HL 17: Nitrides: Growth and Characterization

Time: Monday 14:30–16:45 Location: POT 51

HL 17.1 Mon 14:30 POT 51

Epitaxial GaN around ZnO nanopillars — •Mohamed Fikry[1], Manfred Madel[2], Ingo Tischer[2], Klaus Thonke[2], and Ferdinand Scholz[1] — [1]Institut für Optoelektronik, Universität Ulm, Albert-Einstein-Allee 45, 89081 Ulm — [2]Institut für Quantenmaterie ,Universität Ulm, Albert-Einstein-Allee 45, 89081 Ulm

We report on an investigation of the epitaxial quality of GaN layers overgrown coaxially around ZnO nanopillars. In a first step, regularly arranged ZnO nanopillars were grown using pre-patterning by e-beam lithography or self-organized hexagonal polystyrene sphere masks. Alternatively, ZnO pillars were also successfully grown on top of GaN pyramids. In a second step, GaN layers were grwon around the ZnO pillars by Metal Organic Vapor Phase Epitaxy. At growth temperatures above 800 °C, the ZnO pillars are dissolved by the hydrogen carrier gas leaving hollow GaN nanotubes. Characterization involved photoluminescence (PL), scanning electron microscopy and cathodoluminescence. The fair quality of the deposited GaN layers is confirmed by a sharp low temperature PL peak at 3.48 eV attributed to the donor bound exciton emission. Further peaks at 3.42 eV and 3.29 eV show the possible existence of basal plane and prismatic stacking faults.

HL 17.2 Mon 14:45 POT 51

Optical properties of inversion domain boundaries in GaN — •Thomas Kure[1], Ronny Kirste[1], Ramon Collazo[2,3], Gordon Callsen[1], Juan Sebastián Reparaz[1], Anthony Rice[2], Seji Mita[3], Jinqiao Xie[3], Zlatko Sitar[2,3], and Axel Hoffmann[1] — [1]Technische Universität Berlin, Berlin, Germany — [2]North Carolina State University, Raleigh, North Carolina, USA — [3]HexaTech Inc., Raleigh, North Carolina, USA

Influenced by the growth method and growth parameters the polarity of epitaxial grown GaN films can be manipulated to form pure N- or Ga-polarity or states of mixed polarity. GaN grown on heterosubstrates can even form spatially adjacent areas of different polarities differentiated by an inversion domain boundary (IDB). Besides their structural differences each of the areas has unique optical properties, likewise the IDB itself. Furthermore, due to a polar selective doping behaviour, it is possible to fabricate a lateral p/n junction.

Using spatially-resolved photoluminescence spectroscopy (μ-PL) we revealed a temperature dependant enhancement of the luminescence by one order of magnitude at the IDB. Thereby, we confirmed an earlier published model [1]. Samples intentionally doped with Mg, which led to a p/n-junction, revealed an unexpected difference of the enhancement compared to the undoped samples. In addition, we used spatially-resolved electroluminescence spectroscopy (μ-EL) to investigate the influence of an external electric field. [1] V. Fiorentini, Applied Physics Letters 82, 1182 (2003)

HL 17.3 Mon 15:00 POT 51

Raman spectroscopic investigations on epitaxial grown GaN on sapphire — •Christian Röder[1], Cameliu Himcinschi[1], Jens Kortus[1], Frank Habel[2], and Gunnar Leibiger[2] — [1]TU Bergakademie Freiberg, Institute for Theoretical Physics, Leipziger Str. 23, D-09596 Freiberg — [2]Freiberger Compound Materials GmbH, Am Junger-Löwe-Schacht 5, D-09599 Freiberg

One of the biggest challenges of GaN layer preparation is the lack of cost-efficient and high-quality substrates for homoepitaxy. In order to optimize the growth conditions and to understand relaxation mechanisms we investigated a series of heteroepitaxial grown GaN layers on sapphire differing in their layer thickness. By means of confocal Raman spectroscopy we obtained depth spatial information. Analyzing the position of the E2(high) phonon mode we found a wavenumber shift within all layers. This indicates a stress relaxation from the interface to the top of the layer. Furthermore we observed a decreasing compressive stress with increasing layer thickness. Assuming a planar stress state the determined shifts were converted to stress values. These results were compared with simulations using a model of wafer curvature. Additionally the shift of the E2(high) mode was correlated with results of photoluminescence (PL) measurements performed at 293 K. The changes of the band gap derived from the PL data were in excellent agreement compared with the strain dependent band structure at the Γ point. The authors would like to thank the European Union (EFRE) as well as the Free State of Saxony for financial support within the ADDE project.

HL 17.4 Mon 15:15 POT 51

Growth and microstructure of GaN:Cu - a possible spinaligner for nitride-based spintronic — •Philipp R. Ganz[1,2], Gerda Fischer[3], Christoph Sürgers[1,3], Huang Teng Hsing[4], Liuwen Chang[4], and Daniel M. Schaadt[1,2] — [1]DFG-Center for Functional Nanostructures, Karlsruhe Institute of Technology (KIT), 76131 Karlsruhe, Germany — [2]Institut für Angewandte Physik, Karlsruhe Institute of Technology (KIT), 76131 Karlsruhe, Germany — [3]Physikalisches Institut, Karlsruhe Institute of Technology (KIT), 76131 Karlsruhe, Germany — [4]Department of Materials and Optoelectronic Science / Center for Nanoscience and Nanotechnology, National Sun Yat-Sen University, Kaohsiung 80424, Taiwan, R. O. C.

Group-III nitride semiconductors are attractive for spintronic device applications due to the long and temperature independent spin-lifetime in InN quantum dots. For spin-injection into these quantum dots, spin-aligner which yields at room-temperature ferromagnetism and a high spin-polarization is essential. A possible candidate for a nitride-based spin-aligner is GaN:Cu, which exhibit ferromagnetic behavior far above room-temperature, although Cu is an intrinsic non-magnetic material. However, questions regarding the incorporation of Cu in GaN and the origin of the ferromagnetic behavior are still open. Bulk GaN:Cu samples were grown by plasma assisted MBE. We carried out a detailed study on the structural and magnetic properties from nitrogen- to Ga-rich conditions. Under Ga-rich conditions, the formation of Cu-Ga-islands on the surface was observed. The properties of these islands and the bulk material were studied by transmission electron microscopy.

15 min. break

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Defect Characterisation of GaN Based High Electron Mobility Transistors — •Sebastian Rönsch[1], Michael Krieger[1], Heiko Weber[1], Giorgio Schweeger[2], and Markus Sickmöller[2] — [1]Lehrstuhl für Angewandte Physik, Universität Erlangen-Nürnberg — [2]AZZURRO Semiconductors AG, Magdeburg

GaN and related III-V semiconductors are promising materials for the application in high-power electronics. In particular, epitaxially grown AlGaN/GaN heterojunctions are excellent suited for the development of high-power transistors. The intrinsic material properties of AlGaN and GaN induce a two dimensional electron gas with high electron mobility at the interface of the heterojunction. For further improvement of the overall device performance, the heterojunction and its two dimensional electron gas was characterized by different measurement techniques. Hall measurements were performed to investigate the charge carrier concentration and the mobility of the two dimensional electron gas. The mobility of the charge carriers is limited due to electrically active defects within the band gap of GaN. In order to achieve a profound understanding of the defect mechanisms Deep Level Transient Spectroscopy (DLTS) was applied resulting in the defect parameters: activation energy, capture cross section and concentration. Additional Capacitance-Voltage (CV) measurements were carried out to verify the charge carrier concentration determined by the Hall measurements.

HL 17.6 Mon 16:00 POT 51

Band offsets in cubic GaN/AlN superlattices - Theory and Experiment — •Marc Landmann, Christian Mietze, Eva Rauls, Klaus Lischka, Donat J. As, and Wolf Gero Schmidt — Universität Paderborn, Germany

The presently unknown band offset in non-polar cubic GaN/AlN superlattices has been investigated by intersubband and interband spectroscopy as well as ab-initio calculations [1]. On the one hand, the conduction band offset has been determined from the comparison of the measured transition energies with model calculations within the effective mass approximation. On the other hand, the valence and conduction band offset has been accurately simulated by calculating many body corrections within the GW approximation on top of hybrid-functional density functional theory (DFT) calculations. A conduction band offset of (1.4±0.1) eV and a valence band offset of (0.5±0.1) eV has been thus obtained as a result of both approaches.

[1] C. Mietze, M. Landmann, E. Rauls, M. Tchernycheva, F.H. Julien, W. G. Schmidt, K. Lischka and D. J. As (submitted to Phys. Rev. B, 2010).

HL 17.7 Mon 16:15 POT 51

Second- and third-harmonic generation in periodically polarity-inverted GaN wave guides — •Stefan Krischok[1], Sindy Hauguth-Frank[1], Pierre Lorenz[1], Vadim Lebedev[2], Oliver Ambacher[2], Rüdiger Goldhahn[3], Björn Braunschweig[4], Gerhard Lilienkamp[4], and Winfried Daum[4] — [1]Inst. für Mikro- und Nanotechnologien, TU Ilmenau — [2]Fraunhofer IAF, Freiburg — [3]Inst. für Exp. Physik, OvG Universität Magdeburg — [4]Inst. für Energieforschung und Phys. Technologien, TU Clausthal

Quasi-phase matching has proven as promising technique for efficient second- and third-harmonic generation (SHG and THG). For hexagonal GaN the spatial modulation of the nonlinear coefficients can be achieved by a periodic polarity inversion, which was realized by etching periodic stripes into an AlN nucleation layer on sapphire substrates followed by GaN overgrowth by molecular beam epitaxy leading to either Ga- or N-face films with sharp inversion domain boundaries. The nonlinear frequency conversion was studied by an amplified Ti:sapphire laser system pumping an optical parametric amplifier to provide continuous tuning of the fundamental wave length between 1000 and 1600 nm. For a structure with 5.36 μm periodicity, quasi-phase-matched SHG was observed at 1070 nm which is consistent with expectation based on the ordinary and extraordinary refractive indices obtained by ellipsometry. In addition, quasi-phase-matched THG is detected at 1217, 1313, and 1452 nm. A detailed interpretation of these data as well as results of the structural and optical characterization of the N- and Ga-face layers will be presented.

HL 17.8 Mon 16:30 POT 51

Quantum-Confined Stark Effect Observed in (In,Ga)N/GaN Nanowire Heterostructures — •J. Lähnemann, C. Pfüller, O. Brandt, U. Jahn, E. Luna, T. Flissikowski, L. Schrottke, M. Knelangen, A. Trampert, and H. T. Grahn — Paul-Drude-Institut für Festkörperelektronik, Hausvogteiplatz 5–7, 10117 Berlin

Light emitting diodes for the visible spectral region based on planar (In,Ga)N/GaN heterostructures suffer from a high dislocation density and lack of suitable substrates. An alternative is the integration of these heterostructures into nanowires (NWs) grown on Si by molecular beam epitaxy. Indications for the absence of the quantum-confined Stark effect (QCSE) have been reported in the literature, when the piezoelectric polarization is reduced due to an efficient strain relaxation in the NW geometry. In order to elucidate the origin of the observed luminescence centered at 2.4 eV, we combine transmission electron microscopy, cathodoluminescence and micro-photoluminescence (μ-PL) spectroscopy on single NWs. The μ-PL spectra contain a combination of two types of transitions: (i) several sharp lines from localization centers, which are not affected by the excitation power and (ii) a broader band that blueshifts with higher excitation powers. The former are probably related to composition fluctuations in the (In,Ga)N, while the latter is attributed to an inter-well transition between the two 11 nm thick (In,Ga)N insertions separated by an only 2 to 3 nm thick barrier layer. The blueshift under high excitation evidences a screening of the polarization field. Thus, the QCSE appears to be present in these NW heterostructures in contrast to previous reports.