HL 76: Nitride-based Green Lasers

Time: Thursday 11:45–13:15 Location: POT 51

HL 76.1 Thu 11:45 POT 51

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 data we derive the carrier lifetime at threshold and the differential gain.

HL 76.2 Thu 12:00 POT 51

The loss mechanisms in green-emitting laser diodes — •Andreas Kruse[1], Moritz Brendel[1], Uwe Rossow[1], Hyonju Chauveau[2], Jean-Yves Duboz[2], and Andreas Hangleiter[1] — [1]Institut für Angewandte Physik, TU Braunschweig — [2]CRHEA-CNRS, Valbonne, France

While GaInN violet-blue laser diodes with high output power and long lifetimes are already commercially available, strong decrease in power performance by extending the emission wavelength beyond to 500 nm is observed. The aim of our investigations 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 gain amplitude as well as inhomogeneous broadening of the gain spectra and (2) the influence of AlInN 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 30cm^{-1}. Moreover, an increase of the inhomogeneous broadening with increasing number of QWs is observed. For the laser structures with AlInN as lower cladding layer very high net optical gain is achieved compared to those with AlGaN cladding layers.

HL 76.3 Thu 12:15 POT 51

Growth and characterization of AlInN for cladding layers in long wavelength GaN based laser structures — •Ernst Ronald Buss[1], Heiko Bremers[1], Uwe Rossow[1], Egidijus Sakalauskas[2], Rüdiger Goldhahn[3], and Andreas Hangleiter[1] — [1]Institute of Applied Physics, TU Braunschweig, Mendelssohnstraße 2, Braunschweig — [2]Institute of Physics, TU Ilmenau, Weimarer Straße 32, Ilmenau — [3]Institute of Experimental Physics, Otto-von-Guericke-University Magdeburg, Universitätsplatz 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 AlInN can be grown matched to the a-lattice constant of 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 has been varied. HRXRD measurements on samples with $x_{In} \approx 0.179$ show pseudomorphic growth and lattice matching for 845°C and 50mbar. 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.

HL 76.4 Thu 12:30 POT 51

Strain Relaxation Mechanisms in Green Emitting GaInN/GaN Laser Diode Structures — •Lars Hoffmann[1], Heiko Bremers[1], Holger Jönen[1], Uwe Rossow[1], Johannes Thalmair[2], Josef Zweck[2], Marco Schowalter[3], Andreas Rosenauer[3], and Andreas Hangleiter[1] — [1]TU Braunschweig, Institute of Applied Physics, Braunschweig, Germany — [2]Universität Regensburg, Institut für Experimentelle und Angewandte Physik, Regensburg, Germany — [3]Universität Bremen, Institute of Solid State Physics, Bremen, Germany

While GaN-based blue light emitting devices exhibit exceptionally large internal quantum efficiencies (up to 80% at room temperature) their green counterparts quickly become less efficient at longer wavelength ("green gap"). Green emitting laser diodes based on polar as well as non- and semipolar planes have also been demonstrated, but it remains increasingly difficult to push the emission to longer wavelength. Using Transmission Electron Microscopy (TEM) and X-ray diffraction (XRD) we have studied ultrathin (< 2nm) high indium content quantum well (QW) structures suitable for blue-green laser diodes. We investigate the mechanisms of relaxation and possible misfit dislocation generation in c-plane LD structures, partial relaxation and thermal degradation. We observe threading dislocations (TD) bending by several degrees at highly strained interfaces. The results indicate that larger lattice mismatch strain leads to larger bend angles. Furthermore, if two of those TDs are crossing each other, they could annihilate and reduce the TD density.

HL 76.5 Thu 12:45 POT 51

Growth of AlGaN stripes with semipolar side facets as waveguide claddings for semipolar laser structures — •Robert Anton Richard Leute[1], Kamran Forghani[1], Frank Lipski[1], Ferdinand Scholz[1], Ingo Tischer[2], Benjamin Neuschl[2], and Klaus Thonke[2] — [1]Institut für Optoelektronik, Universität Ulm — [2]Institut für Quantenmaterie / Gruppe Halbleiterphysik, Universität Ulm

Selective area growth of group III nitrides allows the epitaxy of semipolar facets with reduced piezoelectric field on 2-inch sapphire substrates. Additionally, the 3D growth of stripes, pyramids or the like enables us to manipulate the extraction and propagation of light by changing the surface topology. LEDs grown on GaN stripes with $\{11\bar{2}2\}$ facets and GaN stripes with $\{10\bar{1}1\}$ facets have been published. The fabrication of laser structures with resonators along the stripes depends critically on the controlled growth of a waveguide cladding for optical confinement, typically realized by AlGaN layers. However, the growth parameters of AlGaN are challenging for selective epitaxy. The high growth temperature promotes lateral growth, leading to the emergence of an undesirable c-plane facet, whereas the reduced selectivity of the mask material for Al atoms leads to polycrystalline growth on masked areas. We investigate the selective growth of AlGaN with Al contents up to 10% with structured SiO_2 and SiN_x masks. The influence of mask geometries (stripes $\parallel m$ and $\perp m$, variable opening sizes and periods) on topology, material quality and Al incorporation is examined. Therefore, we present SEM investigations, spatially resolved cathodoluminescence as well as low temperature photoluminescence.

HL 76.6 Thu 13:00 POT 51

Electroluminescence from InGaN quantum dots in a monolithically grown GaN/AlInN cavity — •Heiko Dartsch[1], Christian Tessarek[1], Stephan Figge[1], Timo Aschenbrenner[1], Carsten Kruse[1], Marco Schowalter[2], Andreas Rosenauer[2], and Detlef Hommel[1] — [1]University of Bremen, Institute of Solid State Physics - Semiconductor Epitaxy — [2]University of Bremen, Institute 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 hybride 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/AlInN 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 surrounded by a 40 fold bottom- and a 10 fold GaN/AlInN top-DBR. Electroluminescence of the InGaN QDs was achived by the application of intra cavity contacts. Optical and structural properties of the device will be discussed.