HL 45: GaN devices

Time: Thursday 9:30–11:45 Location: EW 202

HL 45.1 Thu 9:30 EW 202

Dünnschicht-LEDs auf der Basis von InGaN/GaN MQW auf Si(111) — •Stephanie Fritze[1], Oliver Schulz[2], Annette Diez[1], Jürgen Bläsing[1], Lars Reissmann[1], Thomas Hempel[1], Armin Dadgar[1,2], Jürgen Christen[1] und Alois Krost[1,2] — [1]Institut für Experimentelle Physik, Otto-von-Guericke-Universität Magdeburg, Deutschland — [2]AZZURRO Semiconductors AG, Universitätsplatz 2, 39106 Magdeburg

Gegenüber den bereits etablierten GaN-basierten LEDs auf Saphir oder SiC bieten Strukturen auf Silizium einen deutlichen Preisvorteil. Da Silizium jedoch über 94% des generierten Lichts absorbiert, müssen für Anwendungen in der Beleuchtungstechnik solche LEDs als verlustarme Dünnschicht-LEDs hergestellt werden. Dazu wurde nach dem Verlöten der LED auf einen leitfähigen Träger das Substrat mittels Dünnen und nasschemischem Ätzen entfernt. Kontaktwiderstände verschiedener p-Kontakte wurden mittels Transmissions-Linien-Modell (TLM)-Strukturen bestimmt und verglichen. Die Reflektivität der p-Kontakte, die gleichzeitig als Reflektor dienen, wurde für verschiedene Metallisierungen untersucht. Für eine Maximierung der Effizienz wurden verschiedene LED-Designs bezüglich einer homogenen Ladungsträgerinjektion analysiert. Die Dünnschicht-LEDs werden konventionell prozessierten Bauelementen gegenübergestellt, die aus den selben Halbleiterstrukturen hergestellt wurden. Hierzu werden diese bezüglich ihrer Emissionseigenschaften optisch und elektrisch charakterisiert.

HL 45.2 Thu 9:45 EW 202

External field dependent spatial resolved PL spectroscopy on InGaN/GaN heterostructures — •Clemens Vierheilig[1], Harald Braun[1], Ulrich T. Schwarz[1], Werner Wegscheider[1], Nikolaus Gmeinwieser[2], Ansgar Laubsch[2], and Berthold Hahn[2] — [1]NWF II - Physik, Universität Regensburg, Universitätsstraße 31, 93053 Regensburg — [2]Osram Opto Semiconductors, Leibnizstraße 4, 93055 Regensburg

The optical properties of InGaN based quantum well structures are strongly affected by internal electric fields and fluctuations of the indium content. By micro-photoluminescence of InGaN LEDs with applied bias and micro-electroluminescence we study the correlation between QW emission intensity and energy, both of which fluctuate on a micrometer length scale. Particularly interesting is the characteristic dependency of this energy-intensity correlation on the applied external electric field. For a spatially resolved measurement of the tunnel barrier we also measure the laser induced photocurrent under reverse bias. Purpose of this study is to separate QW composition or width fluctuation from fluctuations of the internal fields.

HL 45.3 Thu 10:00 EW 202

Semipolar $\{1\bar{1}01\}$ GaInN quantum wells for green light emitting diodes — •Martin Feneberg[1], Thomas Wunderer[2], Frank Lipski[2], Peter Brückner[2], Ferdinand Scholz[2], Rolf Sauer[1], and Klaus Thonke[1] — [1]Institut für Halbleiterphysik, Universität Ulm — [2]Institut für Optoelektronik, Universität Ulm

Semipolar GaInN/GaN light emitting devices are a heavily discussed topic in current research. These devices are supposed to help filling the so-called "green gap"of wavelengths between 500nm and 600nm where no efficient emitters exist.

Semipolar $\{1\bar{1}01\}$ quantum wells were grown, processed and finally analyzed by electric-field-dependent photoluminescence and electroluminescence. From the PL emission energy as a function of the externally applied voltage which modifies the built-in polarization field we have determined the remaining polarization field. For this purpose, model calculations were carried out which self-consistently take full account of the tilted band structure, charge accumulation, fields in the depletion region and other relevant parameters. With these results we are able to calculate the internal quantum efficiencies of semipolar quantum wells. After carefully adjusting growth and process parameters while maintaining material quality we demonstrate first semipolar light emitting diodes operating at about 500nm.

HL 45.4 Thu 10:15 EW 202

Spectral Identification of Filaments in Broad Ridge 405 nm (Al,In)GaN Laser Diodes — •Harald Braun[1], Hans-Michael Solowan[1], Dominik Scholz[1], Tobias Meyer[1], Ulrich Theodor Schwarz[1], Stefanie Brüninghoff[2], Alfred Lell[2], and Uwe Strauss[2] — [1]NWF II - Physik, Universität Regensburg — [2]Osram Opto Semiconductors GmbH, Regensburg

In broad area (Al,In)GaN laser diodes (LDs) with ridge widths larger than a few micrometer the laser mode in the waveguide builds up filaments, which influence the far field of the LD. Employing temporal and spectral resolved scanning near-field optical microscopy (SNOM) on pulsed electrically driven LDs we analyse the lateral mode profile on a nanosecond to microsecond timescale. Furthermore we are able to resolve the single Fabry-Perot modes of the laser mode correlated to the lateral position in the ridge waveguide. Different filaments have slightly different effective refractive indices and thus show up as separate longitudinal mode combs. In this way we can reconstruct the optical mode in the waveguide as a superposition of filaments, identified by their spectral fingerprint. Different samples, grown on SiC and GaN substrates, respectively, were investigated. The measurements show similar results for all samples concerning the lateral mode profile, whereas the samples grown on GaN substrate exhibit a less chaotic behaviour in the temporal and spectral regime compared to the LDs grown on SiC substrate.

HL 45.5 Thu 10:30 EW 202

GaInN/GaN quantum well laser structures emitting in the blue-green spectral range — •Daniel Dräger[1], Uwe Rossow[1], Holger Jönen[1], David Schenk[2], Jean-Yves Duboz[2], and Andreas Hangleiter[1] — [1]Institute of Applied Physics, Technical University of Braunschweig, Germany — [2]CRHEA-CNRS, Valbonne, France

Presently, GaN-based laser diodes are limited to the violet-blue region of the spectrum. Our aim is to obtain laser emission in the blue-green spectral range. In order to study GaInN-based laser structures, low pressure MOVPE was used to grow such structures on a variety of substrates (freestanding GaN, GaN templates, and SiC). This allows investigations of the influence of the substrate related dislocation densities on gain, losses and carrier recombination. Our samples were investigated by optical gain spectroscopy using the variable stripe length method.

In order to reach wavelengths longer than 450 nm an increase of the indium concentration to more than 25 % is needed. Such high In content requires careful optimization of the growth conditions in order to avoid damaging of the quantum wells by thermal stress. Combining the results of the gain measurement with a theoretical calculation of the gain spectra we determine the threshold power, carrier density and the carrier recombination times of the sample. On bulk GaN substrates we find threshold power levels as low as 20 kW/cm^2. Up to now we obtain optical gain up to a peak wavelength of 465 nm with losses of about 30 cm^{-1}. Our next targets are a wavelength of 480 nm as well as a further reduction of the threshold power.

HL 45.6 Thu 10:45 EW 202

Characteristics of (Al,In,Ga)N multiple quantum well structures for blue-green laser diodes — •Veit Hoiffmann[1], Arne Knauer[1], Frank Brunner[1], Carsten Netzel[1], Markus Weyers[1], Günther Tränkle[1], Tim Kolbe[2], Jan Robert van Look[2], and Michael Kneissl[1,2] — [1]Ferdinand-Braun-Institut für Höchstfrequenztechnik, Gustav-Kirchhoff-Straße 4, 12489 Berlin — [2]Institut für Festkörperphysik, Technische Universität Berlin, Hardenbergstraße 36, 10623 Berlin

(Al,In,Ga)N based laser diodes (LD) emitting in the violet spectral region are already commercially available with excellent lifetimes and high efficiencies. In order to extend the emission wavelength of these devices towards the blue and green high quality InGaN quantum well structures have to be realized. However, multiple quantum well (MQW) structures with high indium content exhibit low efficiencies, due to the large piezoelectric fields (F_{PZ}) as well as the deterioration in crystal quality. We have investigated the growth of InGaN MQW structures emitting in the blue-green wavelength region with photoluminescence and high resolution X-Ray diffraction. In our studies we were able to determine F_{PZ} quantitatively and show how F_{PZ} is influenced by the barrier composition, e.g. by adding indium to the barriers and by partially doping the barriers with silicon. By increasing the growth temperature $_G$ during the barrier growth, we were able to improve the ratio of radiative to non-radiative recombination. Finally, we will discuss the effects of barrier composition and optimized growth conditions on light output and threshold current densities for LDs.

HL 45.7 Thu 11:00 EW 202

Temperature and current dependent electroluminescence measurements on colour-coded Multiple Quantum Well Light Emitting Diodes — •Werner Bergbauer[1,2], Ansgar Laubsch[1], Matthias Peter[1], Tobias Mayer[1], Stefan Bader[1], Günther Benstetter[2], Raimund Oberschmid[1], and Berthold Hahn[1] — [1]OSRAM Opto Semiconductors GmbH, 93055 Regensburg, Germany — [2]FH Deggendorf, 94469 Deggendorf, Germany

As the efficiency and the luminous flux have been increased enormously in the last few years, today Light Emitting Diodes (LEDs) are even pushed to applications like general lighting and Home Cinema Projection. Still, InGaN / GaN heterostructure based LEDs suffer from loss-mechanisms like non-radiative defect and Auger recombination, carrier leakage and piezo-field induced carrier separation. To optimize the high current efficiency we evaluated the benefit of Multiple Quantum Well (MQW) compared to Single Quantum Well (SQW) LEDs. Temperature dependent electroluminescence of colour-coded structures with different Indium content in certain Quantum Wells was measured. The experiments demonstrated a strong temperature and current dependence of the MQW operation. The comparison between different LED structures showed effectively the increased LED performance of those structures which operate with a well adjusted MQW active area. Due to the enhanced carrier distribution in the high current range, these LEDs show a higher light output and additionally a reduced wavelength shift.

HL 45.8 Thu 11:15 EW 202

Effect of the barrier composition on the efficiency and emission spectra of GaN-based near ultraviolet light emitting diodes — •T. Kolbe[1], A. Knauer[2], V. Küller[2], S. Einfeldt[2], J. R. van Look[1], P. Vogt[1], M. Weyers[2], and M. Kneissl[1,2] — [1]TU Berlin, Institute of Solid State Physics, Hardenbergstr. 36, 10623 Berlin, Germany — [2]Ferdinand-Braun-Institut für Höchstfrequenztechnik, Gustav-Kirchhoff-Str. 4, 12489 Berlin, Germany

Light Emitting Diodes (LEDs) based on III-nitride semiconductors have attracted great interest in recent years. Carrier confinement, piezoelectric fields and a low external quantum efficencies are particularly problematic for ultraviolet LEDs.
Here we present continuous wave and pulsed electroluminescense measurements of GaN-based multi quantum well LEDs with different barrier compositions. These devices were grown by metalorganic vapour phase epitaxy on (0001) sapphire substrates. The emission wavelength is approximately 375nm for an active region comprised of $In_{0.03}Ga_{0.97}N$ quantum wells (QWs) and surrounded by GaN, $Al_{0.16}Ga_{0.84}N$ or $In_xAl_{0.16}GaN$ barrier layers. We found that the blue-shift of the emission wavelength related to the piezoelectric field in the QWs and the resulting quantum confined Stark effect (QCSE) clearly depends on the barrier composition and is zero for samples with lattice matched $In_{0.04}Al_{0.16}Ga_{0.80}N$ barrier. An InAlGaN barrier with 3.3% indium resulted in a 50-fold increase of output power compared to LEDs with GaN barriers.

HL 45.9 Thu 11:30 EW 202

Enabling factors for the improvement of nitride-based LED efficiency — •Ansgar Laubsch[1], Werner Bergbauer[1], Matthias Sabathil[1], Matthias Peter[1], Tobias Meyer[1], Georg Brüderl[1], Joachim Wagner[2], Norbert Linder[1], Klaus Streubel[1], Raimund Oberschmid[1], and Berthold Hahn[1] — [1]OSRAM Opto Semiconductors GmbH, Regensburg, Germany — [2]Fraunhofer-Institut für Angewandte Festkörperphysik, Freiburg, Germany

Recent progress in the epitaxial growth of LEDs with InGaN/GaN quantum-well heterostructures has led to a significant enhancement of output power. In this talk, we will discuss the mechanisms limiting the devices' internal efficiency and identify enabling factors for further improvements. We compare samples with different Indium content as well as different design of the active layer.

Although heteroepitaxial growth of GaN on sapphire generates high defect densities, non-radiative defect-related Shockley-Read-Hall recombination does not seem to substantially limit the efficiency of standard InGaN/GaN LED structures. We rather discuss a supplemental Auger-like non-radiative path for carrier recombination that becomes dominant at quantum-well carrier densities typical for LED operation. Additionally, the piezo-field induced reduced overlap of electron and hole wavefunction in standard c-plane grown InGaN quantum wells reduces the radiative recombination rate.