HL 52: Nonpolar and Semipolar Nitrides

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

HL 52.1 Wed 11:45 POT 51

Influence of Si-doping on heteroepitaxially grown a-plane GaN — •Matthias Wieneke, Barbara Bastek, Martin Noltemeyer, Thomas Hempel, Antje Rohrbeck, Harmut Witte, Peter Veit, Jürgen Bläsing, Armin Dadgar, Jürgen Christen, and Alois Krost — Otto-von-Guericke-Universität Magdeburg, FNW/IEP, Universitätsplatz 2, 39106 Magdeburg

Si-doped a-plane GaN samples with nominal doping levels up to 10^{20} cm^{-3} were grown on r-plane sapphire by metal organic vapor phase epitaxy. Silane flow rates higher than 59 nmol/min lead to three dimensional grown crystallites as revealed by scanning electron microscopy. High resolution X-ray diffraction, photoluminescence and cathodoluminescence suggest considerably reduced defect densities in the large micrometer-sized GaN crystallites. Especially, transmission electron microscopy images verify a very low density of basal plane stacking faults less than 10^4 cm^{-1} [1] in these crystallites consisting of heteroepitaxially grown a-plane GaN. In our presentation the influence of the Si doping on the basal plane stacking faults will be discussed. [1] Wieneke et al., Phys. Status Solidi B, 2010, 10.1002/pssb.201046372

HL 52.2 Wed 12:00 POT 51

Single phase semipolar ($11\bar{2}2$) GaN on ($10\bar{1}0$) sapphire — •S. Ploch[1], J. B. Park[2], J. Stellmach[1], T. Schwaner[1], M. Frentrup[1], T. Wernicke[1], T. Niermann[2], M. Pristovsek[1], M. Lehmann[2], and M. Kneissl[1] — [1]Institute of Solid States Physics, — [2]Institute of Optics and Atomic Physics, TU Berlin, Hardenbergstr. 36, 10623 Berlin

InGaN quantum well based light emitters grown on (0001) GaN suffer from poor quantum efficiencies with increasing indium mole fraction due to strong polarization fields along the polar crystal orientation. This effect can be greatly reduced by growing on semi- and non-polar GaN orientations. Semipolar ($11\bar{2}2$) GaN layers were deposited by metalorganic vapour phase epitaxy on ($10\bar{1}0$) sapphire. After sapphire substrate nitridation at 1000°C, a GaN nucleation layer was deposited at high temperature, followed by the deposition of 1.5 nm thick GaN buffer layers. The samples show predominantly ($11\bar{2}2$) orientation with a small fraction of ($10\bar{1}3$) oriented domains. With increasing nitridation layer thickness the ($10\bar{1}3$) phase is suppressed leading to a very smooth surface morphology (rms roughness $<$ 4nm). PL measurements show dominant basel plane stacking fault (BSF) I_1 luminescence without any other defects. Transmission electron microscopy measurements reveal a high BSF density. The FWHM of the X-ray diffraction rocking curve measurements of the ($11\bar{2}2$) reflection decreases to 1193 arcsec and 739 arcsec along [$1\bar{1}00$] and [$11\bar{2}3$] respectively with increasing nucleation temperature. Using high temperature nucleation smooth and homogeneous ($11\bar{2}2$) phase GaN layers have been obtained.

HL 52.3 Wed 12:15 POT 51

Polarisation of the spontaneous emission from nonpolar and semipolar InGaN quantum wells — •Lukas Schade[1,2], Ulrich Schwarz[1,2], Simon Ploch[3], Tim Wernicke[3], Arne Knauer[4], Veit Hoffmann[4], Markus Weyers[4], and Michael Kneissl[3,4] — [1]Department of Microsystems Engineering, University of Freiburg (IMTEK) — [2]Fraunhofer Institute for Applied Solid State Physics (IAF) — [3]Institute of Solid State Physics, Technical University Berlin — [4]Ferdinand-Braun-Institute, (FBH)

Spontaneously emitted light stemming from semipolar and nonpolar InGaN quantum wells is polarized. This property is a consequence of the broken in-plane symmetry of non c-plane wurtzite quantum wells. We studied the polarized photoluminescence of semipolar and nonpolar InGaN/InGaN multi quantum wells grown on low defect density GaN substrates with a setup for confocal microscopy. For excitation of charge carriers we use a 375 nm diode laser. The photoluminescence is collected with an objective of small NA, to avoid polarisation scrambling, and analyzed with a broadband polarizer and a spectrometer. The experimental results are compared to k·p band structure calculations for semipolar and nonpolar InGaN quantum wells. These simulations provide the polarisation degree of the confined states of the valence band and their energetic splitting. Next, from the thermal occupation the polarized spectra are calculated. The comparison with experimental results allows the determination of the valence subband splitting. Our experiments show a splitting of the two topmost valence subbands in nonpolar direction which is larger than predicted.

HL 52.4 Wed 12:30 POT 51

Spatially and spectrally resolved photoluminescence of InGaN MQWs grown on highly Si doped a-plane GaN buffer — •Martin Thunert, Matthias Wieneke, Anja Dempewolf, Frank Bertram, Armin Dadgar, Alois Krost, and Jürgen Christen — Institute of Experimental Physics, Otto-von-Guericke-University Magdeburg, Germany

A set of InGaN multi quantum well (MQW) samples grown by MOVPE on highly Si doped a-plane GaN on r-plane sapphire templates has been investigated using spatially resolved photoluminescence spectroscopy (μ-PL). The Si doping level of nominal about 10^{20} cm^{-3} leads to three dimensionally grown crystallites mostly terminated by m-facets. The MQW thickness has been systematically varied from nominally 2.1 to 4.2 nm, as well as the InGaN growth temperature, which was varied from 760 °C to 700 °C. The growth of a-plane GaN based devices leads to a non-polar growth direction avoiding the polarization field affected Quantum-Confined-Stark-Effect. Spatially resolved PL studies show for all samples low near band edge (NBE) GaN emission intensity over the whole area under investigation accompanied by highly intense InGaN MQW emission for single crystallites. The MQW luminescence shows a systematic blueshift with increasing InGaN growth temperature due to lower In incorporation as well as a systematic redshift with increasing MQW thickness. Excitation power dependent spectra at 4 K as well as temperature dependent PL spectra will be presented.

HL 52.5 Wed 12:45 POT 51

Highly spatially and spectrally resolved cathodoluminescence microscopy of planar semipolar InGaN/GaN MQWs grown on pre-patterned sapphire substrate — •Silvio Neugebauer[1], Sebastian Metzner[1], Frank Bertram[1], Thomas Hempel[1], Jürgen Christen[1], Stephan Schwaiger[2], and Ferdinand Scholz[2] — [1]Institute of Experimental Physics, Otto-von-Guericke-University Magdeburg, Germany — [2]Institute of Optoelectronics, Ulm University, Germany

The optical properties of a 5-fold InGaN multiple quantum well (MQW) grown on planar semipolar ($11\bar{2}2$) GaN directly grown on prepatterned r-sapphire substrate by MOVPE have been investigated using highly spatially and spectrally resolved cathodoluminescence (CL) microscopy. The sapphire was masked and structured via RIE generating grooves with c-plane-like sidewalls. Here the growth of GaN is initiated and single stripes are formed along the sapphire a-direction. The integral spectrum of the GaN substructure exhibits a dominant (D^0,X) emission at 357,4 nm and a weak luminescence at about 361,7 nm related to basal plane stacking faults (BSFs). The BSF-CL was exclusively observed at the -c-wing of the stripes. Dark stripes in CL intensity image running from the c-plane-like sidewalls to the surface indicate bundles of dislocations acting as nonradiative recombination centers. In complete contrast, the area of the +c-wing exhibits a homogeneous CL distribution without any BSF contribution. The luminescence of the InGaN MQW shows three different emission wavelengths at 425 nm, 445 nm and 470 nm according to surface morphology.

HL 52.6 Wed 13:00 POT 51

Indium incorporation in GaInN quantum wells on various surface orientations — •Holger Jönen[1], Uwe Rossow[1], Heiko Bremers[1], Stephan Schwaiger[2], Ferdinand Scholz[2], Sebastian Metzner[3], Frank Bertram[3], Jürgen Christen[3], and Andreas Hangleiter[1] — [1]Institut für Angewandte Physik, TU Braunschweig — [2]Institut für Optoelektronik, Universität Ulm — [3]Institut für Experimentelle Physik, Otto-von-Guericke-Universität Magdeburg

While GaN based blue-violet lasers are commercially available, several problems occur on the way towards the green spectral region. Among others the high indium contents needed for green emission result in high piezoelectric fields which dramatically reduce the oscillator strength. One promising approach to reduce the influence of polarization fields is to grow on non- or semipolar surfaces of the wurtzite structure. In this contribution we compare the In incorporation in GaInN multiple quantum wells on various surface orientations. Our samples were grown by MOVPE on bulk GaN substrates, (HVPE) GaN templates or foreign substrates. The In content in the QWs was determined by high res-

olution X-ray diffraction and photoluminescence. Applying the same growth conditions we find similar growth rates and In contents for the nonpolar layers compared to conventional c-plane structures. Preliminary experiments indicate that the In incorporation on the semipolar $(11\bar{2}2)$-plane is significantly larger which is assigned to a reduction of the strain-induced repulsive interaction between incorporated In atoms on the surface[1].

[1] J. Northrup, Appl. Phys. Letters **95**, 133107 (2009).