HL 34: Nitrides: Dots, rods, and structures

Time: Tuesday 11:15–13:00 Location: EW 201

HL 34.1 Tue 11:15 EW 201

Direct evidence of quantum dot emission from GaN islands nucleated at threading dislocations — •G. Schmidt[1], S. Metzner[1], C. Berger[1], P. Veit[1], G. Callsen[2], J. Bläsing[1], F. Bertram[1], A. Dadgar[1], A. Hoffmann[2], A. Strittmatter[1], and J. Christen[1] — [1]Institute of Experimental Physics, Otto-von-Guericke-University Magdeburg, Germany — [2]Institute of Solid State Physics, Technical University Berlin, Germany

We give direct evidence of quantum dot (QD) emission from nanometer-sized GaN islands nucleated in close proximity of threading dislocations (TDs) using cathodoluminescence spectroscopy performed in a scanning transmission electron microscope (STEM-CL).

The islands result from a GaN quantum well (QW) layer growth by metal-organic vapor phase epitaxy on AlN/sapphire templates. After deposition of few monolayers of GaN forming the QW layer a growth interruption without ammonia supply was applied prior to 40 nm of AlN cap layer growth.

We are able to spatially resolve cathodoluminescence between 220 nm and 300 nm from the nanometer-sized GaN islands nucleated in the close proximity of AlN TDs, which do not inhibit the luminescence. Very sharp emission lines with line widths below 500 μeV are measured confirming quantum dot like electronic properties within these islands. This full width at half maximum represents a state-of-the-art line width compared to Stranski-Krastanov grown wurtzite polar, non-polar, and zinc-blende GaN QDs as well as GaN QDs embedded in nanowires.

HL 34.2 Tue 11:30 EW 201

Temperature dependence of the luminescence dynamics of InGaN/GaN MQW microrod structures — •Angelina Vogt[1], Linus Krieg[2], Matin Sadat Mohajerani[1], Xue Wang[1,3], Jana Hartmann[1], Martin Strassburg[3], Tilman Schimpke[3], Hergo-Heinrich Wehmann[1], Andreas Waag[1], Jürgen Gutowski[2], and Tobias Voss[1] — [1]Institute of Semiconductor Technology and LENA, TU Braunschweig — [2]Institute of Solid State Physics, University of Bremen — [3]Osram Opto Semiconductors GmbH

Three-dimensional core-shell GaN-based microrods with embedded InGaN multi-quantum-well structures (MQW) are promising candidates for sensors and light-emitting diodes in the green to ultraviolet spectral region. The large area of active layers in relation to the surface area of the substrate is one of the advantages of the microrod structures. Here, we study the temperature dependence of the luminescence dynamics of microrod LED structures with a picosecond time resolution. Their luminescence dynamics were studied in order to characterise the fundamental optical properties and to investigate the influence of varying sample compositions. We compare and discuss the luminescence dynamics of different InGaN/GaN microrod LEDs with regard to the variation of the decay time for different sample positions and temperatures. All samples show a characteristic decay time of the InGaN PL between 50 and 300 ps. In particular, the luminescence on the high energy side typically exhibits a faster decay than that on the low energy side. This is attributed to relaxation and recombination processes of the charge carriers in that energy range.

HL 34.3 Tue 11:45 EW 201

Nano-scale-characterization of ordered core-shell GaN micropillars — •Marcus Müller[1,2], Gordon Schmidt[1], Eduardo Mayolo[1], Peter Veit[1], Frank Bertram[1], Sergiy Krylyuk[2,3], Ratan Debnath[2,4], Matthew King[5], Jong-Yoon Ha[2,3], Baomei Wen[2,4], Abhishek Motayed[2,3,4], Albert Davydov[2], and Jürgen Christen[1] — [1]Institute of Experimental Physics, Otto-von-Guericke-University Magdeburg, Germany — [2]Materials Science and Engineering Division, National Institute of Standards and Technology, USA — [3]Institute for Research in Electronics and Applied Physics, University of Maryland, USA — [4]N5 Sensors Inc., USA — [5]Northrop Grumman ES, USA

In this study we report on the approach of combining top-down principle and the bottom-up processes to fabricate ordered core-shell GaN micropillars. The overgrowth of inductively coupled plasma etched GaN pillars by hydride vapor phase epitaxy produces hexagonally shaped micropillars with vertical non-polar sidewalls and top facet truncated by highly vicinal facets. Scanning electron microscopy measurements of the samples reveal a homogeneous growth. The strain tensors at selected regions of micropillars were analysed, using electron-backscattered-diffraction. Direct correlation of the optical and structural properties of the core-shell GaN micropillars has been achieved using highly spatially resolved cathodoluminescence spectroscopy. CL mappings of the MOVPE grown GaN-bulk template, and the etched core-shell GaN heterostructures reveal a distinct blue-shift of the donor-bound exciton emission due to a strain relaxation.

HL 34.4 Tue 12:00 EW 201

Highly reflective distributed Bragg reflectors for LEDs by modulation doped GaN:Ge — •Christoph Berger, Armin Dadgar, Jürgen Bläsing, Peter Veit, and André Strittmatter — Otto-von-Guericke-Universität Magdeburg

We report on the growth of strain-free, vertically conductive nitride-based Bragg reflectors for LED applications by taking advantage of the Burstein-Moss-effect in highly Ge-doped GaN. The Burstein-Moss-effect describes an increase of the effective bandgap for high carrier concentrations leading to a reduction of the refractive index of the layer. Significant changes of the refractive index can be achieved for carrier concentrations of the order of 1020 cm-3 which is possible in GaN using Ge-doping. For such doping levels, the refractive index of GaN:Ge is reduced to GaN:uid by more than 2 % at a wavelength of 430 nm . We have grown reflectors with 60 periods of GaN:Ge/GaN:uid. Layer growth was monitored by in-situ metrology and no degradation of the layer structure was observed. Close to the targeted wavelength at 430 nm, a stopband centered at 426 nm wavelength with a maximum reflectivity of 60 % was found, which is below the expected reflectivity of 90 %. The reasons for this are under investigation. An InGaN/GaN multiple quantum well grown on top of a 100-pair GaN:Ge/GaN:uid DBR shows significantly altered photoluminescence spectra compared to MQWs grown on an undoped GaN buffer. The spectra of MQW grown on the GaN:Ge/GaN:uid DBR exhibits a drastically reduced linewidth and doubled emission intensity.

HL 34.5 Tue 12:15 EW 201

High-reflectivity, crack-free AlN/AlGaN Bragg mirrors for deep UV micro-cavity structures — •Christoph Berger, Gordon Schmidt, Peter Veit, Armin Dadgar, Jürgen Bläsing, Jürgen Christen, and André Strittmatter — Otto-von-Guericke-Universität Magdeburg

GaN quantum dots are potential candidates to realize single photon emitters at room temperature due to their large exciton binding energy and zero-dimensional confinement potential. We have recently demonstrated narrow emission lines from single GaN quantum dots grown on AlN/sapphire templates by employing the Stranski-Krastanov regime in a MOVPE growth environment. From uPL measurements we find single emission lines with one of the smallest ever reported line width of only 450 ueV for GaN. Maximizing the emission into a distinct direction generally requires the use of mirrors which may also allow for enhanced spontaneous emission rates if such QDs were integrated inside in a resonant cavity structure. Therefore, we have developed highly reflecting, epitaxially grown distributed Bragg reflectors consisting of 50 periods of AlN/Al0.7Ga0.3N. Since these materials have a strong lattice-mismatch, in general these DBRs are subject of distinct crack-formation. Growing the DBR on a thin AlN buffer with a thickness of about 200 nm, smooth DBRs nearly free of cracks could be realized. These DBRs exhibit very high-reflectivities above 98 % at a wavelength around 270 nm. Optical and structural results from GaN quantum dots grown on top of such reflectors will be presented.

HL 34.6 Tue 12:30 EW 201

Structural and optical properties of a GaN-bulk semi-microcavity structure — •Alexander Reuper, Gordon Schmidt, Peter Veit, Frank Bertram, Silke Petzold, Christoph Berger, Armin Dadgar, Alois Krost, André Strittmatter, and Jürgen Christen — Institute of Experimental Physics, Otto-von-Guericke-University Magdeburg, Germany

Using transmission electron microscopy combined with cathodoluminescence spectroscopy (STEM-CL) we analyze structural and spatially resolved optical properties of a GaN-based bulk semi-microcavity structure.

The sample has been grown by metal-organic vapor phase epitaxy on a c-plane Al_2O_3 substrate. A lattice matched 45 pair AlInN/AlGaN distributed Bragg reflector (DBR) serves as bottom mirror for the GaN emission. As active medium consists the whole GaN-bulk cavity which ensures the complete overlap with the cavity mode.
Within the buffer structure, dislocation reduction by a SiN mask is found, whereas low temperature AlN layers, intended for stress control, generate new threading dislocations. In the DBR structure high resolution TEM images show the formations of thin AlN interlayers located at AlInN-AlGaN interfaces, indicating In desorption. Highly spatially resolved STEM-CL at 15 K exhibits GaN-NBE emission at 356 nm, corresponding to compressive strain of about 0.3 GPa. Furthermore, we observe a continuous redshift of GaN-NBE luminescence in growth direction from 356.5 nm at the cavity/DBR interface to 356.9 nm at the surface, indicating elastic relaxation of the GaN cavity.

HL 34.7 Tue 12:45 EW 201

Direct correlation of structural properties and luminescence of an AlInN/AlGaN based microcavity structure — •Max Trippel, Gordon Schmidt, Peter Veit, Frank Bertram, Christoph Berger, Armin Dadgar, André Strittmatter, and Jürgen Christen — Institute of Experimental Physics, Otto-von-Guericke-University Magdeburg, Germany

Using transmission electron microscopy combined with cathodoluminescence spectroscopy (STEM-CL) we present the spatially resolved optical properties of a microcavity structure (MC) on nanometer scale at 15 K.

The MC structure was grown by metal-organic vapor phase epitaxy (MOVPE) on a c-plane sapphire substrate with optimized AlGaN buffer. A lattice matched 45 pairs $Al_{0.85}In_{0.15}N/Al_{0.17}Ga_{0.83}N$ distributed Bragg reflector (DBR) operates as the bottom mirror. The active medium consists of two InGaN/AlGaN multiple quantum well stacks (MQW), which are separated by a 50 nm thick AlGaN barrier.

STEM-CL images clearly resolve the complete stacking sequence of the MC structure. At 15 K the integrated STEM-CL spectrum is dominated by the MQW emission at about 360 nm. Highly spatially resolved STEM-CL linescans reveal a constant MQW peak position along growth direction indicating spectrally identical QWs. Both MQW stacks show distinct luminescence and can be resolved separately. The capture length of both MQWs was calculated to 15 nm.