HL 12: Group-III-Nitrides: Optical Properties I

Time: Monday 14:00–15:30 Location: H15

HL 12.1 Mon 14:00 H15

Cathodoluminescence hyper-spectral imaging of InGaN/GaN quantum wells — •Jochen Bruckbauer[1], Paul R. Edwards[1], Tao Wang[2], and Robert W. Martin[1] — [1]Dept. of Physics, SUPA, University of Strathclyde, Glasgow, G4 0NG, UK — [2]Dept. of EEE, University of Sheffield, Sheffield, S1 3JD, UK

Cathodoluminescence (CL) spectroscopy is a powerful tool for investigation of light-emitting semiconductors [1, 2]. A field-emission gun SEM has been used to study the CL of InGaN/GaN quantum wells (QWs) with high spatial resolution approaching 10 nm. Forming a hyper-spectral image by collecting CL spectra at each pixel within a 2D map allows observable surface features to be correlated to observed changes in CL spectra. Comparison is made to photoluminescence measurements as a function of temperature down to 16 K. InGaN/GaN QWs were grown on c-plane sapphire substrates by MOCVD, emitting in the blue and green. To improve crystal quality a high-temperature AlN buffer layer technology was applied [3]. SEM imaging revealed the well-known V-shaped pits in addition to trench-like features. CL spectral mapping showed shifts of the emission energy as well as changes in the line shape of spectra from those features. The non-uniformity of the emission of the QW is strongly influenced by the surface morphology and is related to local variations in dislocations, composition or strain. High spatial resolution CL provides useful information on the material properties and performance on a sub-micron scale. [1] Christen et al., J. Vac. Sci. Technol. B 9, 2358 (1991), [2] Martin et al., phys. stat. sol. (a) 201, 665 (2004), [3] Bai et al., JAP 99, 023513 (2006).

HL 12.2 Mon 14:15 H15

Spinodal and binodal decomposition of a thin InGaN layer grown on GaN — •Christian Tessarek, Timo Aschenbrenner, Stephan Figge, and Detlef Hommel — Institut für Festkörperphysik, Universität Bremen, Otto-Hahn-Allee 1, 28359 Bremen

Unstrained InGaN is known to have a large miscibility gap due to spinodal decomposition [1]. Considering strain of an InGaN layer grown on GaN, the spinodal and binodal phase diagram changes significantly [2]: the ciritcal temperature, i.e. the maximum of the spinodal and binodal graph, is reduced and moved to higher x of $In_xGa_{1-x}N$.

Strong phase separation of a thin uncapped InGaN layer grown on GaN occurs into both high and low In content phases when the growth parameters are set into the unstable region of this strain considering spinodal phase diagram. The different InGaN phases were determined by x-ray diffraction and photoluminescence measurements. Furthermore, surface analysis of the decomposed structures were performed via scanning electron and atomic force microscopy. The phase separation forms among others dot-like and/or meandering InGaN structures as predicted in [3]. These structures are used as active material in light emitting devices.

[1] Ho, Stringfellow, APL **69**, 2701 (1996)

[2] Karpov, MRS Internet J. Nitride Semicon. Res. **3**, 16-1 (1998)

[3] Okumura, Ishida, Kamikawa, Jpn. J. Appl. Phys. **39**, 1044 (2000)

HL 12.3 Mon 14:30 H15

Kathodolumineszenz-Untersuchungen an dicken rissfreien GaN-Schichten auf Si(111)-Substraten — •Anja Dempewolf, Frank Bertram, Thomas Hempel und Jürgen Christen — Institut für Experimentelle Physik, Otto-von-Guericke-Universität Magdeburg, Deutschland

Die Heteroepitaxie von GaN auf Siliziumsubstraten stellt eine geeignete und wirtschaftliche Alternative zum Wachstum auf anderen Substraten, wie Saphir oder SiC, dar. Um dicke rissfreie GaN-Schichten hoher kristalliner und optischer Qualität für effiziente LEDs zu erzielen, ist ein geeignetes Stressmanagement erforderlich, das z. B. durch den Einsatz von LT-AlN-Zwischenschichten erreicht wird. Mittels hoch orts- und spektral aufgelöster Kathodolumineszenzmikroskopie (KL) wurden die Lumineszenzeigenschaften dicker rissfreier GaN-Schichten auf Si(111)-Substraten bei Heliumtemperatur untersucht. Auf einem optimierten Template, bestehend aus einer AlN-Keimschicht, einem AlGaN-Puffer mit stufenweise reduzierter Al-Konzentration, abgeschlossen mit einer nominell undotierten GaN-Schicht, wurden mehrere Mikrometer Si-dotiertes GaN, unterbrochen von AlN-Zwischenschichten, aufgewachsen. Ortsaufgelöste Messungen an der Bruchkante zeigen den Einfluss der Zwischenschichten auf die Quantenausbeute. Die Analyse der spektralen Position der bandkantennahen GaN-Emission in spektral hoch aufgelösten Linescans entlang der Bruchkante erlaubt direkte Rückschlüsse auf den Verspannungszustand und die Veränderung der freien Ladungsträgerdichte vom Substrat zur Oberfläche.

HL 12.4 Mon 14:45 H15

Impact of the AlN seeding layer thickness on GaN orientation on high index Si-substrates — •Roghaiyeh Ravash, Jürgen Bläsing, Peter Veit, Thomas Hempel, Armin Dadgar, Jürgen Christen, and Alois Krost — Otto-von-Guericke-University Magdeburg, FNW/IEP/AHE, Postfach 4120, 39016 Magdeburg, Germany

Silicon is considered to be a reasonable alternative to substrates such as sapphire and SiC, because of its low price and availability in large diameters. Because of spontaneous and strain induced piezoelectric polarization field along the c-axis, leading to the separation of electrons and holes in quantum wells reducing the recombination efficiency, c-axis oriented GaN-based light emitters have a low efficiency, especially in the longer wavelength region. In order to reduce or eliminate these polarization effects, semi-polar or non-polar GaN-heterostructure is favored. In this work we investigated the growth of GaN applying a low temperature AlN seeding layer with various thicknesses. The impact of the AlN seeding layer on GaN orientation using different Si substrate orientations (e. g. (211), (711), (410), (100)+4.5° off) were investigated by x-ray diffraction measurements in Bragg-Brentano geometry and x-ray pole figure measurements. We found that the thickness of the AlN seeding layer plays a significant role in obtaining different GaN textures. Applying a about 4 nm AlN seeding layer we achieved a single crystalline GaN epilayer on Si (211) with a 18 ° tilted c-axis orientation. Some of the samples were characterized by scanning electron microscopy and transmission electron microscopy.

HL 12.5 Mon 15:00 H15

Ein Indium Defekt Komplexes und die Lumineszenzeigenschaften von GaInN und AlInN — •Patrick Kessler[1], Katharina Lorenz[2,3], Jens Niederhausen[6], Bettina Steitz[1], Joao G. Correia[2,3,4], Karl Johnston[4,5], Reiner Vainden[1] und ISOLDE Collaboration[4] — [1]Helmholtz Institut für Strahlen und Kernphysik, Universität Bonn — [2]Instituto Tecnólogico e Nuclear, P-2686-953 Sacavém, Portugal — [3]Centro de Fisica Nuclear da Universidade de Lisboa, Portugal — [4]PH dept, CERN, Schweiz — [5]Technische Physik, Universität des Saarlands, Saarbrücken — [6]Physikalisches Institut der Humboldt Universität, Berlin

LEDs aus GaN zeigen trotz hoher Versetzungsdichte eine hohe Lichtausbeute. Dabei werden meist in der Anwendung zusammengesetzte Systeme wie AlInN oder GaIN verwendet. Die Rolle des Indiums im Lumineszenzeprozess wird mit der Methode der gestörten Winkelkorrelation (PAC) untersucht. Frühere Messungen zeigen einen Defektkomplex der Sonde ^{111}In und einer möglichen Stickstofflehrstelle, der bis zu hohen Temperaturen stabil ist. Als Konkurrenz zum strahlungslosen Übergang an Versetzungen, könnte der Komplex eine konkurrierende Exzitonenfalle sein, die die Lichtausbeute positiv beeinflusst.

Um weitere Informationen über den Komplex zu erhalten, werden ^{111}In mit ^{111m}Cd Messungen verglichen, um den Einfluss eines möglichen äfter effect"des Zerfalls zu untersuchen. Dieser kann auftreten, wenn nach dem Elekroneneinfang ein Loch in der Atomhülle zurückbleibt und wieder aufgefüllt wird. Zusätzlich werden Ergebnisse von e^--γ-Korrelationsmessungen vorgestellt.

HL 12.6 Mon 15:15 H15

Cathodoluminescence microscopy analysis of structural and optical properties of HVPE ELO-AlN layers — •Martin von Kurnatowski[1], Barbara Bastek[1], Juergen Christen[1], Thomas Hempel[1], Frank Bertram[1], Hideto Miyake[2], Yusuke Katagiri[2], Kazuki Okuura[2], and Kazumasa Hiramatsu[2] — [1]Institute of Experimental Physics, Otto-von-Guericke-University Magdeburg, Germany — [2]Department of Electrical and Electronical Engineering, Mie University, Japan Institute of Solid State

Aluminum nitride is a promising candidate for solid state electronic

and optical applications in the deep UV due to its large direct bandgap. However, there is a mismatch between the lattice constants and thermal expansion coefficients of AlN and conventional substrates. Consequently, a high density of dislocations and micro-cracks occurs. The approach of "epitaxial lateral overgrowth" (ELO) has already lead to a drastic reduction of this problem in GaN and AlGaN.
We investigate the microscopic, optical, and structural properties of HVPE-ELO-AlN layers with thicknesses of up to 25 μm. The ELO pattern consists of 1.3 μm wide trenches which were etched into the Sapphire leaving ridges of 2 μm widths. Integral CL spectra show a dominant near band edge (NBE) emission at 6.105 eV at coalescence height. Towards the surface the NBE peak shifts about 18 meV to lower energies. Right at the surface the near band edge energy is modulated by only 5 meV with the periodicity of the underlying trench-pattern.