission beyond 520 nm is observed. The aim of our investigation is to understand the limits of optical gain for green-emitting LDs. For this purpose we carried out optical gain measurements by using the variable stripe length method on laser structures grown on c-plane sapphire and GaN bulk substrates, in which various parameters such as number and thickness of quantum well (QW) as well as indium content in QW up to ca. 30% were varied. We focus our studies on two aspects: (1) the impact of defects on optical gain amplitude as well as inhomogeneous broadening of the gain spectra and (2) the influence of AlN and AlGaN lower cladding layers on the optical confinement properties due to their different refractive index contrast. Our SQW laser structures emitting at longer wavelength show a net optical gain with internal optical losses smaller than 30 cm⁻¹. Moreover, an increase of the inhomogeneous broadening with increasing number of QWs is observed. For the laser structures with AlN as lower cladding layer very high optical gain is achieved compared to those with AlGaN cladding layers.

Growth and characterization of AlNn for cladding layers in long wavelength GaN based laser structures — Ernst Ronald Buss1, Heiko Bremer2, Uwe Rossow1, Egidius Sakalakskas2, Rudiger Goldmann3, and Andreas Hangleiter1 — 1Institute of Applied Physics, TU Braunschweig — 2CHRHEA-CNRS, Valbonne, France — 3Institute of Experimental Physics, Otto-von-Guericke University Magdeburg, Universitaetsplatz 2, Magdeburg

Cladding layers in actual GaN based laser structures usually consist of AlGaN, or AlGaN/GaN superlattices. Alloying GaN with AlN does always lead to strain in the whole compositional range, and the difference of the refractive indices of GaN and AlGaN is very small. In contrast AlN/GaN is known to be lattice matched to GaN, so the stress in these structures can be minimized. Furthermore, the refractive index contrast is about 0.08 at 530 nm resulting in a better optical confinement in green laser structures. The samples are grown by low pressure MOVPE. To optimize growth conditions parameters like temperature, reactor pressure and source fluxes have been varied. HRXRD measurements on samples with $x_{\text{Al}} \approx 0.179$ show pseudomorphic growth and lattice matching for $x_{\text{Al}} < 0.17$ and 0.50nm. Investigations by AFM exhibit smooth surfaces with low RMS roughnesses built up of small domains surrounding pits generated by crystal defects. The refractive index and the band gap energy are obtained from spectroscopic ellipsometry. Optical gain has already been shown and first laser structures are realized.

Electroluminescence from InGaN quantum dots in a monolithically grown GaN/AlNn cavity — Heiko Dartsch1, Christian Tessarowicz2, Stephan Figge3, Timo Aschenbrenner1, Carsten Kruse1, Marco Schowalter2, Andreas Rosenauer1, and Detlef Hommel — 1Institute for Optoelectronics, Universitat Ulm — 2Institut für Quantenmaterie / Gruppe Halbleiterphysik, Universität Ulm — 3Institute of Solid State Physics - Electron Microscopy

InGaN quantum dots (QDs) and their implementation into the micro cavity of a vertical distributed Bragg reflector (DBR) resonator are the key elements to achieve single photon emission required for quantum cryptography. However, the epitaxial overgrowth of InGaN QDs is challenging because they are easily destroyed by elevated temperatures. For this reason a common approach is the fabrication of a hybrid cavity structure by non epitaxial deposition of a dielectric top DBR. We will present the first successful implementation of electrically driven InGaN QDs into a monolithic GaN/AlNn cavity structure fully epitaxial grown by metal organic vapor phase epitaxy. Therefore a single layer of InGaN QDs has been embedded in a n- and p-type doped 5λ GaN cavity structure by 40 fold bottom- and a 10 fold GaN/AlNn top-DBR. Electroluminescence of the InGaN QDs was achieved by the application of intra cavity contacts. Optical and structural properties of the device will be discussed.