HL 41: Nitrides: InGaN

Time: Tuesday 14:15–15:15 Location: POT 51

HL 41.1 Tue 14:15 POT 51

Systematics of nonradiative recombination in blue and green emitting GaInN/GaN quantum wells — •Torsten Langer, Andreas Kruse, Markus Göthlich, Holger Jönen, Heiko Bremers, Uwe Rossow, and Andreas Hangleiter — Institut für Angewandte Physik, Technische Universität Braunschweig

Light emitters based on GaInN/GaN quantum wells (QW) exhibit a strong drop of efficiency for increasing peak emission wavelengths known as "green gap". In this contribution, we analyze its origin by temperature dependent time-resolved photoluminescence spectroscopy, separating non-radiative and radiative contributions to the carrier recombination processes. We control the peak emission wavelength by varying the indium mole fraction x_{In} between 18% and 38%. The QW thickness is kept below 2 nm to reduce both the risk of lattice relaxation and the diminishing influence of piezoelectric fields on the oscillator strength (especially for c-plane QWs). While the influence of piezoelectric fields is experimentally observed by an increase of radiative lifetimes towards higher x_{In} and thicker QWs, a strong reduction of nonradiative lifetimes τ_{nr} occurs for high x_{In} ($> 25\%$). As the experiments were performed in the low carrier density regime, the nonradiative recombination rate $R_{\mathrm{nr}} \propto 1/\tau_{\mathrm{nr}}$ is of defect-related nature following an exponential temperature dependence $R_{\mathrm{nr}} \propto \exp\left(-E/(kT)\right)$ with an activation energy E. We compare the lifetimes of uncapped multi quantum well (MQW) structures with efficiency optimized structures as well as samples grown on different substrates: sapphire and HVPE-grown pseudo-bulk GaN.

HL 41.2 Tue 14:30 POT 51

Preparation of reconstructed $\mathrm{In}_x\mathrm{Ga}_{1-x}\mathrm{N}(0001)$ surfaces — •C. Friedrich[1], A. Biermann[1], V. Hoffmann[2], N. Esser[1,3], M. Kneissl[1], and P. Vogt[1] — [1]TU Berlin, Inst. f. Festkoerperphysik EW6-1, Hardenbergstr. 36, 10623 Berlin, Germany — [2]Ferdinand-Braun-Institut, Leibniz-Institut, Gustav-Kirchhoff-Str. 4, 12489 Berlin, Germany — [3]Leibniz-Inst. fuer Analytische Wissenschaften - ISAS e.V., Albert-Einstein Str. 9, 12489 Berlin, Germany

The $\mathrm{In}_x\mathrm{Ga}_{1-x}\mathrm{N}(0001)$ is a promising alloy system to investigate the principal mechanisms for the formation of group-III-nitride surface reconstructions, such as metal adlayer formation on reconstructed GaN(0001) or intrinsic surface electron accumulation on InN(0001). However, there is still not much known about the atomic structure of $\mathrm{In}_x\mathrm{Ga}_{1-x}\mathrm{N}(0001)$ grown by metal organic vapour phase epitaxy (MOVPE) mainly because the preparation of such surfaces is crucial for measurements in ultra high vacuum (UHV). Here were present results on $\mathrm{In}_{0.15}\mathrm{Ga}_{0.85}\mathrm{N}(0001)$ surfaces after annealing under UHV conditions and alternatively in nitrogen plasma at temperatures between 500 °C and 800 °C. Auger electron spectroscopy, low energy electron diffraction and atomic force microscopy measurements were performed to elucidate the chemical composition, symmetry and morphology. On clean surfaces we obtained a (1+1/6) symmetry similar to the pseudo-(1×1) surface as reported for GaN(0001). By changing the preparation conditions a (2×2) and $(\sqrt{3}\times\sqrt{3})\mathrm{R}30^\circ$ symmetry is formed. All surfaces exhibit different group-III to group-V ratios and differ significantly in morphology and roughness.

HL 41.3 Tue 14:45 POT 51

InGaN quantum wells in quaternary AlInGaN barriers — •Julian Mack, Clemens Wächter, Alexander Meyer, Michael Jetter, and Peter Michler — Institut für Halbleiteroptik und Funktionelle Grenzflächen and Research Center SCoPE, University of Stuttgart, Pfaffenwaldring 57, D-70569 Stuttgart, Germany

The luminescence efficiency of green emitting InGaN quantum wells grown in between c-plane GaN barriers suffers from strong electrical fields. To overcome this problem we have grown InGaN quantum wells embedded in quaternary AlInGaN barriers by metal-organic vapor phase epitaxy. By using a growth sequence for the barriers with pulsed metal-organic supply we enhanced the photoluminescence efficiencies of these structures. The amount of material was varied, resulting in AlInGaN barriers with constant thickness and indium contents between 1% and 20%. We have analyzed the material properties by x-ray diffraction (XRD) and ensemble photoluminescence (PL) measurements. The observed XRD-spectra and the PL-intensity show the high quality of the deposited material. The Pl spectra of the InGaN quantum wells shift from 2.60 eV to 2.75 eV with decreasing indium content of the barrier. This shift can be attributed to a reduction of the internal electric fields at the heterointerface between InGaN and AlInGaN and the associated quantum confined stark effect (QCSE).

HL 41.4 Tue 15:00 POT 51

effect of mocvd growth parameters on high In content InGaN layers — •öcal tuna[1], hannes behmenburg[1,2], christoph giesen[1], egidijus sakalauskas[3], rüdiger goldhahn[3], holger kalisch[2], rolf h. jansen[2], and michael heuken[1,2] — [1]AIXTRON AG, Kaiserstr. 98, 52134 Herzogenrath, Germany — [2]Chair of Electromagnetic Theory, RWTH Aachen University, Kackertstr. 15-17, 52072 Aachen, Germany — [3]Institut für Micro- und Nanotechnologien, Technische Universität Ilmenau, PF 100565, 98684 Ilmenau, Germany

In this study, several growth parameters have been varied to investigate MOCVD of high-quality InGaN bulk layers using AIXTRON reactors. TMIn, TMGa and NH3 have been used as precursors, N2 as carrier gas and GaN layers as templates. Structural and optical properties have been studied by X-ray diffraction, atomic force microscopy and spectroscopic ellipsometry, respectively. The growth temperature increment from 705 to 755oC results in higher crystal quality but reduced In incorporation due to the low InN dissociation temperature. Also the effect of TMIn and TMGa flows on InGaN growth was investigated. With increasing TMIn flow from 2.5 to 4.4 *mol/min, In incorporation increased from 11.5% to 16.3% without diminishing quality (clear layer fringes observed in ω-2θ X-ray scans). Increasing TMGa flow causes a growth rate enhancement from 22 nm/hr to 37 nm/hr and a simultaneous increment of In content from 16.8% to 17.4% which were calculated by fitting ω-2θ X-ray scans. Even at that high In content, we still have fully strained InGaN layers with observable layer fringes and low RMS roughness around 1.1 nm.