HL 31: Nitrides: Preparation and characterization II

Time: Wednesday 15:00–17:15 Location: H31

HL 31.1 Wed 15:00 H31

GaN/AlGaN Microfin Core-Shell-Structures for Efficient DUV Emitters — •Christoph Margenfeld[1], Hendrik Spende[1], Hao Zhou[1], Hans-Jürgen Lugauer[2], Hergo-Heinrich Wehmann[1], and Andreas Waag[1] — [1]Institut für Halbleitertechnik, epitaxy competence center ec[2] and Laboratory for Emerging Nanometrology, Technische Universität Braunschweig, Braunschweig, Germany — [2]Osram Opto Semiconductors GmbH, Regensburg, Germany

Conventional DUV LEDs grown on c-plane sapphire substrates suffer from a high density of threading dislocations, which sensitively affects the internal quantum efficiency (IQE), an increasing fraction of TM mode radiation leading to low light extraction efficiency (LEE), and impaired carrier injection efficiency as a result of strong polarization fields. These issues can be circumvented by employing three-dimensional AlGaN microstructures with nonpolar sidewalls.

A GaN/AlGaN core-shell architecture based on microfin structures grown by selective area MOVPE is introduced and the solutions to challenges occurring during growth are discussed. Characterization by XRD reciprocal space mapping, hyperspectral CL mapping and temperature-dependent CL reveals very promising results such as high structural quality, low threading dislocation density and intense emission from nonpolar a-plane MQWs at 280 nm up to 100 °C.

HL 31.2 Wed 15:15 H31

Excess carrier density dependent recombination dynamics on GaN quantum wells — •Silvia Müllner[1], Philipp Hornburg[1], Philipp Henning[1], Heiko Bremers[1,2], Uwe Rossow[1], and Andreas Hangleiter[1,2] — [1]Institute of Applied Physics, TU Braunschweig, Germany — [2]Laboratory for Emerging Nanometrology, Braunschweig, Germany

Recombination dynamics in quantum wells (QW) are commonly described by the ABC-model. Previous results from *c*-plane GaN QW and recent results from *m*-plane GaN QW, however, disagree with this model. Our time-resolved photoluminescence experiments provide information on recombination dynamics. By tuning the pulse energy density, P_{pulse}, the excess carrier density, δn, is varied systematically. The low injection region shows a linear dependence between the radiative process and δn suggesting a recombination process of excitonic nature, which is neglected in the ABC-model. The recombination dynamics in these QW will be compared and discussed for both orientation.

HL 31.3 Wed 15:30 H31

Towards a Deeper Understanding of Shell Growth on GaN Microstructures — •Irene Manglano Clavero[1], Christoph Margenfeld[1], Jana Hartmann[1], Hergo-Heinrich Wehmann[1], Adrian Avramescu[2], Hans-Juergen Lugauer[2], and Andreas Waag[1] — [1]Institut für Halbleitertechnik, epitaxy competence center ec[2] and Laboratory for Emerging Nanometrology, Technische Universität Braunschweig, Braunschweig, Germany — [2]Osram Opto Semiconductors GmbH, Regensburg, Germany

In the last decade, 3D nano and micro light emitting diodes with nonpolar planes have been regarded as promising optical devices to mitigate the droop and provide reduced density of extended defects. Although different groups have investigated the growth mechanism of these 3D structures, there is still no thorough understanding of the mechanisms governing the core-shell growth.

The impact of gallium supply and carrier gas composition on the morphology and growth rate of c- and a-plane shells on GaN microfins grown by selective area metal-organic vapor-phase epitaxy (SaMOVPE) are studied. We evaluate the resulting growth rates in terms of a model based on Chapman-Enskog theory of gas phase diffusion and obtain qualitative and quantitative agreement. It is found that shell growth on 3D microstructures deviates significantly from the mass-transport limited regime which is conventionally observed for the planar case, as is concluded from evaluating the sticking coefficients obtained from the model for the polar and nonpolar crystal planes.

HL 31.4 Wed 15:45 H31

A quantum-mechanical study of pressure-induced isostructural transition in YN and ScN characterized by a reversal in their elastic anisotropy — •Martin Friák[1,2], Pavel Kroupa[1,3], David Holec[4], and Mojmír Šob[5,1,2] — [1]Institute of Physics of Materials, Academy of Sciences of the Czech Republic, Brno, Czech Republic — [2]Central European Institute of Technology, CEITEC MU, Masaryk University, Brno, Czech Republic — [3]Department of Physics, Imperial College London, London, United Kingdom — [4]Department of Materials Science, Montanuniversität Leoben, Leoben, Austria — [5]Department of Chemistry, Faculty of Science, Masaryk University, Brno, Czech Republic

Using quantum-mechanical calculations of 2$^{\text{nd}}$- and 3$^{\text{rd}}$-order elastic constants for YN and ScN with the rock-salt (B1) structure we predict that the studied materials change the fundamental type of their elastic anisotropy by rather moderate hydrostatic pressures of a few GPa. In particular, YN with its zero-pressure elastic anisotropy characterized by the Zener anisotropy ratio $\mathrm{A_Z} = 2C_{44}/(C_{11}$ - $C_{12}) = 1.046$ becomes elastically isotropic at the hydrostatic pressure of 1.2 GPa. The lowest values of the Young's modulus (so-called soft directions) change from $\langle 100\rangle$ (in the zero-pressure state) to the $\langle 111\rangle$ directions (for pressures above 1.2 GPa). It means that the crystallographic orientations of stiffest (also called hard) elastic response and that of the softest one become reversed. Qualitatively the same type of transition is predicted for ScN with the zero-pressure value of the Zener anisotropy factor $\mathrm{A_Z}$ = 1.117 and the transition pressure about 6.5 GPa.

15 min. break

HL 31.5 Wed 16:15 H31

Optical and structural properties of one-directionally lattice-matched $(11\bar{2}2)$ **oriented** $\mathrm{Al_{1-x}In_xN/GaN}$ **heterostructures** — •Savutjan Sidik[1], Philipp Horenburg[1], Heiko Bremers[1], Uwe Rossow[1], Tobias Meisch[2], Ferdinand Scholz[2], and Andreas Hangleiter[1] — [1]Institut für Angewandte Physik, Technische Universität Braunschweig — [2]Institut für Optoelektronik, Universität Ulm

The difference of a/c-ratios of AlInN and GaN allows to realize an intentional one-directional relaxation of the AlInN lattice in a non-lattice-matched direction in semipolar structures. We investigate the evolution of emission features and polarization anisotropy of semipolar $(11\bar{2}2)$ AlInN samples by varying the layer thicknesses and compositions. These samples are grown via MOVPE on $(11\bar{2}2)$ GaN templates grown on patterned r-sapphire substrates. The room temperature photoluminescence spectroscopy (PL) results show a broad luminescence band at around 3.0 eV from AlInN layers intended to be lattice-matched in $[11\bar{2}\bar{3}]$ direction. Also, the spectral position of samples is red-shifted with increasing indium content. However, samples with lower In content do not show luminescence related to AlInN which is also observed in our *c*-plane AlInN structures. We investigate the effects of relaxation and anisotropic strain on polarization anisotropy of AlInN layers with a polarization-resolved PL setup. The measurements reveal polarization of 34%, 23% and 21% for samples with In content of 26.9%, 28.4% and 28.8%, respectively. Modeling of polarization properties based on $\mathbf{k}\cdot\mathbf{p}$ calculation by considering the anisotropic strain is in progress.

HL 31.6 Wed 16:30 H31

Optical properties of nonpolar GaN/AlN superlattice structures — •Michael Winkler[1], Hagen Brähmer[1], Martin Feneberg[1], Norbert Esser[2], Eva Monroy[3], and Rüdiger Goldhahn[1] — [1]Institut für Physik, Otto-von-Guericke-Universität Magdeburg, Germany — [2]Leibniz-Institut für Analytische Wissenschaften - ISAS, Berlin, Germany — [3]University Grenoble-Alpes, CEA, Grenoble, France

Semiconductor superlattice structure are used in optoelectronic devices as active material, for strain management or are parts of waveguides. The dielectric losses in this multilayer structures have a significant impact on efficiency of such devices.

The anisotropic optical properties of $(1\bar{1}00)$ oriented gallium-nitride/aluminium-nitride superlattice structures were studied by synchrotron-based spectroscopic ellipsometry for photon energies up to 10eV. The samples were grown by plasma-assisted molecular-beam epitaxy. Samples with period length of 5.1nm, 5.9nm, and 6.7nm were studied.

Both, a multilayer and an effective layer approach were used to model the experimental data. From the latter, ordinary and extraordinary dielectric functions were deduced by fitting wavelength-by-wavelength. We compare the obtained DFs with results from the multilayer approach, photoluminescence data, and calculated interband transitions. The effects of the non-parabolic valence bands and the limits for the effective layer approach will be discussed in detail.

HL 31.7 Wed 16:45 H31

Nanoscale structural and optical properties of deep UV-emitting GaN/AlN quantum well stack — •Bowen Sheng[1,2], Yixin Wang[1], Xin Rong[1], Zhaoying Chen[1], Tao Wang[1], Ping Wang[1], Gordon Schmidt[2], Frank Bertram[2], Peter Veit[2], Jürgen Bläsing[2], Hideto Miyake[3], Hongwei Li[4], Shiping Guo[4], Zhixin Qin[1], Andre Strittmatter[2], Jürgen Christen[2], Bo Shen[1], and Xinqiang Wang[1] — [1]School of Physics, Peking University, Beijing, China — [2]Institute of Physics, Otto-von-Guericke-University Magdeburg, Magdeburg, Germany — [3]Department of Electrical and Electronic Engineering, Mie University, Mie, Japan — [4]Advanced Micro-Fabrication Equipment Inc., Shanghai, China

We successfully have grown 100 periods of GaN/AlN MQWs with monolayer-thick GaN quantum well on high-quality thermally annealed AlN template by MOCVD. The thickness of AlN barriers is nominally 10 nm. The STEM image contrast is evidencing that the GaN quantum wells are nicely embedded in AlN matrix with sharp interfaces and monolayer thickness of the GaN QWs. A cross-sectional CL linescan performed at 17 K overall reveals the emission evolution: at the beginning of GaN MQWs, the emission has a slight redshift from 225 to 230 nm, then stays perfectly constant towards the top surface. Finally, under higher magnification, the panchromatic CL map resolves the first 13 QW pairs. The CL intensity modulation matches perfect with HAADF contrast. Under this high spatial resolution we are able to resolve the distance between two quantum wells determined as 10.8 nm, not only in HAADF but also in CL intensity.

HL 31.8 Wed 17:00 H31

Ultrathin GaN/InN/GaN QW structures grown by MBE — •Frederik Lüssmann, Tobias Meyer, Jörg Malindretos, Michael Seibt, and Angela Rizzi — Georg-August Universität Göttingen, IV. Physikalisches Institut, 37077 Göttingen

Lately, topological insulators (TIs) have drawn much attention as a new state of quantum matter. In particular, two-dimensional TIs can be achieved by growing QWs with an inverted band structure. For InN/GaN it has been predicted that the large piezoelectric fields in pseudomorphic QWs grown along the [0001] direction can trigger band inversion. The minimum critical thickness of InN for the topological phase transition is expected to be about 4 MLs. In this study we therefore aim at the fabrication of ultrathin pseudomorphic InN/GaN QWs. The samples are grown by MBE and analysed by AFM, STEM and PL. We have examined a growth mode, already known in literature, in which InN QWs are grown at elevated substrate temperatures of 620°C to 670°C, which is well above the dissociation temperature of InN. The high In supply and the subsequent capping with GaN are expected to induce a phase separation resulting in stable InN layer. Furthermore, segregation of the excess In occurs at the growing GaN cap surface. In this way, very well defined and sharp QWs can be grown, as shown by STEM. Sharp PL emission at low temperature also indicates the successful growth of the QW structures.