HL 19: Nitrides: Devices

Time: Monday 15:00–17:15 Location: POT 151

HL 19.1 Mon 15:00 POT 151

Comparison of gallium nitride nanorod growth in MBE and MOVPE on nitridated c-plane sapphire — •Julian Stoever, Marc Sauerbrey, Stephan Figge, Jan Ingo Flege, Timo Aschenbrenner, Gerd Kunert, Jens Falta, and Detlef Hommel — Institute of Solid State Physics, University of Bremen, Bremen

Free-standing, nanocrystalline gallium nitride structures on c-plane sapphire substrates were fabricated by metal-organic vapour phase epitaxy (MOVPE) as well as by molecular beam epitaxy (MBE).
Prior to the growth, a substrate nitridation at high temperature and high ammonia flux in MOVPE was carried out to form AlN islands. These nanoislands act as nucleation centers for the rods. The formation process of the islands was investigated in detail by atomic force microscopy and x-ray photoelectron spectroscopy.
Ga-rich conditions, a sufficient silane supply and MOVPE growth temperatures of 1150 °C result in well separated microcolumns. Structures with diameters up to 3 μm and lengths up to 8 μm were fabricated.
On the other hand, nitrogen-rich growth conditions are necessary to achieve columnar growth in MBE. At temperatures of 835 °C, nanorods with diameters of 50 nm and lengths up to 200 nm occur.
Although the same substrate preparation is used, the growth process differs between MOVPE and MBE resulting in different structures. Scanning electron microscopy and micro photoluminescence investigations performed for both types of columns will be presented.

HL 19.2 Mon 15:15 POT 151

Light Emitters Based on GaN Nano-Stripes with Semipolar Quantum Wells — •Robert Anton Richard Leute[1], Junjun Wang[1], Tobias Meisch[1], Benjamin Neuschl[2], Klaus Thonke[2], and Ferdinand Scholz[1] — [1]Institute of Optoelectronics, Ulm University, 89081 Ulm, Germany — [2]Institute of Quantum Matter / Semiconductor Physics Group, Ulm University, 89081 Ulm, Germany

Patterning of silicon dioxide masks on c-oriented GaN/AlGaN templates by imprint lithography allows to fabricate InGaN/GaN nanostripes with semipolar $\{10\bar{1}1\}$ side facets. These stripes have a triangular cross section and form a 1D grating with a period of 260 nm. Subsequent embedding in GaN creates an asymmetric waveguide. The emission of the quantum wells is investigated under electrical and optical excitation. Photoluminescence measurements are performed at varying temperatures. We discuss the performance and suitability of such nano-structures for optical devices.

HL 19.3 Mon 15:30 POT 151

$(11\bar{2}2)$ **InGaN/GaN LEDs grown on 2" patterned sapphire substrates** — •Tobias Meisch[1], Sabine Schörner[2], Junjun Wang[1], Klaus Thonke[2], and Ferdinand Scholz[1] — [1]Institute of Optoelectronics, University of Ulm, 89081 Ulm, Germany — [2]Institute of Quantum Matter, Workgroup Semiconductor Physics, , University of Ulm, 89081 Ulm, Germany

We have grown high quality $(11\bar{2}2)$ GaN on $(10\bar{1}2)$ patterned sapphire. The patterning of the substrate was done by reactive ion etching to produce periodic trenches with a depth of about 1.5 μm and a width of 1.5 μm, revealing a c-plane-like facet on one side. In the following MOVPE process, GaN nucleates on this unmasked side facet, grows out of the trench and forms a coalesced semipolar surface. By comparing the doping behavior of c-plane and $(11\bar{2}2)$ GaN, a significant reduced magnesium incorporation efficiency on the semipolar surface was detected. To achieve similar electrical properties, an about 10 times higher Mg flux is necessary. However, making use of this conclusion, now we are able to grow LEDs on $(11\bar{2}2)$ GaN. Therefore, five InGaN quantum wells with GaN barriers are deposited on an about 1 μm thick silicon doped GaN layer. On the top, a 200 nm thick p-doped GaN layer was grown. First EL measurements show very promising results: At 20 mA, an optical output of 0.2 mW at 450 nm was achieved. By increasing the indium flux step by step, the emission wavelength could be shifted to 475 nm. Adjusting the QW properties and inserting an InGaN pre-QW should help to increase the output power further.

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Al(Ga)N electron blocking heterostructure design for high injection efficient 290 nm light emitting diodes — •Martin Guttmann[1], Christoph Reich[1], Tim Kolbe[1,2], Frank Mehnke[1], Christian Kuhn[1], Jens Rass[1,2], Tim Wernicke[1], Mickael Lapeyrade[2], Sven Einfeldt[2], and Michael Kneissl[1,2] — [1]Technische Universität Berlin, Institut für Festkörperphysik, Hardenbergstr. 36, 10623 Berlin, Germany — [2]Ferdinand-Braun-Institut, Leibniz-Institut für Höchstfrequenztechnik, Gustav-Kirchhoff-Str. 4, 12489 Berlin, Germany

We report on the optical and electronic properties of AlGaN-based light emitting diodes (LEDs) with a wavelength near 290 nm using different electron blocking heterostructures. Using a conventional $Al_{0.7}Ga_{0.3}N$:Mg electron blocking layer (EBL) carrier injection into 290 nm LEDs proves to be challenging. A broad parasitic luminescence around 350 nm was observed, originating from electron overflow into the Mg-doped $Al_{0.4}Ga_{0.6}N/Al_{0.3}Ga_{0.7}N$ superlattice. Our studies show that by inserting an AlN:Mg interlayer (IL) between active region and EBL, electron overflow can be prevented. This is confirmed by electroluminescence measurements and simulations. With increasing IL thickness the emission output power increases, reaches a maximum at 3 nm and remains constant for thicker IL. We present a detailed analysis of the electron and hole injection into 290 nm LEDs using simulations as well as a study of current-voltage-characteristics and the emission spectra obtained from temperature dependent and pulsed electroluminescence measurements.

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Characteristics of sub-300 nm AlGaN multiple quantum well lasers grown on epitaxially laterally overgrown AlN/sapphire substrates — •Martin Martens[1], Peter Schneider[1], Frank Mehnke[1], Christian Kuhn[1], Christoph Reich[1], Viola Kueller[2], Arne Knauer[2], Carsten Netzel[2], Jens Rass[1,2], Tim Wernicke[1], Markus Weyers[2], and Michael Kneissl[1,2] — [1]Technische Universität Berlin, Institut für Festkörperphysik, Hardenbergstr. 36, 10623 Berlin, Germany — [2]Ferdinand-Braun-Institut, Leibniz-Institut für Höchstfrequenztechnik, Gustav-Kirchhoff-Str. 4, 12489 Berlin, Germany

We have investigated the characteristics of AlGaN-based multiple quantum well (MQW) lasers emitting in the UV-B to UV-C spectral range. The laser heterostructures were grown by metal organic vapor phase epitaxy in [0001] direction on low defect density epitaxially laterally overgrown AlN/sapphire substrates. The separate confinement heterostructures consist of $Al_xGa_{(1-x)}N/Al_{0.70}Ga_{0.30}N$ MQWs and $Al_{0.70}Ga_{0.30}N/Al_{0.80}Ga_{0.20}N$ waveguiding heterostructures. Opitcally pumped lasing was obtained in a wavelength range between 272 nm and 293 nm with threshold energy densities down to 15 mJ/cm^2 for resonant pumping of the MQW. Laser emission was transverse electric polarized independent of the wavelength. The variable stripe length method was applied to determine the gain spectra of different laser heterostructures. The influence of emission wavelength and sample morphology on the laser threshold and gain characteristics will be discussed.

HL 19.6 Mon 16:15 POT 151

Sub-250 nm LEDs with enhanced charge carrier injection — •C. Kuhn[1], F. Mehnke[1], M. Guttmann[1], C. Reich[1], T. Kolbe[1], V. Kueller[2], A. Knauer[2], T. Wernicke[1], M. Weyers[2], and M. Kneissl[1,2] — [1]Technische Universität Berlin, Institut für Festkörperphysik, Germany — [2]Ferdinand-Braun-Institut, Leibniz-Institut für Höchstfrequenztechnik, Berlin, Germany

For AlGaN-based LEDs emitting at 250 nm and below, the aluminum content of the active region and surrounding layers exceeds 60%. For LEDs with such high Al mole fractions, carrier injection is a major challenge due to increasing donor and acceptor activation energies and small band offsets between AlGaN quantum wells (QW), barriers and electron blocking layers (EBL). In this study, we investigate the influence of the $AlN/Al_{0.7}Ga_{0.3}N$:Mg electron blocking heterostructure on the injection efficiency of 245 nm LEDs. Increasing thickness of the AlN EBL leads to a rise of the QW luminescence for Mg-doped and undoped AlN layers. However, there is still strong parasitic luminescence centered at 280 nm which depends on the Mg supply during the AlN EBL growth. AlN EBLs grown without Mg enable a drastic reduction of the parasitic luminescence, if the AlN thickness is larger than 4 nm. We were able to demonstrate 245 nm LEDs with an 8 nm thick undoped AlN EBL with external quantum efficiency of 0.19%.

Finally, this improved design was applied to UV-C LEDs with different emission wavelengths. AlGaN-based LEDs in the emission range between 235 nm and 263 nm were demonstrated with maximum EQE of 1.1% at 263 nm.

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Surface passivation studies of AlInN/GaN based HEMTs grown on Si(111) by MOVPE — •Jonas Hennig, Aqdas Fariza, Hartmut Witte, Juergen Blaesing, Armin Dadgar, and Alois Krost — Institut of Experimental Physics, Otto-von-Guericke-University Magdeburg, Magdeburg, Germany

GaN is a wide bandgap material and therefore a good candidate for building high electron mobility transistors (HEMTs) or switching devices with large breakdown voltages. Furthermore, the high electron mobility predestines this material system for high frequency applications that are needed in the telecommunication industry. The spontaneous polarization difference at the AlInN/GaN heterojunction results in a high carrier density of the two dimensional electron gas (2DEG) and therefore in a higher source drain current compared with well-established AlGaN/GaN HEMTs. Although this makes AlInN/GaN HEMTs promising candidates for the application mentioned above these devices suffer from large gate leakage. To reduce the leakage current different capping layers for surface passivation can be chosen. We will present a comparative study of GaN passivation as well as in-situ and ex-situ SiN capping layer and discuss the impact on the device performance. Structural analyses are carried out by XRD and AFM. The electrical characterization includes Hall-effect, C-V measurements and admittance spectroscopy.

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Defect characterisation in AlInN/AlN/GaN HEMT structures on Si(111) — •Aqdas Fariza, Hartmut Witte, Jonas Hennig, Oliver Krumm, Jürgen Bläsing, Armin Dadgar und Alois Krost — Institute of Experimental Physics, Otto-von-Guericke-University-Magdeburg, Magdeburg, Germany

AlGaN/GaN based high electron mobility transistors (HEMTs) are well established for many applications and can be improved in carrier density by using AlInN instead of AlGaN. Growing such structures on Si is advantageous due to lower substrate cost and large substrate diameter, as well as simpler processing. But, due to unavoidable traps performance problems occur. They mostly lead to leakage currents but also other limitation in device parameters. Therefore, investigations of these traps are essential to optimize HEMT devices. We have grown capped AlInN/AlN/GaN HEMTs on Si(111) by MOVPE with nearly lattice matched In-content. Samples were prepared with a Ni/Au-Schottky like contact and an annealed Ohmic contact deposited on top of the layers. I-V- and C-V-characteristics were carried out in dependence of frequencies and temperatures. Simultaneously, we measured the frequency and temperature dependent capacitances and conductance. These investigations exhibit several strong interface defect states located between the metal contact and the GaN buffer layer. Based on a complex equivalent circuit we were able to localize two interface defect states. We will also show significant differences in the interface defect densities between the investigated samples.

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A comparative study of V/Al/Ni/Au and Ti/Al/Ni/Au ohmic contacts on n-AlGaN/GaN — •Christopher Schröter[1], Alexander Schmid[1], Volker Klemm[2], and Johannes Heitmann[1] — [1]Institute of Applied Physics, TU Bergakademie Freiberg, 09599 Freiberg — [2]Institute of Materials Science, TU Bergakademie Freiberg, 09599 Freiberg

A study of ohmic contact formation by V/Al/Ni/Au and Ti/Al/Ni/Au on $n - Al_{0.23}Ga_{0.77}N/GaN$ heterostructures is presented. Vanadium was chosen as a potential alternative for titanium due to lower annealing temperatures required for the ohmic contact formation. For the V/Al/Ni/Au metallization low resistance ohmic contacts were achieved after annealing at 650°C for 30 s. This is a reduction of 150 K compared to the reference Ti/Al/Ni/Au stack. The minimum measured specific contact resistivity was $2.3 * 10^{-6} \Omega cm^2$ at an annealing temperature of 800°C and $2 * 10^{-5} \Omega cm^2$ at an annealing temperature of 650°C. A variation of the vanadium layer thickness from 35 nm to 15 nm showed an improved contact formation for the thinner layer.

After annealing the V/Al/Ni/Au metallization exhibited sharper edges and smoother surfaces compared to the rough Ti/Al/Ni/Au reference stack. For further investigation of the contact microstructure, transmission electron microscopy (TEM), electron energy loss spectroscopy (EELS) and energy dispersive x-ray diffraction (EDX) measurements were performed.