HL 34: Poster I: III-V Semiconductors

Time: Tuesday 18:30–20:30 Location: Poster D2

HL 34.1 Tue 18:30 Poster D2

Theoretical Description of optical properties in III-V Semiconductor Nanostructures — •Marc Landmann, Michal Pochwala, Jens Förstner, Torsten Meier, Eva Rauls, and Wolf Gero Schmidt — Universität Paderborn

We present a joint theoretical study of the optical properties of GaAs and AlAs bulk and heterostructures. Thereby, we compare the theoretical description of optical excitation on several levels of theory. Results obtained from kp theory [1] are discussed along with data from ab initio calculations within the frameworks of independent-particle (DFT), independent quasiparticle (GW), or Coulomb-correlated quasiparticle (BSE) approximation. [2]

[1] M. Reichelt et al., Phys. Rev. B 68, 045330 (2003)
[2] W. G. Schmidt et al., Phys. Rev. B 67, 085307 (2003)

HL 34.2 Tue 18:30 Poster D2

In situ characterization of homo- and heteroepitaxial GaP(100) surfaces by reflectance anisotropy spectroscopy — •Sebastian Brückner, Henning Döscher, Oliver Supplie, Anja Dobrich, Peter Kleinschmidt, and Thomas Hannappel — Helmholtz-Zentrum Berlin für Materialien und Energie, Hahn-Meitner-Platz 1, 14109 Berlin

Reflectance anisotropy spectroscopy (RAS) is an extremely surface sensitive optical probe applicable for in situ measurements during metal-organic vapour phase epitaxy (MOVPE). Here, we study gallium phosphide deposition on Si(100) as an exemplary model system for the heteroepitaxial III-V growth on non-polar substrates.

The created heterointerface gives rise to the formation of anti-phase domains (APDs) according to the step structure of the substrate. The quantitative in situ RAS control over this crucial defect mechanism requires at first reliable surface preparation and the correct consideration of all influences on the structure and intensity of the characteristic spectra such as surface reconstruction, atomic order or temperature.

Then the reliable in situ quantification of the ADP content of a sample is still corrupted by interferences of the signal with interfacial reflections. These mainly affect the normalization of the RAS signal, which we were able to correct by the empirical calculation of the appropriate relative reflectance. Minor deviations still occur due to the specific anisotropy of the III-V/Si heterointerface, which may be derived by optical simulations.

HL 34.3 Tue 18:30 Poster D2

Structuring the sample surface of MOVPE grown InP QDs on $(Al_xGa_{1-x})_{0.51}In_{0.49}P$ barriers by nanosphere photolithography — •Elisabeth Koroknay, Wolfgang-Michael Schulz, Clemens Wächter, Marcus Eichfelder, Robert Rossbach, Michael Jetter, and Peter Michler — Institut für Halbleiteroptik und Funktionelle Grenzflächen, Stuttgart, Germany

Systems of single and coupled quantum dots (QDs) are of high interest for quantum information processing. The material system of InP QDs embedded in $(Al_xGa_{1-x})_{0.51}In_{0.49}P$ barriers is a promising candidate for applications at elevated temperatures [1]. However MOVPE grown InP QDs in (Al)GaInP barriers show a high quantum dot density of $1.3 \cdot 10^{10}/cm^2$ to $8 \cdot 10^{10}/cm^2$. This requires additional structuring of the sample surface after the growth process for microphotoluminescence (μ-PL) measurements on single quantum dots and quantum dot molecules. As standard structuring methods are either time consuming (electron-beam-lithography) or limited to feature sizes of 1 μm (contact photolithography), microsphere photolithography [2] is used in order to get large area patterns in a standard UV-sensible photoresist. Here, polystyrene microspheres are used as lenses to focus the UV-light. In this way feature sizes from 300 nm to 700 nm can be realized in the photoresist which can be used for the fabrication of shadow masks and pillar structures.

[1] W.-M. Schulz et al, PRB 79, 035329 (2009)
[2] W. Wu et al, Nanoscale Res Lett 03, pp. 123 (2008)

HL 34.4 Tue 18:30 Poster D2

Entwicklung einer Kohlenstoff-Flüssigmetallionenquelle für die fokussierte Ionenimplantation — •Markus Greff, Paul Mazarov, Dirk Reuter und Andreas D. Wieck — Lehrstuhl für Angewandte Festkörperphysik, Ruhr-Universität Bochum, Universitätsstrasse 150, D-44780 Bochum, Germany

Seit ihrer Entwicklung am Ende der 70er Jahre wurde die fokussierte Ionenimplantation (FIB-Implantation) stark weiter entwickelt, so dass mit ihr heutzutage ein hochleistungsfähiges Werkzeug zur maskenlosen, lokalen Dotierungen und zum Sputtern mit Auflösungen um 10nm zur Verfügung steht. Für viele Anwendungen, wie z.B. das lokale p-typ Dotieren von GaAs, Implantation in Diamant, Carbon-Nanoröhrchen und Graphen sowie die Materialmodifikation in organischen Materialien, ist eine fokussierte Kohlenstoffimplantation wünschenswert. Jedoch stellt die Herstellung einer entsprechenden Flüssigmetallquelle eine große Herausforderung dar. In diesem Beitrag stellen wir erste Ergebnisse für eine C-Ce-Quelle vor.

HL 34.5 Tue 18:30 Poster D2

Low energy focused ion beam implantation on GaAs substrate for the preparation of site selected self-assembled InAs quantum dots — •Yu-Ying Hu and Andreas D. Wieck — Ruhr-Universität Bochum, D-44780 Bochum, Germany

Focused ion beam (FIB) technology has received attention for its utilization in fabricating nanostructures. The purpose of this study is to gain low energy ions by applying a high voltage on the target, e.g. in a retarding mode: the high potential will decelerate the 30 keV ions, generating a very low landing energy ion beam of the order of a few tens to a few hundreds of eV for deposition or implantation which yields implantation depths of about 1 nm according to SRIM simulations. In this manner, Indium atoms are placed in the uppermost monolayers which should enhance the self organization of InAs QDs inside the implanted region of a few μm size, resulting in local growth instead of random distribution which is the conventional growing characteristic of self-assembled QDs. For this experiment, an Indium liquid metal ion source is produced. Using an *in situ* focus ion beam connected with a molecular beam epitaxy (MBE) system allows then the growth of the QDs including an subsequent MBE-overgrowth without breaking the ultra high vacuum. The decelerating voltage to be employed on the GaAs target is at maximum 30 kV while the beam current will be scaled in the range of a few pA. IMPRS-SurMat is greatly acknowledged for providing the scholarship and T-courses.

HL 34.6 Tue 18:30 Poster D2

Fabrication of μ-Schottky diode by using molecular beam epitaxy and ion beam lithography — •Asha Bhardwaj[1], Ashish Rai[1], Oleg Petracic[2], Philipp Szary[2], Hartmut Zabel[2], Hans-Werner Becker[3], Dirk Reuter[1], and Andreas Wieck[1] — [1]Lehrstuhl für Angewandte Festkörperphysik, Ruhr-Universität Bochum, D-44780 Bochum, Germany — [2]Experimentalphysik IV, Ruhr-Universität Bochum, D-44780 Bochum, Germany — [3]Fakultät für Physik und Astronomie, Ruhr-Universität Bochum, 44780 Bochum, Germany

Schottky junctions of the metal-intrinsic-n-doped type are widely used to apply electric field to quantum dots (QD) and thus control the charge in the QDs. To apply this concept to single QD is a significant technical challenge and requires μ-Schottky diodes with an active area of approximately 1 μm. In this contribution, we present a novel approach to create such μ-diodes: After growing the basic layer sequence by molecular beam epitaxy, we define a buried stripe in the n-layer by Ar ion implantation. After that a metal line oriented perpendicular to the buried stripe is defined on the surface by electron beam lithography, so that the active area of the junction is only the overlap region of both stripes. The diode characteristic was confirmed by I-V measurements at room temperature as well as at low temperature (4.2K).

HL 34.7 Tue 18:30 Poster D2

Photo-modulated reflectivity and photocurrent measurements of $B_xGa_{1-x}As$ layers grown by MOVPE — •Thomas Sander, Richard K. Thöt, and Peter J. Klar — I. Physikalisches Institut, Justus-Liebig-Universität Giessen, Heinrich-Buff-Ring 16, 35392 Giessen, Germany

$B_xGa_{1-x}As$ samples were grown by low-pressure metal-organic vapour-phase epitaxy (MOVPE) on semi-insulating (001) GaAs substrates with boron concentrations between 0% and 3.4% determined by high-resolution x-ray diffraction. Prior to the BGaAs growth a 150

nm thick GaAs buffer layer was deposited.

Photo-modulated reflectivity measurements were performed between 77 K and 300 K using a halogen lamp as a light source and a 20 mW red diode laser (635 nm) for modulation. To clearly identify the optical transitions photocurrent measurements in the same temperature range have been carried out. Applying a voltage of up to 10 V over the sample and using the same halogen lamp as light source.

The optical transitions in the spectra will be assigned and discussed in terms of the band structure and the boron localized states. The changes of the spectra as a function of temperature and of boron concentration will be analysed.

HL 34.8 Tue 18:30 Poster D2

Carbon doped InAlAs/InGaAs/InAs heterostructures — •Marika Hirmer[1], Imke Gronwald[1], Dieter Schuh[1], and Werner Wegscheider[1,2] — [1]Institut für Experimentelle und Angewandte Physik, Universität Regensburg, D 93040 Regensburg, Germany — [2]present address Laboratorium für Festkörperphysik, ETH Zürich, Schafmattstr. 16, 8093 Zürich, Switzerland

InAlAs/InGaAs heterostructures with a high In content are promising candidates for spintronic applications such as spin-valve mesoscopic devices due to their large Landé g-factor (around 15 in InAs) and large Rashba effect.

Here we present results on carbon doped InGaAs/InAlAs heterostructures with embedded InAs channel. Two different types of structure, one with the doping layer in growth direction above the InGaAs/InAs conducting channel (normal structure) and one with the doping layer below the conducting channel (inverted structure) were investigated. As expected, magnetotransport experiments with these samples show no magnetic effects as a similar Mn doped structures [1] but a direction dependent longitudinal resistance. In addition the influence of the thickness of the embedded InAs channel and the influence of the In content on carrier density and on longitudinal resistance were investigated.

[1] U. Wurstbauer, I. Gronwald, U. Stöberl, A. Vogl, D. Schuh, D. Weiss, W. Wegscheider, Physica E 40, 1563 (2008).

HL 34.9 Tue 18:30 Poster D2

Gate-controlled zero-magnetic-field spin splitting in the valence band of asymmetric AlGaAs/GaAs Quantum Wells — •Michael Hirmer, Marika Hirmer, Dieter Schuh, Werner Wegscheider, Tobias Korn, and Christian Schüller — Institut für Experimentelle und Angewandte Physik, Universität Regensburg, 93040 Regensburg

Zero-Magnetic-Field-Spin-Splitting (ZMFSS) in two-dimensional quantum wells (QW) induced by the structure inversion asymmetry, and its control, are of major importance for both fundamental research and spintronic applications, due to its influence on the dynamics and manipulation of the spin. In hole systems the asymmetry leads to a ZMFSS of the heavy hole (HH) states in third order of the in-plane wave vector $k_{||}$. In our experiments, we focus on highly p-doped asymmetric 2D AlGaAs/GaAs quantum wells (QW). with different QW widths and spacer thicknesses and the manipulation of the Rashba spin splitting via top gates. We utilize electronic intersubband Raman measurements in backscattering geometry at 4.2K. Using polarization selection rules, one can distinguish between charge-density excitation (CDE, polarized spectra) and spin-density excitation (SDE, depolarized spectra) in the Raman spectra. In all samples we observe a low-energy SDE with excitation energies in the range of 0-2 meV. Comparing these excitation energies to 8 band k·p calculations of the valence subbands, the SDE can be interpreted as an intersubband excitation of the spin-split HH ground state, reflecting directly the ZMFSS.

HL 34.10 Tue 18:30 Poster D2

Spin dynamics in high-mobility (110) GaAs based quantum wells — •Roland Völkl[1], Tobias Korn[1], Michael Griesbeck[1], Andreas Maurer[1], Dieter Schuh[1], Werner Wegscheider[2], Sergey Tarasenko[3], Eugenius Ivchenko[3], and Christian Schüller[1] — [1]Universität Regensburg, Germany — [2]ETH Zurich, Switzerland — [3]A. F. Ioffe Physical-Technical Institute, Russia

[110]-grown quantum wells have been studied intensely in recent years, due to the observation of long spin life times, which are caused by the suppression of the Dyakonov-Perel mechanism. Here, we present the results of electron/spin diffusion experiments in (110) grown GaAs-based quantum wells. The Hanle-MOKE method is used to determine the spin lifetime and for mapping the motion of spin-polarized electrons. Spins are continuously injected with a circularly polarized CW laser and the net spin polarization perpendicular to the sample plane is measured by detecting the Kerr rotation of a linearly polarized laser. Both laser beams are focused through an optical microscope onto the sample. Measurements of the spin lifetime show two regions with different increase of the dephasing rate with respect to the excitation intensity due to a saturation of the spin polarization. The pump beam spot can be moved on the sample with a motorized mirror. Hereby, a mapping of the spin diffusion is possible and the spin polarized electrons can be followed up to a distance of about 50 microns from the excitation spot. The effect of the saturation of the spin polarization affects also the diffusion behavior at high intensities.

HL 34.11 Tue 18:30 Poster D2

Temperature dependent investigation of spin dynamics in a Mn-contaminated AlGaAs/GaAs quantum well near an epitaxial GaMnAs layer — •Sebastian Krinner, Michael Griesbeck, Sebastian Fehringer, Robert Schulz, Tobias Korn, Dieter Schuh, Werner Wegscheider, and Christian Schüller — Institut für Experimentelle und Angewandte Physik, Universität Regensburg, D-93040 Regensburg, Germany

GaMnAs is a candidate for future semiconductor-based, all electrical spin injection devices. Due to the diffusion of the Mn^{2+} ions, the properties of quantum structures in the vicinity of a GaMnAs layer can be dramatically affected [1]. In our sample, consisting of two nominally undoped AlGaAs/GaAs quantum wells, where one is close to an 50 nm thick GaMnAs layer and the other (as a reference) is separated by a 100 nm AlGaAs barrier, we could observe long spin lifetimes on the order of a few ns and an increase of the spin lifetime with increasing Mn contamination. In this system we observed strong dependences of the spin lifetime on applied inplane magnetic fields, the sample temperature and the excitation intensity, using all optical techniques like time-resolved Kerr rotation (TRKR), time-resolved photoluminescence (TRPL) and the resonant spin amplification technique (RSA). The dependence on temperature and excitation intensity shows that for $T > 30$ K the system is in the motional narrowing regime of the D'yakonov-Perel mechanism.

[1] R. Schulz et al., Physica E **40**, 2163 (2008)

HL 34.12 Tue 18:30 Poster D2

Spin-injection by resonant tunneling of optically excited carriers — •Stefan Oertel[1], Jens Hübner[1], Dieter Schuh[2], Werner Wegscheider[2,3], and Michael Oestreich[1] — [1]Universität Hannover, Institut für Festkörperphysik, Abteilung Nanostrukturen, Appelstr. 2, D-30167 Hannover — [2]Universität Regensburg, Institut für Experimentelle und Angewandte Physik, D-93040 Regensburg — [3]*Now at:* Solid State Physics Laboratory, ETH Zürich, Switzerland

High efficient spin injection is a desirable prerequisite for threshold reduction of optically pumped spin VCSELs. The injection wavelength differs in this kind of experiments significantly from the emission wavelength and the maximum spin injection polarization is thereby usually restricted to 50 %. Here we investigate a specially designed spin injection heterostructure based upon resonant tunneling of optically injected spins. The MBE grown (110) GaAs structure consists of a 9 nm QW seperated by 3 nm $Al_{0.36}Ga_{0.64}As$ barriers from two adjacent 4 nm QWs. The resonant excitation of the lowest heavy hole exciton transition of the thin QWs enables the generation of up to 75 % electron spin polarization in the thick QW, which is in our experiment detected by time- and polarization resolved photoluminiscence spectroscopy. The spin injection efficiency and the spin dynamics in the drain QW is investigated in dependence on excitation energy and density.

HL 34.13 Tue 18:30 Poster D2

Anisotropic g-factors and isotropic spin lifetimes in reduced symmetry (100) GaAs/AlGaAs quantum wells — •Peter S. Eldridge[1], J. Hübner[1], S. Oertel[1], M. Henini[2], R. T. Harley[3], and M. Oestreich[1] — [1]Institute for Solid State Physics, Gottfried Wilhelm Leibniz University Hannover, Appelstr. 2, 30167 Hannover, Germany — [2]School of Physics and Astronomy, University of Nottingham, Nottingham, UK, NG7 4RD — [3]School of Physics and Astronomy, University of Southampton, Southampton, UK, SO17 1BJ

Zincblende semiconductor quantum wells grown on (100) substrates possessing low symmetry (C_{2v}) provide an interesting medium for the study of electron spin dynamics as the in-plane lifetime and g-factor

can be anisotropic. The origin of the expected lifetime anisotropy is interference of bulk (BIA) and structural (SIA) inversion anisotropy terms in the conduction band spin-orbit splitting while that of the g-factor is the effective conduction band electric field. Interpretation of cw Hanle measurements is difficult as the depolarisation half width depends on both g-factor and spin lifetime simultaneously. In this work we investigate separately the in-plane electron spin lifetime and the g-factor in GaAs/AlGaAs quantum wells with alloy asymmetry using time-resolved spin quantum-beat spectroscopy. The measurements show easily detectable in-plane anisotropy of the electron g-factor but no anisotropy of the spin lifetime. The results therefore demonstrate that the electron g-factor can be readily engineered through the effective conduction band electric field but that the SIA splitting in such systems is unmeasurably small.

HL 34.14 Tue 18:30 Poster D2

Spin Injection in GaAs by Cleaved Edge Overgrowth — •Arne Ludwig[1], Hasmik Harutyunyan[2], Sani Noor[2], Mingyuan Li[3], Henning Soldat[3], Dirk Reuter[1], Andreas Wieck[1], Ulrich Köhler[2], and Martin Hofmann[3] — [1]Lehrstuhl für Angewandte Festkörperphysik — [2]Oberflächenphysik — [3]Lehrstuhl für Photonik und Terahertztechnologie, all Ruhr-Universität Bochum

Spin injection in semiconductors is still a challenging topic. Successful spin injection has been demonstrated by the detection of circularly polarized light, resulting from the recombination of spin polarized electrons and unpolarized holes in a n-i-p-diode. In a conventional approach, the spins are injected from a ferromagnetic metal grown on top of the n-i-p diode. At the interface either a tailored Schottky barrier or an inserted MgO layer serves as tunnel-barrier into the n-doped region of the device. Some technical problems occur, e. g., protecting the semiconductor surface from impurities before depositing the metal/tunnelling barrier and the need for a magnetic material with out-of-plane anisotropy. In our approach, the sample is patterned and ohmic contacts to the p-doped region are evaporated before transferring the sample to a metal-MBE, where it is cleaved under ultra high vacuum conditions. Then, the FM-contacts with MgO- tunnel-barriers are evaporated in situ on the cleavage plane. The spins in this device are thus injected from the side. We will discuss the advantages of this spin injection method as well as the electroluminescence and polarization results from these diodes.

HL 34.15 Tue 18:30 Poster D2

generating InxGa1-xAs quantum dots with low areal density and tailored ground state emission — •ashish rai, dirk reuter, and andreas wieck — Lehrstuhl für Angewandte Festkörperphysik Ruhr-Universität Bochum, Universitätsstraße 150, Gebäude NB, D-44780, Bochum, Germany

In a new concept for an electrically pumped single photon source,quantum dots with low areal density ($\sim 1\times10^8/\mathrm{cm}^2$) and a ground state emission wavelength below 1000nm at 4.2K are required.To achieve this low density, we use a gradient approach where on one side of the wafer the density is high and on other side no QDs are present at all.In the transition region, the desired QD density is present. The evolution of the QD density gradient is checked by photoluminescence spectroscopy. We will also present two growth protocols to obtain the desired emission wavelength.

HL 34.16 Tue 18:30 Poster D2

Surface band structure of GaN(0001)-2×2 — Pierre Lorenz[1], Liverios Lymperakis[2], Richard Gutt[3], •Marcel Himmerlich[1], Juergen A. Schaefer[1], Jörg Neugebauer[2], and Stefan Krischok[1] — [1]Institut für Physik and Institut für Mikro- und Nanotechnologien, TU Ilmenau, P.O. Box 100565, 98684 Ilmenau, Germany — [2]Max-Planck-Institut für Eisenforschung GmbH, Max-Planck-Straße 1, 40237 Düsseldorf, Germany — [3]Fraunhofer-Institut für Angewandte Festkörperphysik, Tullastraße 72, 79108 Freiburg, Germany

The results of an in-situ angle-resolved ultraviolet photoelectron spectroscopy investigation of 2×2 reconstructed GaN(0001) surfaces prepared by plasma assisted molecular beam epitaxy are presented. The valence band dispersion was measured by variation of the detection angle with respect to the surface normal along the $[1\bar{1}00]$ ($\overline{\Gamma}-\overline{K}$) and the $[11\bar{2}0]$ ($\overline{\Gamma}-\overline{M}$) direction using He I ($h\nu = 21.2\,\mathrm{eV}$) and He II ($h\nu = 40.8\,\mathrm{eV}$) radiation. In addition to the bulk states which exhibit strong dispersion, two non-dispersive surface states at 2 eV and 3 eV below the Fermi level are detected in both directions. In order to identify the origin of these states and to validate the experimentally determined k-dependence of the surface and bulk electron states we performed *ab-initio* calculations within the density functional theory and we calculated the band structures of different 2×2 surface reconstructions. Based on these calculations we could identify that the aforementioned states arise from a 2×2 N adatom surface reconstruction.

HL 34.17 Tue 18:30 Poster D2

Interaction of InN(0001)-(2×2) surfaces with water — •Anja Eisenhardt, Stephanie Reiss, Marcel Himmerlich, Juergen A. Schaefer, and Stefan Krischok — Institut für Physik and Institut für Mikro- und Nanotechnologien, TU Ilmenau, P.O. Box 100565, 98684 Ilmenau, Germany

The interaction of water with (2×2) reconstructed InN(0001) surfaces prepared by plasma assisted molecular beam epitaxy will be presented. Thin InN films were characterised in-situ by photoelectron spectroscopy (XPS, UPS) and exposed to water directly after growth. During molecular exposure changes in the core level as well as valence band spectra were measured. Upon H_2O interaction different oxidation stages can be identified due to the formation of several O1s states. Furthermore, three different electron states appear in the valence band at 5.2 eV, 10.2 eV and 8.2 eV. The first two structures can be assigned to oxygen adsorbates based on the comparison to experiments upon InN interaction with O_2, whereas the origin of the latter state is to be identified yet. Additionally the interaction with water molecules results in the disappearance of the (2×2) reconstruction as well as the related surface state at the Fermi level. In parallel the work function decreases and a change in the surface band bending is observed. The results of InN-water interaction will be compared to O_2-induced changes of the InN(0001) surface properties.

HL 34.18 Tue 18:30 Poster D2

Comparison of c- and a-plane aluminum nitride by cathodoluminescence and positron annihilation spectroscopy — •Martin von Kurnatowski[1], Barbara Bastek[1], Matthias Wieneke[1], Thomas Hempel[1], Frank Bertram[1], Armin Dadgar[1], Juergen Christen[1], Alois Krost[1], Jussi-Matti Mäki[2], and Filip Tuomisto[2] — [1]Institute of Experimental Physics, Otto-von-Guericke-University Magdeburg, Germany — [2]Department of Applied Physics, Helsinki University of Technology, Espoo, Finland

Due to its large band gap of more than 6 eV AlN is an important material for III-nitride-based electronic and optoelectronic devices operating in the ultraviolet region. It has already been successfully applied in AlN/AlGaN heterostructures. However, for the reduction of internal polarization fields non- and semipolar III-nitride layers are mandatory, which has been attracting interest in research in the past few years.

In this contribution a set of c-plane and a-plane AlN samples grown under identical growth conditions was investigated. The growth temperature as well as the V/III-ratio was varied for each orientation. Plan-view FE-SEM-images show a brain-like surface structure of the c-plane samples. The surface quality improves with increasing growth temperature. Spatially averaged low temperature CL-spectra reveal a more intense near band edge emission from the c-plane AlN indicating higher material quality than in the a-plane samples. In addition to that, the luminescence attributed to Al-vacancies is less intense in the c-plane samples. These measurements are in agreement with the findings in positron annihilation spectroscopy.

HL 34.19 Tue 18:30 Poster D2

Growth and Doping of AlGaN in MOVPE — •Igor Kuznecov, Joachim Stellmach, Markus Pristovsek, and Michael Kneissl — TU Berlin, Institute of Solid State Physics, Hardenbergstr. 36, 10623 Berlin, Germany

There are numerous applications for ultraviolet (UV) light like water disinfection. Especially around 265 nm the DNA is most sensitive. To achieve this wavelength AlGaN light-emitting diodes (LEDs) with aluminium contents up to 60 % are required. However, for n-doped AlGaN the silicon ionization energy increases from 17 meV for GaN up to 50 meV for $Al_{0.4}Ga_{0.6}N$. The increase in aluminium content is accompanied by the increase in concentration of centers deeper then silicon that have to be filled with electrons before the Fermi level can be shifted to the silicon donor level [1].
Silicon doped $Al_xGa_{1-x}N$ ($0\leq x\leq 0.4$) layers have been grown on AlN/sapphire templates in a close-coupled showerhead (CCS) metalorganic vapour phase epitaxy (MOVPE) reactor. The influence of two key parameters reactor pressure and chamber height, i.e. the distance between showerhead and susceptor were investigated. The aluminium

content was estimated with x-ray diffraction. Carrier concentrations and mobilities have been determined with temperature dependent Hall measurements. The surface quality was studied with atomic force microscopy (AFM).

[1] A. Polyakov, et al., Solid-State Electronics **42** (1998) 627

HL 34.20 Tue 18:30 Poster D2

Wachstum von Al(1-x)In(x)N mittels Molekularstrahlepitaxie — •Raimund Vöhringer, Dongzhi Hu und Daniel Schaadt — Karlsruhe Institut für Technologie, CFN, 76131 Karlsruhe,Deutschland

Um den großen Bereich der von Nitriden abgedeckten Bandlücke zu nutzen ist die Herstellung ternäre Legierungen unterschiedlicher metallischer Konzentration notwendig. Durch gezielte Vermischung von InN (Egap= 0,7eV) und AlN (Egap=6,2eV) könnten diese Halbleiter einen Bereich vom infraroten bis zum ultravioletten Spektrum abdecken.

Die Substratwahl ist bei dem epitaktischen Herstellungsprozess der Halbleiterschichten von entscheidender Bedeutung. So bietet die Si(111) Oberfläche nicht nur eine geeignete hexagonale Oberflächenstruktur, sondern stellt auch ein kostengünstiges und in bestehende Systeme leicht integrierbares Substrat dar. Wir untersuchen das Wachstum von ternären Gruppe III-Nitriden auf Silizium(111) mittels Plasma unterstützter Molekularstrahlepitaxie (PAMBE). Durch die in der Plasmazelle angeregten Stickstoffmoleküle können Nitridhalbleiter schon bei vergleichsweise tiefen Temperaturen gewachsen werden.

Wir haben gezeigt, dass sich ein direktes Wachstum von InN auf Si(111) als nicht erfolgreich erweist. Erst mit Verwendung einer AlN Pufferschicht konnten wir gute Kristallqualitäten erreichen. Kristallqualität und Morphologie der Halbleiterschichten wurde mittels Röntgendiffraktometrie und Elektronenmikroskopie untersucht.

HL 34.21 Tue 18:30 Poster D2

Winkelkorrelationsuntersuchungen an ^{172}Lu(^{172}Yb) in GaN und AlN und Messung bei tiefen Temperaturen — •Riccardo Valentini[1], Karl Johnston[2,3], Reiner Vianden[1] und Isolde Collaboration[3] — [1]Helmholtz - Institut für Strahlen- und Kernphysik der Universität Bonn, Nußallee 14-16, 53115 Bonn — [2]Universität des Saarlandes, 66041 Saarbrücken — [3]CERN, 1211 Genf 23, Schweiz

Für optoelektronische Bauteile werden Halbleiter mit großer Bandlücke verwendet, die mit Seltenen Erden dotiert sind. Um deren Verhalten nach der Implantation zu untersuchen, hat sich die Methode der γ-γ-Winkelkorrelation (PAC) bewährt. Ein geeignetes Isotop zur Untersuchung solcher Halbleiter ist ^{172}Yb.

Die Temperaturabhängigkeit der Hyperfeinfelder für ^{172}Lu(^{172}Yb) in GaN wurde untersucht. Der Verlauf bei Temperaturen unter 50 K konnte bisher noch nicht eindeutig geklärt werden. Bei tiefen Temperaturen zwischen 13 K und 295 K wird generell eine Zunahme der Wechselwirkungsfrequenz erwartet. Hier konnte insbesondere das Vorzeichen des Gitterfeldgradienten bestimmt werden.

Es wurden erstmals temperaturabhängige Untersuchungen der Hyperfeinfelder für ^{172}Lu(^{172}Yb) in AlN durchgeführt. Die Ergebnisse werden präsentiert und diskutiert.

HL 34.22 Tue 18:30 Poster D2

Formation of Ga2O3 by the oxidation of p-type GaN thin films — •Melanie Pinnisch, Daniel Reppin, Jan Stehr, Andreas Laufer, Detlev M. Hofmann, and Bruno K. Meyer — 1. Physikalisches Institut, Justus-Liebig-University-Giessen, Heinrich-Buff-Ring 16, D-35392 Giessen

Both GaN and Ga2O3 are wide band gap semiconductors with energies of 3.45 eV and 4.9 eV, respectively. While GaN can be achieved p- or n-type conducting by doping, Ga2O3 is n-type or high resistive dependent on the presence of oxygen vacancies. We studied the conversion of p-type Mg doped GaN thin films to Ga2O3 by thermal treatments in the temperature range from 600 °C to 1200 °C and in different atmospheres. Changes of the film properties were studied by means of X-ray diffraction, photo-electron spectroscopy and atomic force microscopy. Optical and magnetic resonance methods were used to investigate the evolution of the dopands and defects.

HL 34.23 Tue 18:30 Poster D2

Defect and intra-4f luminescence of rare earth doped group-III nitrides synthesized by high pressure high temperature method — Sven Müller[1], Takashi Taniguchi[2], •Ulrich Vetter[1], and Hans Hofsäss[1] — [1]Georg-August-Universität Göttingen, II. Physikalisches Institut, Friedrich-Hund-Platz 1, 37077 Göttingen, Germany — [2]National Institute for Materials Science, Namiki 1-1, Tsukuba, Ibaraki 305-0044, Japan

Cubic boron nitride (c-BN) and AlN exhibit the largest band gaps among all group-III nitrides with 6.2 and 6.0 eV, respectively. Both materials posses the ability for optoelectonic building blocks which can operate at high temperatures, high power, high frequencies and under extreme chemical conditions. The intensive and narrow intra-4f luminescence of rare earth doped c-BN and AlN crystals could be employed for laser diodes or in optical communication technology. Rare earth doped c-BN and AlN crystals were synthesized via the high temperature high pressure method, with temperatures and pressures between 1450 - 1620 °C and 4.5 - 6.3 GPa, respectively. $Ba_3B_2N_4$ and Li_3AlN_2 were used as solvents with addition of rare earth fluorides as source material for the synthesis of c-BN and AlN, respectively. The luminescence of rare earth doped c-BN and AlN is a superposition of different defect transitions of the host material and intra-4f transitions of the rare earth dopant ion. Intrinsic defects as well as impurity defect complexes serve as origin for various defect bands in c-BN and AlN.

HL 34.24 Tue 18:30 Poster D2

Optical measurements on Gd doped GaN — •Ole Hitzemann[1], Martin Kaiser[1], Enno Malguth[1,2], Markus R. Wagner[1], Jan-H. Schulze[1], Axel Hoffmann[1], Shalini Gupta[2], Tahir Zaidi[2], Ian T. Ferguson[2], Martin Röver[3], Dong-Du Mai[3], Jörg Malindretos[3], and Angela Rizzi[3] — [1]Institut für Festkörperphysik, Technische Universität Berlin, Germany — [2]School of Electrical and Computer Engineering, Georgia Institute of Technology, Atlanta, USA — [3]IV. Physikalisches Institut and VISel, Georg-August Universität Göttingen, Germany

Gd doped GaN has recently gained considerable interest as a potential material for spintronics applications producing a large number of publications. The results, however, are inconsistent: While some authors claim to have achieved ferromagnetic behavior at RT with a high magnetic moment per Gd atom, others did not find any ferromagnetism at all. Optical measurements also showed varying results and there were several contradictory theories describing the role of defects and vacancies for the magnetization. In an attempt to bring clarity to this matter, we examined MOVPE and MBE grown layers of this diluted magnetic semiconductor with Gd concentrations ranging from 10^{17} cm^{-3} to 10^{19} cm^{-3}. p-type and n-type co-doping allowed the investigation of the effect of the position of the Fermi level. We present photoluminescence (PL) spectra of excitonic, DAP and defect luminescence that are related to the incorporation of Gd but also point to other defects and impurities. These results are discussed concerning the ferromagnetic behavior reported for GaN:Gd.

HL 34.25 Tue 18:30 Poster D2

Transport geometry dependence of magnetoresistance behaviour in wurtzite $Al_xGa_{1-x}N$/GaN heterostructures — •Andreas Jupe[1], Kirill Trunov[1], Rüdiger Schott[1], Stepan Shvarkov[1], Dirk Reuter[1], Yvon Cordier[2], and Andreas D. Wieck[1,2] — [1]Ruhr-Universität Bochum, Deutschland — [2]Centre de Recherche sur l'Hétéro-Epitaxie et ses Applications, France

The use of a ferromagnetic semiconductor as a spin injector has attracted great interest because of possible applications in spintronics. Gd doped GaN was reported to exhibit ferromagnetism at room temperature and in this contribution, we present magnetotransport measurements at low temperature in Hall bar geometry, which were carried out on Gd doped $Al_xGa_{1-x}N$/GaN heterostructures. The doping has been performed by focussed ion beam implantation employing 100 kV Gd^{+++} ions with fluences up to 1×10^{12} cm^{-2} into molecular beam epitaxy grown wurtzite $Al_xGa_{1-x}N$/GaN heterostructures, containing a two dimensional electron gas 27 nm below the surface.

The influence of the Hall bar's in-plane orientation, perpendicular to the [0001] direction on the ferromagnetic signature will be discussed.

HL 34.26 Tue 18:30 Poster D2

Cathodoluminescence on heteroepitaxial grown a-plane GaN - reduction of the BSF-luminescence — •Martin Noltemeyer, Matthias Wieneke, Thomas Hempel, Armin Dadgar, Jürgen Bläsing, Alois Krost, and Jürgen Christen — Otto-von-Guericke-Univeristy Magdeburg, Germany

Until now heteroepitaxially grown a-plane GaN films have a high density of structural defects (basal plane stacking faults - BSF) that causes a luminescence-line at about $\lambda = 362$ nm. We present a Si-doped a-plane GaN film, grown on r-sapphire with a high temperature AlGaN nucleation layer without an evidence of basal plane stacking faults in

x-ray diffraction measurements. Using highly spatially and spectrally resolved cathodoluminescence spectroscopy (CL) the Si doped, heteroepitaxially grown a-plane GaN sample was analyzed. Low temperature ($T = 5.2\,\mathrm{K}$) CL spectra, integral as well as local spectra of the three dimensionally grown crystallites, are dominated by the near band edge emission and have a comparatively weak intensity at the spectral region of the BSF-luminescence ($\lambda_{\mathrm{BSF}} = 362\,\mathrm{nm}$). The broadening of the spectra, caused by the Si-doping, with a full width at half maximum of 105 meV is, following [1], appreciated to an impurity concentration ($N_D + N_A$) of about $n = 3 \cdot 10^{19}\,\mathrm{cm}^{-3}$. In addition, the defect-luminescence intensity in the yellow spectral region (around $\lambda = 550\,\mathrm{nm}$) is very weak compared to the near band edge emission which indicates a good crystalline quality. [1] E.F. Schubert, I.D. Goepfert, W. Grieshaber, J.M. Redwing, Appl. Phys. Lett. Vol. 71, No. 7 (1997)

HL 34.27 Tue 18:30 Poster D2

Entstehung selbstorganisierter GaN-Nano-Strukturen durch reaktives Ionenätzen in einer ECR-RIE-Anlage — •Mathias Müller, Thomas Hempel, Bernd Garke, Hartmut Witte, Armin Dadgar, Jürgen Christen und Alois Krost — Institut für Experimentelle Physik, Otto-von-Guericke-Universität Magdeburg

Trockenätzen von GaN-Bauelementschichten ist ein wichtiger Prozessschritt zur Erzeugung von Mikrostrukturen. Hierbei ist das Abtragen der Oberflächen vorrangiges Ziel. Allerdings können unter bestimmten Voraussetzungen auch gezielt Oberflächenreliefs erzeugt werden, die zu Nanostrukturen führen. (Yoshida, H. et al., Jap. J. Appl. Ph. (2001), 12A, 1301-1304)
Die Entstehung von hohlkegelförmigen Nanostrukturen mit einem Durchmesser von ca. 50 nm ohne eine Mikrostrukturierung wird für GaN-InGaN-basierte LED-Strukturen vorgestellt. Hierzu wurde eine ECR-RIE-Plasmaquelle, mit Cl_2 und Ar als Ätzgasen, verwendet. Die selbstorganisierten Strukturen entstehen sowohl im reinen RIE-Betrieb als auch im kombinierten ECR-RIE-Betrieb unter Verwendung von relativ hohen Prozessdrücken. Die Strukturen wurden mittels AFM, REM, XPS und verschiedenen optischen Methoden untersucht.

HL 34.28 Tue 18:30 Poster D2

Microscopic investigations of the optical and structural properties of nonpolar InGaN MQWs on a-plane GaN ELOG structures — •Torsten Schwarz[1], Barbara Bastek[1], Thomas Hempel[1], Peter Veit[1], Jürgen Christen[1], Tim Wernicke[2], Markus Weyers[2], and Michael Kneissl[2,3] — [1]Institute of Experimental Physics, Otto-von-Guericke-University Magdeburg, Germany — [2]Ferdinand-Braun-Institut für Höchstfrequenztechnik, Berlin, Germany — [3]Institute of Solid State Physics, Technical University Berlin, Germany

We present the optical and structural properties of InGaN MQWs which were grown by MOVPE on fully coalesced lateral epitaxially overgrown (ELOG) a-plane GaN on r-plane sapphire substrate and stripe masks orientated in the [01$\underline{1}$0] direction. Photoluminescence (PL) measurements exhibit a strong emission from the InGaN MQW at 3.109 eV at 4 K dominating the GaN (D^0,X) emission at 3.488 eV by two orders of magnitude. The emission from basal plane stacking faults (BSF) was even more suppressed. Transmission electron microscopy showed a drastic reduction of the BSF in the lateral overgrown area (I) compared to the area of coherent growth (II). μ-PL and highly spatially resolved cathodoluminescence (CL) measurements revealed an intensity increase of the MQW emission by a factor of two for the defect reduced region (I) compared to the defective region (II). Also a blue shift by 20 meV of the MQW peak emission wavelength in the area (I) in comparison with defective area (II) was observed.

HL 34.29 Tue 18:30 Poster D2

Morphology and atomic structure of InGaN(0001) surfaces — •Amelie Biermann[1], Christian Friedrich[1], Veit Hoffmann[2], Norbert Esser[3,1], Michael Kneissl[1], and Patrick Vogt[1] — [1]TU Berlin, Institute of Solid State Physics EW6-1, Hardenbergstr. 36, 10623 Berlin, Germany — [2]Ferdinand-Braun-Institut f. Hoechstfrequenztechnik, Gustav-Kirchhoff-Str. 4, 12489 Berlin, Germany — [3]ISAS-Berlin, Albert-Einstein Str. 9, 12489 Berlin, Germany

Group III-nitrides offer a broad application spectrum in optoelectronic devices. Although the fabrication of high-quality devices requires the control of nanometer thick layers, there is only limited knowledge about the atomic structure of the surface. Here we present a study on the morphology and atomic structure of (0001) $In_xGa_{1-x}N$ surfaces grown by MOVPE. Samples are prepared under UHV conditions by thermal annealing between 600°C and 800°C to achieve clean, decontaminated surfaces. Additionally thermally cracked ammonia and nitrogen plasma are used as nitrogen sources in order to vary surface stoichiometries and to prevent nitrogen depletion of the crystal. The chemical composition of the surface during preparation is determined by Auger Electron Spectroscopy. Clean (0001) $In_xGa_{1-x}N$ surfaces were prepared at 760°C revealing no surface carbon and low residual oxygen compounds. Depending on the surface preparation, surface structures showing different surface symmetries such as (1×1), (1+1/6) or (2×2) were obtained as determined by LEED. The chemical composition remains similar for all structures. In order to get further information STM measurements of the atomic structure are presented.

HL 34.30 Tue 18:30 Poster D2

Semipolar InN grown on m-plane sapphire using MOVPE — •Duc Van Dinh, Markus Pristovsek, and Michael Kneissl — Institute of Solid State Physics, Technische Universität Berlin, Hardenbergstraße 36, 10623 Berlin, Germany

Growth of InN is still a challenging issue even on (0001) c-plane sapphire. Thus very little results exist about growth of non-polar InN and nothing about growth of semi-polar InN on sapphire.

We have investigated the growth of InN layers on (0001) c-plane and (10-10) m-plane sapphire substrates by metal-organic vapor phase epitaxy. Similar to growth of GaN, for growth of InN on sapphire substrate, a nitridation process is employed to improve crystalline quality. By using X-ray diffraction we found that InN grown on m-plane sapphire exhibited one dominant peak of (10-13) InN. The surface morphology of (0002) InN on c-plane sapphire is much smoother than the InN grown on m-plane sapphire. The rougher surface of semi-polar InN on m-plane sapphire is likely caused by twinning of the (10-13) InN. The in-plane relationship for (10-13) InN was [30-3-2]InN//[1-210]sapphire and [1-210]InN//[0001]sapphire. The optical properties of the grown InN were also investigated by photoluminescence measurement and spectroscopic ellipsometry.

HL 34.31 Tue 18:30 Poster D2

Influence of growth rate and V/III ratio on the critical layer thickness for relaxation of thick MOVPE grown InGaN layers — •André Kruse, Martin Leyer, Markus Pristovsek, and Michael Kneissl — Technische Universität Berlin, Institut für Festkörperphysik, Hardenbergstr. 36, 10623 Berlin

To improve the quality of InGaN light emitting diodes and laser diodes InGaN was grown on GaN templates with metal-organic vapour phase epitaxy (MOVPE). Two processes occur, depending on the growth parameters. First a 2D to 3D transition is seen. Depending on the indium content and the size of Quantum dots (QD) the InGaN layer decomposes lateral. For higher indium content the layer is rather homogeneous and reaches its critical thickness for relaxation. We studied systematically the influence of the InGaN growth rates at temperatures between 700 °C and 850 °C. Additionally the V/III ratio was varied from 2000 to 7000 to investigate the influence of surface kinetics and chemistry on homogeneity and the critical layer thickness. Growth rates and the onset of relaxation will be analysed with in-situ spectroscopic ellipsometry. Layer quality and strain state are measured ex-situ with x-ray diffraction.

HL 34.32 Tue 18:30 Poster D2

Intracavity contacts for nitride based monolithic surface emitters by focused ion beam processing — •Malte Fandrich, Heiko Dartsch, Christian Tessarek, Timo Aschenbrenner, and Detlef Hommel — Institut für Festkörperphysik - Halbleiterepitaxie, Universität Bremen, Otto-Hahn-Allee 1, 28359 Bremen, Germany

The realization of electrically driven nitride based vertical-cavity surface-emitting lasers (VCSELs) is challenging due to limitations in the conductivity of the distributed Bragg reflectors (DBRs). Therefore monolithic approaches are based on a doped cavity and one or two undoped DBRs. This requires the use of technologically complex intracavity contacts.

The presented process yields intracavity contacts applicable to monolithically grown VCSEL structures. Initially mesas are structured by photolithography and chemical assisted ion beam etching. The precise structuring of the prestructured mesas is performed in a focused ion beam system (FIB), where the micropillars are thinned stepwise down to a diameter of 0.5 - 5 μm. The contacting of the pillars is realized by FIB deposited metal and insulator structures. Insulator separated Pt ringcontacts connect the micropillars with large-scale contact pads. This procedure was applied to a VCSEL structure con-

sisting of a bottom AlInN/GaN-DBR with 40 pairs, a p/n-doped 5 λ GaN-cavity with embedded InGaN quantum dots and a top 10 pair AlInN/GaN-DBR. The developed contacting structure enables a current up to 15 mA through the cavity which documents the capability for the electrical operation of VCSEL devices.

HL 34.33 Tue 18:30 Poster D2

Präparation von GaN-basierten Proben mittels Niedrigenergie-Ionendünnung für Transmissionselektronenmikroskopie — •Stephanie Bley, Thorsten Mehrtens und Andreas Rosenauer — AG Elektronenmikroskopie, Institut für Festkörperphysik, Universität Bremen, Otto-Hahn-Allee 1, 28359 Bremen, Deutschland

Auf der Oberfläche von TEM-Proben (TEM - transmission electron microscopy) lagern sich durch die Präparation (mechanisches Dünnen oder FIB (focused ion beam)) und nach längerem Kontakt mit der Luft schwach gebundene Atome (z.B. O,C,N etc.) an. Durch die Niedrigenergie-Ionendünnung werden diese schwach gebundenen Atome von der Probenoberfläche entfernt. Anhand von GaN-basierten Proben wird gezeigt, welchen Einfluss die Ionendünnung auf die Proben hat. Dazu wurden Untersuchungen mittels HRTEM (high resolution TEM) und STEM (scanning TEM) durchgeführt. Unter anderem werden für verschiedene Ionenenergien Dickenprofile der Probe erstellt. Dickenprofile werden durch den Vergleich der normierten Intensität aus STEM-Bildern mit einer durch die Frozen Lattice-Methode simulierten Referenzintensität erzeugt.

HL 34.34 Tue 18:30 Poster D2

InGaN layers in visible LEDs and solar cells — •Samir Hammadi, Joerg Hisek, Holger Jönen, Uwe Rossow, and Andreas Hangleiter — Institut für Angewandte Physik, Technische Universität Braunschweig

By applying InGaN quantum well layers in light emitting heterostructures, efficiencies greater than 80% in the blue-violet wavelength range can be achieved. This requires a high structural perfection of the underlying layers and the active region - grown by metal organic vapour phase epitaxy (MOVPE) - as well as suitable process steps in order to suppress the effects of the remaining dislocations as nonradiative recombination centers. Naturally, it should be possible to utilize similar structures for solar cells. By varying the In content of InGaN, the band gap can be altered between 0.67 * 3.4 eV, covering almost the whole solar emission spectrum. Such a heterostructure would, however, require InGaN layers with a rather high ($>$ 50%)) and low ($<$ 30%) In content. For a high In incorporation relatively low growth temperatures are necessary, making it difficult to achieve high quality layers with conventional MOVPE growth. Plasma assisted molecular beam epitaxy (RF-MBE) may overcome this problem, does, however not enable higher growth temperatures for low indium incorporation. In this contribution we compare high-In quantum wells (30-50%) grown by MOVPE and by MBE and study the influence of defects and recombination centers by analyzing X-ray diffraction, transmission electron microscopy, and photoluminescence data.

HL 34.35 Tue 18:30 Poster D2

Optical gain studies of green emitting GaInN based laser structures — •Moritz Brendel, Alexander Daniel Dräger, Holger Jönen, Uwe Rossow, and Andreas Hangleiter — Institut für Angewandte Physik, TU Braunschweig, Germany

Violet-blue emitting laser diodes based on GaInN with high output powers and long lifetimes are now commercially available. Recently, structures based on the same material system emitting in the green spectral range were obtained [1]. The aim of this work is to systematically investigate and characterize the parameters of c-plane GaInN single quantum well laser structures grown by MOVPE on c-plane sapphire substrates. For tuning the wavelength beyond 500 nm we increase the indium concentration of the active region far above 30% and by utilizing thin quantum wells of about 1.5 nm the evoking influence of the piezoelectric fields is reduced. We perform optical gain measurements using the variable stripe length technique to determine the optical gain and losses. Furthermore, by combining the measured data with model calculations of the optical gain spectra we have access to threshold power densities, carrier densities as well as to radiative and nonradiative lifetimes. We find a rather small broadening of the gain spectra but an increasing threshold pump power for longer wavelengths.

[1] Avramescu et al, APL vol95, p071103 (2009)

HL 34.36 Tue 18:30 Poster D2

Near-field microscopy on GaInN/GaN green light emitting quantum-well structures — •Peter Clodius, Holger Jönen, Lars Hoffmann, Heiko Bremers, Uwe Rossow, and Andreas Hangleiter — Institut für Angewandte Physik, Technische Universität Braunschweig

In contrast to blue emitting GaInN/GaN quantum well structures, which show a quite high internal quantum efficiency (IQE), the IQE of green emitting GaInN/GaN quantum well structures is dropping quickly towards longer wavelengths. Another difference between blue and green quantum wells is the fact that the effect of thermal annealing on the luminescence is much stronger for the structures emitting in the green. In this contribution we will present spatially resolved photoluminescence measurements on structures emitting in the blue and green respectively, before and after a thermal annealing process to further investigate the inferior performance of green-emitting structures. The measurements were done with a scanning near-field optical microscope (SNOM) with which we are able to investigate the luminescence structure with a spatial resolution far below the diffraction limit ($\approx 50nm$).

HL 34.37 Tue 18:30 Poster D2

Behaviour of the spontaneous polarisation field in polar and nonpolar GaInN/GaN quantum well structures — •Martina Finke, Holger Jönen, Heiko Bremers, Uwe Rossow, and Andreas Hangleiter — Institut für Angewandte Physik, TU Braunschweig, Germany

The spontaneous and piezoelectric fields in wurtzite GaN-based quantum well structures induce the quantum confined Stark effect(QCSE). The QCSE causes a decrease in the effective bandgap and a reduction of the oscillator strength in the polar c-direction. Unlike in case of the polar direction, the electric fields and the QCSE vanishes in the nonpolar directions, like m-plane. We use GaInN quantum wells as a sensitive probe for the magnitude and changes of the spontaneous field. By using cathodoluminescence in an UHV environment we were able to investigate field induced effects in the polar direction and the absence of these effects in a nonpolar direction. The complex dynamics are observed as a shift of spectral position and a intensity variation. Various samples grown on polar and nonpolar substrates were investigated. By variation of the sample structure like cap thickness and doping level we study the different time dependent behaviour in screening and descreening of the spontaneous field at different electron beam penetration depth. In this contribution we present measurements on nonpolar heterostructures which clearly shows no electric field induced effects, like emission energy and intensity shifts. Compared to the strong effects on polar samples, these measurements prove the absence of the spontaneous field in nonpolar directions.

HL 34.38 Tue 18:30 Poster D2

TEM Investigation of c- and m-plane GaInN/GaN Quantum Well Structures with high Indium Content — •Lars Hoffmann, Heiko Bremers, Holger Jönen, Uwe Rossow, and Andreas Hangleiter — TU Braunschweig, Institute of Applied Physics, Braunschweig, Germany

While GaN-based blue light emitting diodes exhibit exceptionally large internal quantum efficiencies (up to 80% at room temperature) their green counterparts quickly become less efficient at longer wavelength. A green laser diode based on c-plane GaN has been demonstrated, but the origin of the green gap is still far from being understood. While LED efficiency greatly benefits from V-shaped pits decorating threading dislocations, laser diodes require highly perfect interfaces and homogeneous quantum wells. Using Transmission Electron Microscopy (TEM) we have studied ultrathin ($<$ 2nm) high indium content quantum well (QW) structures suitable for blue-green laser diodes. We investigate the mechanisms of relaxation and possible misfit dislocation generation in c- and m-plane QW structures, partial relaxation and thermal degradation. Moreover, we investigate the appearance of defects in the low temperature grown upper waveguides.

HL 34.39 Tue 18:30 Poster D2

Characterization of m-plane InGaN multiple quantum wells by x-ray diffraction — •Alexander Schwiegel, Heiko Bremers, Holger Jönen, Uwe Rossow, and Andreas Hangleiter — Institut für Angewandte Physik, TU Braunschweig, Germany

The performance of InGaN-based optoelectronic devices grown in the usual [0001] direction is deteriorated by strong spontaneous and piezo-

electric polarization fields. In order to avoid these effects ($1\bar{1}00$) oriented films can be used. However, higher defect densities and lower in-plane rotational symmetry of the unit cell make those structures harder to characterize. We investigate InGaN/GaN multiple quantum wells (MQW) grown on m-plane SiC by X-ray diffraction and are particularly interested in determining the lattice parameters, strain state and composition of the layers. Our fivefold MQWs typically have a period length of 10 nm, a QW thickness of about 1.5 nm and reach an In-content up to 30 %. Here we present our results together with a simulation model for symmetrical scans. The intensity profiles are obtained in analogy to optics by transfer functions in consideration of the strain state and composition of the samples assuming atomically smooth interfaces.