HL 22: Focused Session: Semi- and nonpolar group III nitrides II

Time: Tuesday 14:00–16:30 Location: BEY 118

Topical Talk HL 22.1 Tue 14:00 BEY 118

Optical anisotropy of nitride semiconductors — •Rüdiger Goldhahn — Institut für Physik, Technische Universität Ilmenau

The ordinary and extraordinary dielectric functions (DF) describe the optical response of a semiconductor to an electromagnetic wave with electric field polarization perpendicular and parallel to the optic axis (c-axis), respectively. The spectral dependence is closely related to the valence band ordering at the center of the Brillouin zone as well as to the transition energies and transition probabilities in the vicinity of the high-energy van Hove singularities. We have applied ellipsometry in the photon energy range from 0.7 to 9.5 eV in order to determine the DFs of binary and ternary nitrides with wurtzite structure. Results for both polarization directions will be presented and discussed. The experimental results are compared to the results of theoretical calculations. Density functional theory in the local density approximation leads to independent-particle DFs which emphasize the observed optical anisotropy, but the peaks are found at higher energies with respect to the experimental data. If instead the electron-hole Hamiltonian (exciton effects) is employed for the calculations the overall agreement is strongly improved, i.e. the comparison of both calculated DFs yields the size of the peak shift for the high-energy CPs caused by the final state interaction.

Topical Talk HL 22.2 Tue 14:30 BEY 118

Growth on nonpolar and semipolar GaN: The substrate dilemma — •T. Wernicke[1], M. Weyers[1], and M. Kneissl[1,2] — [1]Ferdinand-Braun-Institute, Berlin, Germany — [2]Institute of Solid State Physics, TU Berlin, Germany

Growth of nonpolar and semipolar GaN is very promising for achieving green laser diodes (LDs). However, the choice of the substrate is a difficult one: Heteroepitaxial growth on sapphire, SiC, $LiAlO_2$ yields GaN films with a poor surface quality and high defect densities. On the other hand non- and semipolar bulk GaN substrates provide excellent crystal quality, but are so far only available in very small sizes. In this paper hetero- and homoepitaxial growth will be compared. For all heteroepitaxially grown semi- and nonpolar GaN layers threading dislocations (TD) and basal plane stacking faults (BSF) can be found. There are four possible mechanisms for the generation of BSF: Growth of the N-polar basal plane, formation during nucleation at substrate steps, formation at the coalescence front of differently stacked nucleation islands, and generation at planar defects occurring in m-plane GaN on $LiAlO_2$. BSF induce surface roughening and are associated with partial dislocations causing nonradiative recombination. Thus they affect the performance of devices. We will show that BSFs and TDs can be reduced by epitaxial lateral overgrowth resulting in several micrometer wide defect free areas. However, for LEDs larger defect-free areas are required. GaN layers grown on bulk GaN substrates exhibit a high crystal quality, but show in many cases long-range surface structures with a height of $\approx 1\,\mu m$.

Topical Talk HL 22.3 Tue 15:00 BEY 118

Microscopic Correlation of Structural, Electronical and Optical Properties of semi- and non-polar grown Group-III-Nitrides — •Frank Bertram — Institute of Experimental Physics, Otto-von-Guericke-University Magdeburg, Germany

Although tremendous progress has been achieved in the growth of GaN, there are still many fundamental problems remaining: In particular reaching higher quantum efficiency and extending the spectral range towards shorter and longer wavelengths. One principal physical problem is the quantum confined Stark effect as a consequence of the strong internal electrical polarization fields in c-direction. The most common strategy to overcome the QCSE-problem is to avoid or minimize the polarization fields by growing the heterostructures in other directions, e.g. perpendicular to the GaN c axis by using a- or m-plane nitrides. Another approach to reduce the fields is growing in semi-polar directions. However, epitaxial growth on such planes is by far less developed than the growth on the commonly used c-plane. Morphological defects like dislocations and - in particular in non-c-axis grown material - stacking faults and spontaneous and piezo-electric polarization fields are the major problems in group-III-nitrides. In ternary and quaternary alloys as well as in their hetero-structures nano-scale fluctuations of stoichiometry and/or interfaces have strong impact on the radiative recombination in light emitters. We correlate the structural, electronical and optical properties of non- and semipolar epitaxial nitride structures on a micro- and nano-scale with the crystalline real structure using spatially/spectrally/time-resolved cathodoluminescence.

15 min. break

HL 22.4 Tue 15:45 BEY 118

Fabrication of high quality semipolar GaN on full 2 inch for green light emitters — •Thomas Wunderer[1], Frank Lipski[1], Stephan Schwaiger[1], Ferdinand Scholz[1], Michael Wiedenmann[2], Martin Feneberg[2], and Klaus Thonke[2] — [1]Institut für Optoelektronik, Universität Ulm, 89069 Ulm — [2]Institut für Halbleiterphysik, Universität Ulm, 89069 Ulm

We present a fabrication method for semipolar GaN planes with high material quality and the possibility for large scale production. Inverse GaN pyramids with semipolar {1-101} and {11-22} planes are formed intentionally on a template masked with different hexagonally ordered patterns. Systematic studies of the 3D GaN growth parameters are performed. By varying the V/III ratio, the temperature, and the pressure during the MOVPE growth big differences in the structural shape of the structures and the homogeneity of their distribution could be observed. As figure of merit an InGaN single quantum well emitting in the blue to green spectral region is grown on the semipolar facets. Optical and scanning electron microscopy (SEM) investigations are combined with photoluminescence (PL) and spatially resolved cathodoluminescence (SEM-CL) measurements. Using the optimized growth conditions a complete LED structure is realized on the 3D surface. First results of electroluminescence measurements with emission in the green spectral region are presented.

HL 22.5 Tue 16:00 BEY 118

Characterization of photoluminescence (PL) emission from semipolar {1-101} InGaN quantum wells — •Hans-Jürgen Möstl[1], Clemens Vierheilig[1], Ulrich T. Schwarz[1], Thomas Wunderer[2], Stephan Schwaiger[2], Frank Lipski[2], and Ferdinand Scholz[2] — [1]Institute for Experimental and Applied Physics, University of Regensburg, 93040 Regensburg, Germany — [2]Institut für Optoelektronik, Ulm University, 89069 Ulm, Germany

The strained growth of InGaN quantum films on polar c-plane GaN induces a strong piezoelectric field in the quantum well structures, which leads to a reduction of the emission energy and a spatial separation of electrons and holes in the QW. In order to reduce this piezoelectric fields for future efficient LEDs and LDs, InGaN quantum films are grown on semi- or nonpolar GaN surfaces. In our work we characterize the PL-spectra of InGaN quantum wells grown on semipolar {1-101} FACELO-samples by highly spatial resolved confocal laser scanning microscopy. The emission intensity and energy and their correlation are investigated for varying sample geometries. Furthermore we study the PL-spectra of InGaN layers with a thickness of about 25 nm grown on the same semipolar planes, which show an increased intensity compared to c-plane layers.

HL 22.6 Tue 16:15 BEY 118

GaInN quantum wells with high indium concentrations on polar and nonpolar surfaces — •Holger Jönen[1], Torsten Langer[1], Daniel Dräger[1], Lars Hoffmann[1], Heiko Bremers[1], Uwe Rossow[1], Sebastian Metzner[2], Frank Bertram[2], Jürgen Christen[2], and Andreas Hangleiter[1] — [1]Institut für Angewandte Physik, TU Braunschweig — [2]Institut für Experimentelle Physik, Otto-von-Guericke-Universität Magdeburg

The strong decrease of the internal quantum efficiency (IQE) of GaN based light emitters towards the green spectral region is a well known problem. Beside a degrading material quality the stronger piezoelectric field with increasing indium content reduces the quantum efficiency. A promising way to solve this problem is to grow on non-polar surfaces such as the $(1\bar{1}00)$ of the wurtzite crystal structure. In this case there is no field in growth direction and therefore devices might be more efficient. However, growth conditions may significantly differ from those on conventional c-plane surfaces. In this contribution we discuss the indium incorporation in c-plane and m-plane GaInN quantum wells.

Our samples were grown by low pressure MOVPE and characterized by SEM, XRD, CL and PL measurements. The In content of GaInN layers increases with decreasing growth temperature and seems to be comparable for both surfaces under same growth conditions. However, for high In concentrations above 30% possible relaxation and a degradation of the quantum wells during high temperature growth steps become critical issues.