Optical properties of ZnO/GaN InGaN core-shell nanorods — Ingo Tischer1, Mohamed Fisch1, Ren Zheng1, Manfred Maelde1, Matthias Hocker2, Ferdinand Scholz2, and Klaus Thonke3 — 1Institut für Quantenmaterie, Gruppe Halbleiterphysik, Universität Ulm, 89069 Ulm — 2Institut für Optoelektronik, Universität Ulm, 89069 Ulm

ZnO/GaN core-shell nanorods standing upright in a well defined pattern can be used for sensing applications. As a first step, we grew ZnO nanopillars on top of GaN pyramids resulting in an ordered array of upright ZnO nanorods with average distance of 6 μm and ≈ 500 nm thickness. This structure was coaxially overgrown with GaN and a subsequent single InGaN quantum well. We report about the different spectral features that are found in these structures. We investigated the various contributions from Zn doping and from the quantum well by spatially resolved cathodoluminescence, transmission electron microscopy, and photoluminescence.

Optical properties of mask-free and uncharacterized GaN nanorods by metal-organic vapor phase epitaxy — Christian Tassarek and Silke Christiansen — Max Planck Institute for the Science of Light, Erlangen, Germany

Nanorod (NR) structures have the potential to significantly reduce the defect density in heteroepitaxially grown GaN. Furthermore, in case of a high density and high aspect ratio the surface to volume ratio is increased in comparison to a two dimensional film.

Our approach is the growth of mask-free and uncharacterized GaN nanorods by metal-organic vapor phase epitaxy. A simple three step method is utilized consisting of nitridation of the sapphire substrate, deposition of a GaN nucleation layer and finally the growth of GaN NRs. Vertically aligned and hexagonal shaped NR structures were achieved with a density of up to 108 cm−2, diameters in the range from 100 nm to some μm, heights up to 30 μm or aspect ratios of up to 30, depending on the growth parameters.

Optical properties of the GaN NRs were determined using spatially and spectrally resolved room temperature cathodoluminescence. It will be shown that the yellow defect band luminescence can be suppressed while the GaN near band edge emission is increased. Finally, the appearance of whispering gallery modes in regular hexagonal shaped GaN NRs will be presented.

Cathodoluminescence investigation of polarization effects in InGaN MQWs with AlInGaN barriers — Silvio Neugebauer, Sebastian Metzner, Frank Bertram, Jürgen Christen, Christoph Berger, Armin Dogan, and Alois Krost — Institute of Experimental Physics, Otto-von-Guericke-University Magdeburg, Germany

The optical properties of In0.25Ga0.75N multiple quantum wells (MQWs) with quaternary AlInGaN barriers have been investigated using highly spatially, spectrally and time-resolved cathodoluminescence (CL) microscopy. The samples were grown on c-plane sapphire substrates by MOVPE using an optimized AlGaN/GaN template. The Indium and Aluminium content of the barriers were increased systematically starting with binary GaN towards matched polarization with respect to the InGaN quantum well. In time-resolved CL measurements, the polarization unmatched reference sample with GaN barriers exhibits a blue-shift of the QW emission wavelength during the onset of the e-beam excitation. The blue-shift clearly indicates the screening of polarization fields. In complete contrast, the polarization matched sample shows a red-shift during onset which indicates that relaxation of carriers into potential fluctuations is the dominant process of the recombination kinetics. During decay both samples consistently show a red-shift of the emission wavelength (field effects as well as potential fluctuations). The results clearly indicate drastically reduced polarization fields when using quaternary barriers.

Optical and Structural Properties of an AlInN/AlGaN Distributed Bragg Reflector using Scanning Transmission Electron Microscopy Cathodoluminescence — Gordon Schmidt, Peter Veit, Alexander Franke, Frank Bertram, Jürgen Christen, Christoph Berger, Armin Dogan, and Alois Krost — Institute of Experimental Physics, Otto-von-Guericke-University Magdeburg, Magdeburg, Germany

We present a direct nano-scale correlation of the optical properties and crystalline real structure of a lattice matched distributed Bragg reflector (DBR) using cathodoluminescence spectroscopy (CL) in a scanning transmission electron microscope (STEM).

The structure was grown by metal organic vapor phase epitaxy on sapphire substrate using an optimized buffer. The highly reflective DBR consists of 35 periods of AlN and AlGaN /λ/4 layers and is capped by a 200 nm thick 33/2 GaN cavity. The STEM-CL images clearly resolve the complete sequence of the DBR structure. The AlGaN n=4 buffer layers emit intense CL at a wavelength of 318 nm. The DBR layers are laterally and vertically homogeneous with sharp AlN/AlGaN interfaces. Local spectra show a blueshift of the DBR emission from 327 nm to 325 nm in growth direction. The direct comparison of the STEM image with the simultaneously recorded monochromatic CL mapping of the DBR luminescence clearly identifies the AlGaN/AlN interfaces as the origin of this emission. This indicates the formation of a 2D electron gas in the polarization field induced potential well at these interfaces.
tially averaged EL peak of the investigated pyramid reveals a very strong blueshift of 290 meV and a high increase in intensity indicating screening of the QCSE and filling of potential fluctuations or local inhomogeneities due to the formation of new current paths.

**HL 80.7 Thu 12:45 ER 270**

**Optical and Structural Nano-Characterization of 62x InGaN MQW on GaN/AlInN DBR** — •Marcus Müller¹, Gordon Schmidt¹, Peter Vett¹, Thomas Hempel¹, Frank Bertram¹, Jürgen Christen¹, Munise Cobet², Raphael Butter², Jean-François Carlin², and Nicolas Grandijn² — ¹Institute of Experimental Physics, Otto-von-Guericke-University Magdeburg, Germany — ²Institute of Condensed Matter Physics, École Polytechnique Fédérale de Lausanne (EPFL), Switzerland

Using low temperature cathodoluminescence spectroscopy (CL) directly performed in a scanning transmission electron microscope (STEM) we present optical and structural properties of a 62x InGaN multi quantum well (MQW) on top of an AlInN/GaN distributed Bragg reflector (DBR). The structure was grown by MOVPE on a sapphire substrate using an optimized GaN buffer.

Direct comparison of the STEM images with simultaneously recorded CL mappings resolve the complete layer sequence, especially the MQW. In particular, the DBR layer stack is laterally and vertically homogeneous with sharp AlInN/GaN interfaces. CL mappings of the DBR show a luminescence at 352 nm originating exclusively from AlInN layers. A dominant emission with a broad spectral range of the InGaN MQW can be observed. Low temperature mappings (T < 20 K) exhibit a systematic redshift of the spectral position of the MQW from the bottom (410 nm) to the top (460 nm), indicating strain relaxation, higher indium incorporation, and/or increasing quantum well thickness.

**HL 80.8 Thu 13:00 ER 270**

**Cathodoluminescence microscopy and X-ray diffraction measurements of semipolar (1T01) GaN structures with InGaN SQWs on patterned Si(001) substrate** — •Christopher Karbaum¹, Frank Bertram¹, Sebastian Metzner¹, Jürgen Christen¹, Jürgen Bläsing¹, Alois Krost¹, Shujian Liu², Vitaliy Avrutin², Natalia Izyumskaya², Ümit Özgür², and Hadis Morkoc² — ¹Institute of Experimental Physics, Otto-von-Guericke-University Magdeburg, Germany — ²Depart. of Electrical and Computer Engineering, VCU, Richmond, USA

The optical and crystalline properties of GaN bars with (1T01) faceted surfaces were investigated using spatially and spectrally resolved cathodoluminescence (CL) at liquid helium temperature and high resolution X-ray diffraction (HRXRD), respectively. Triangular-shaped GaN bars with semipolar (1T01) facets and an InGaN LED structure atop were grown on a structured Si(001) substrate exhibiting V-shaped grooves aligned along Si[110]. In the c-w wing near the Si side facet the (D²X) emission of GaN is shifted to lower energies (∼3.451 eV) due to tensile strain. Intense CL from basal plane stacking faults (BSF) at 3.424 eV can be found in the c-w wing. The CL from the top view reveals intense and broad InGaN emission with an inhomogeneous distribution of the peak energy on the micrometer-scale and emission maxima centered at about 2.48 eV and 3.10 eV. The temperature dependence of the above mentioned CL will be presented. HRXRD measurements indicate an orientation disorder of about one degree of the GaN bars in each direction.

**HL 80.9 Thu 13:15 ER 270**

**Cathodoluminescence study of InGaN quantum wells grown in different crystallographic orientations** — •Sebastian Metzner¹, Frank Bertram¹, Holger Jönen², Torsten Langer³, Uwe Rossow³, Andreas Hangleiter³, Stephan Schwager³, Ferdinand Scholz³, and Jürgen Christen¹ — ¹Inst. of Experimental Physics, Otto-von-Guericke-Univ. Magdeburg — ²Inst. of Applied Physics, Technische Universität Braunschweig — ³Inst. of Optoelectronics, University of Ulm — ⁴now with OSRAM Herbrechtingen

The optical properties of very thin (∼1.5 nm), high indium containing (∼30 %) InGaN QWs which had been grown on conventional polar c-plane GaN/sapphire as well as on semi- and non-polar GaN templates were investigated using spatially, spectrally, and time-resolved cathodoluminescence microscopy. The non-polar QWs were heteroepitaxially grown on m-plane SiC, a-plane GaN/r-plane sapphire templates and homoepitaxially grown on freestanding m-plane GaN. For the semi-polar sample, a planar template of (11-22) GaN grown directly on pre-patterned (10-12)sapphire has been used. Therefore, the sapphire substrate was structured into trenches providing c-plane like sidewalls for the subsequent GaN growth. With the c-direction being inclined to the normal of the surface, the coalescence of GaN stripes forms a planar semipolar (11-22) GaN surface. Especially the local indium incorporation causing lateral fluctuations and the impact of the polarization fields on the recombination kinetics for the various orientations were analyzed in detail at liquid helium and room temperature.