HL 68: Nitrides: Preparation and characterization II

Time: Thursday 15:00–16:45 Location: POT 112

HL 68.1 Thu 15:00 POT 112

Impact of high free-carrier concentrations on optical properties of cubic GaN — •Elias Baron[1], Rüdiger Goldhahn[1], Michael Deppe[2], Donat J. As[2], and Martin Feneberg[1] — [1]Institut für Physik, Otto-von-Guericke-Universität Magdeburg, Germany — [2]Department Physik, Universität Paderborn, Germany

The zincblende III-nitrides are possible candidates for replacing the wurtzite phase nitrides in certain applications such as quantum-dot-based devices. Despite their metastable nature, several improvements concerning control and quality have been reported. Free-electron concentrations n above $10^{20}\mathrm{cm}^{-3}$ are achievable by using Ge as a donor in zincblende GaN and AlGaN. We present a characterization of thin film zincblende GaN, deposited by plasma-assisted molecular beam epitaxy on 3C-SiC/Si substrates in (001) orientation. The complex dielectric functions (DF) in the mid-infrared are obtained by spectroscopic ellipsometry, from which the transverse-optical phonon and plasma frequencies are determined. These results are corroborated by Raman experiments. Utilizing Kane's model for the band structure in the vicinity of the Γ-point of the Brillouin zone, taking into account many-body effects like band-gap renormalization and Burstein-Moss shift, and the optical effectice electron mass determined by the plasma frequency, an all-optical determination of the free-carrier concentration of zincblende GaN is achieved.

HL 68.2 Thu 15:15 POT 112

Absolute internal quantum efficiency of GaInN/GaN quantum wells under steady state conditions — •Savutjan Sidik[1], Philipp Henning[1,2], Philipp Horenburg[1], Heiko Bremers[1,2], Uwe Rossow[1], and Andreas Hangleiter[1,2] — [1]Institut für Angewandte Physik, Technische Universität Braunschweig — [2]Laboratory for Emerging Nanometrology, Technische Universität Braunschweig

An accurate determination of the internal quantum efficiency (IQE) is essential in optimizing the efficiency of GaInN/GaN quantum wells (QWs). A common approach to determine the IQE from temperature-dependent photoluminescence (PL) measurements is based on the assumption that the IQE is 100 % at low temperature. The temperature-dependent integrated PL intensity is normalized to the different incident laser power levels, then normalizing the normalized PL intensity to the maximum value for each temperature and power density gives the IQE. Recently, we have been able to verify this assumption for selected samples using time-resolved PL measurements. In this contribution, we compare samples with known and unknown low-temperature IQE based on their absolute low-temerature PL intensity under otherwise identical conditions. On the one hand, this allows a verification of the 100 % cases. On the other hand, the absolute low-temperature IQE can be assessed by such a comparison for arbitrary samples.

HL 68.3 Thu 15:30 POT 112

Size-effect of donors on the lattice parameters of wurtzite GaN — •Elias Kluth, Karsten Lange, Matthias Wienecke, Jürgen Bläsing, Hartmut Witte, Armin Dadgar, Rüdiger Goldhahn, and Martin Feneberg — Institut für Physik, Otto-von-Guericke-Universität Magdeburg, Germany

We present experimental results on the size effect of the donors Si and Ge in wurtzite GaN. Thin film samples grown by metal-organic vapour phase epitaxy on sapphire with $(11\bar{2}0)$ surfaces were investigated by Hall-effect, high resolution x-ray diffraction, high resolution Raman spectroscopy, and infrared spectroscopic ellipsometry experiments. Phonons and lattice parameters were determined and systematic shifts as a function of carrier and donor concentrations were found. Several contributions are considered: i) epitaxial strain due to epitaxy on foreign substrates, ii) influence of electrons on the lattice parameters, iii) the effect of donor ions on the surrounding GaN matrix which is the so called "size-effect". By comparing GaN:Si with GaN:Ge but similar carrier concentrations, we are able to distangle the different contributions. We report quantitative results of the size-effect of Ge and Si in GaN and phonon deformation potentials for several phonon modes.

HL 68.4 Thu 15:45 POT 112

Electronic properties of $ZnSi_{1-x-y}Ge_xSn_yN_2$ semiconductors — •Masako Ogura, Dan Han, Monika Pointner, Laura Junkers, and Hubert Ebert — Ludwig-Maximilians-University Munich, Munich, Germany

Heterovalent ternary nitrides $Zn(Si,Ge,Sn)N_2$ have a great potential for application in optoelectronics and photovoltaics. We have investigated the mixed crystal system $ZnSi_{1-x-y}Ge_xSn_yN_2$ by means of first-principles electronic structure calculations using the Korringa-Kohn-Rostoker (KKR) Green's function method in combination with the coherent potential approximation (CPA) alloy theory.

Concerning the band gap, good agreement with available experimental data could be achieved by means of the modified Becke-Johnson exchange functional. Calculating the Bloch spectral functions as a function of energy and k-vector allowed to determine the finite lifetime of electron and hole states as well as the corresponding effective masses for the conduction and valence bands, respectively. In addition, representative results for X-ray absorption and emission spectra for the 1s-state of N will be presented.

HL 68.5 Thu 16:00 POT 112

Thermally activated spreading resistance of Si- and Ge-doped lattice matched GaN/InAlN periodic stacks — •Hartmut Witte[1], Cleophace Seneza[1], Prabha Sana[2], Christoph Berger[1], Armin Dadgar[1], and André Strittmatter[1] — [1]Institute of Physics, Otto-von-Guericke-University Magdeburg, Universitätsplatz 2, 39106 Magdeburg, Germany — [2]Fraunhofer Institute for Microstructure of Materials and Systems IMWS, Walter-Huelse-Strasse 1, 06120 Halle, Germany

Si- or Ge-doped lattice-matched GaN/InAlN periodic stack structures were grown by MOVPE for applications as photonic band gap layers in the n-type region of GaN blue laser structures. For electrical transport measurements, mesa structures were realized with ohmic contacts on the bottom and the top of the stack. Besides the sheet resistance, a spreading resistance is observed depending on the contact geometry. Both IV- and CV-characteristics show rectifying behavior at low free electron concentrations and strong ohmic behavior at high electron concentrations. Temperature-dependent Hall- effect measurements verify metallic conduction associated with degenerately doped semiconductors. Contact arrangements for which a higher spreading resistance is found show an opposite temperature dependence of the resistance in IV- measurements. A defect assisted current mechanism via extended defects or the GaN/InAlN interfaces could be presented and will be investigated using CV- and thermal admittance spectroscopy. Kelvin probe microscopy and conductive atomic force microscopy will be employed to analyze surface-related electrical conduction.

HL 68.6 Thu 16:15 POT 112

100% quantum efficiency in III-nitride quantum wells at low temperatures: experimental verification by time-resolved photoluminescence — •Philipp Henning, Savutjan Sidik, Philipp Horenburg, Heiko Bremers, Uwe Rossow, and Andreas Hangleiter — Institut für Angewandte Physik & Laboratory for Emerging Nanometrology, Technische Universität Braunschweig, 38106 Braunschweig, Germany

Using time-resolved photoluminescence (PL) measurements, we present an experimental verification for 100% internal quantum efficiency (IQE) of III-N quantum wells at low temperatures. Conventional IQE measurements, such as temperature- and power-dependent PL, require a low-temperature normalization, where usually an IQE of 100% is assumed. This assumption neglects remaining nonradiative recombination processes, such as tunneling to nonradiative centers, that may be present even at low temperatures. From time-resolved PL measurements, charge carrier lifetimes for radiative and nonradiative recombination can be evaluated separately. We state that the low-temperature IQE corresponds to 100%, whenever the effective charge carrier decay is dominated only by radiative recombination. In this case, the temperature-dependent measurements show a synchronous rise of the effective lifetimes together with the radiative lifetimes, since only the radiative lifetime increases with temperature in a 2D system, while nonradiative processes are thermally activated. Thereby, absolute IQE measurements become possible, since we provide a robust indicator for nonradiative recombination at low temperatures.

HL 68.7 Thu 16:30 POT 112

V-groove patterning of 3C-SiC/Si(001) substrates for cubic GaN epitaxy — •Mario Littmann, Dirk Reuter, and Donat J. As — Universität Paderborn, Department Physik, Warburger Straße 100, 33098 Paderborn

Meta-stable cubic GaN (c-GaN) can be grown by molecular beam epitaxy on 3C-SiC/Si(001) substrates. However, the high lattice mismatch results in many crystal defects. A possible solution to reduce the amount of defects is the pre-pattering of the substrate. In previous works, it was reported that it is possible to create defect-free c-GaN inside a V-shaped groove with an opening angle of 70°. In this case, the walls of the groove match the {111}-facets of the cubic crystal.

In this work, we developed a lithography and etching procedure to create V-shaped grooves inside a 3C-SiC substrate. Electron-beam lithography is applied to create a structure with a width of 100 nm. Reactive-ion etching (RIE) is used to etch a V-shaped groove into the substrate. The RIE process is based on Sulfur hexafluoride to ensure a high lateral etch rate. Scanning electron microscopy (SEM) reveals that the walls are formed by {111}-facets of the cubic crystal. In addition, the first attempts to grow c-GaN on the pre-patterned substrates are discussed. The crystal quality is investigated by high-resolution X-ray diffraction and photoluminescence spectroscopy. The structures are further analyzed by SEM and atomic force microscopy.