HL 16: III-V semiconductors II

Time: Tuesday 9:30–12:00 Location: POT 151

HL 16.1 Tue 9:30 POT 151

Temperaturverhalten des In(Cd)-Defekt-Komplexes in AlN — •Jens Niederhausen[1], Reiner Vianden[1] und Joao Guilherme Martins Correia[2] — [1]HISKP, Universität Bonn — [2]ISOLDE Collaboration, CERN

Implantiert man ^{111}In in eine AlN-Schicht auf Saphir-Substrat und heilt dieses bei 1273 K aus, erwartet man den substitionellen Einbau der Sonde auf einem ungestörten Al-Gitterplatz. Mit der Methode der gestörten Winkelkorrelation (PAC) lässt sich jedoch noch eine weitere Situation nachweisen: ungefähr die Hälfte der Sonden befinden sich in einer Umgebung die einem In-Defekt-Komplex zuzuordnen ist. Diese Konfiguration konnte auch bei bulk-Proben nachgewiesen werden.

Zur Untersuchung seiner Dynamik wurden detaillierte Messungen über ausgewählte Temperaturbereiche mit Proben unterschiedlicher Schichtdicke durchgeführt. Es zeigte sich, dass die Dämpfung des Defektanteils in einem Bereich um 500 K minimal ist, wobei bei größerer Dicke das Plateau breiter ist. Bei Temperaturen bis zu einem Minimum von 4 K wurde keine Abnahme der Dämpfung festgestellt.

Bei Implantationen mit ^{111m}Cd unter ähnlichen Bedingungen konnte die substitionelle Konfiguration (mit deutlich höherem Anteil) ebenfalls beobachtet werden. Dies zeigt, dass sich ein großer Teil der In- und Cd-Atome in gleicher Weise in das Wirtsgitter integrieren, was den Weg für Beta-Gamma-Messungen frei macht, mit Hilfe derer sich das Vorzeichen des EFG bestimmen lässt. Dies ist für theoretische Rechnungen wichtig. Der Cd-Defekt-Komplex ist weniger ausgeprägt als der In-Defekt-Komplex, muss jedoch noch genauer vermessen werden.

HL 16.2 Tue 9:45 POT 151

Temperature and Time Resolved Measurements of Nitride-based Quantumwell Structures on Modified GaN Substrates — •Miran Alic[1], Christian Nenstiel[1], Ronny Kirste[1], Markus R.Wagner[1], Axel Hoffmann[1], Tadek Suski[2], Martin Albrecht[3], and Tobias Schulz[3] — [1]Technische Universität zu Berlin Institut für Festkörperphysik — [2]Institute of High Pressure Physics "Unipress" Warsaw — [3]Leibniz-Institut für Kristallzüchtung Berlin

Over the last few years InGaN-based semiconductors attracted much attention, especially in the domain of light emitting device applications. We report on temperature-dependent time-integrated and time-resolved photoluminescence studies of InGaN/GaN multi quantum wells (MQWs) grown by hydride vapor phase epitaxy. MQW structures composed of 3 InGaN QWs were grown on a GaN substrate with an intended variation of the misorientation angle with respect to the c-axis, as well as a different degree of indium content. The samples exhibit a broad peak around a central wavelength of 2.92eV (5K). Temperature resolved PL measurements for this peak display a red-shift without a characteristic "S-shape" behavior in the range of 0 - 300K. A "S-shape" would indicate an energy transfer mechanism from lower energy levels to higher energy states through the energy barrier. However, the absence of this behavior suggests the barrier to be higher than 27meV. Time resolved measurements at different energies between 2.88eV and 3.02eV revealed a constantly decreasing carrier lifetime. We assume that this behavior is attributed to deep localized quantum dot states.

HL 16.3 Tue 10:00 POT 151

Stain dependent optical properties of AlN measured by means of VUV-spectroscopic Ellipsometry — •Christoph Werner[1], Marcus Röppischer[1], Christoph Cobet[1], Carsten Buchheim[2], Rüdiger Goldhahn[2], Frank Brunner[3], and Nobert Esser[1] — [1]ISAS - Institute for Analytical Sciences, Albert-Einstein-Str. 9, 12489 Berlin — [2]TU - Ilmenau, Institut für Physik, Weimarer Straße 32 (Faradaybau), 98693 Ilmenau — [3]Ferdinand-Braun-Institut für Höchstfrequenztechnik (FBH), Gustav-Kirchhoff-Str. 4, 12489 Berlin

The growth of hexagonal group-III nitrides on foreign substrates causes in-plane strain due to the different thermal expansion coefficients of substrate and layer. Optical properties of semiconductors are strongly influenced by internal strain and electric fields. These effects were investigated in the dielectric function of aluminium nitride samples grown on different substrates (sapphire and silicon carbide) in the photon energy range from 4 to 9.5eV. The region around the fundamental band gap at 6 eV is of particular interest for the strain analysis. On the base of excitonic transitions, we have studied the crystal field and strain dependent ordering of the valence bands and oscillator strength at the Γ-point. Further more, various strain contribution in the temperature related shift of excitonic transitions are also been observed. Our measurements will be discussed in comparison to calculations within the kp-theory, XRD measurements and former published data.

HL 16.4 Tue 10:15 POT 151

High Excitation Photoluminescence studies on epitaxially grown AlN layers — •Robert Anton Richard Leute[1], Martin Feneberg[1], Klaus Thonke[1], Rolf Sauer[1], Sarad Bahadur Thapa[2], Ferdinand Scholz[2], Yoshitaka Taniyasu[3], and Makoto Kasu[3] — [1]Institut für Halbleiterphysik, Universität Ulm, 89069 Ulm, Germany — [2]Institut für Optoelektronik, Universität Ulm, 89069 Ulm, Germany — [3]NTT Basic Research Laboratories, NTT Corporation, 3-1 Morinosato-Wakiyama, Atsugi, 243-0198, Japan

Nominally undoped high quality AlN layers are investigated by lowtemperature photoluminescence (PL) spectroscopy, using the focused beam of an ArF Excimer Laser (193 nm) for excitation. For samples grown by MOVPE on different substrates, namely sapphire and SiC, different types of spectra are found. Comparison with low excitation photoluminescence and cathodoluminescence shows new contributions increasing with superlinear response to the excitation intensity. The observed contributions are discussed in terms of radiative decay of biexcitons, exciton-exciton scattering (P band), and electron hole plasma.

HL 16.5 Tue 10:30 POT 151

Optical characterisation of AlGaN/GaN MQW — •Christian Nenstiel[1], Ronny Kirste[1], Viola Küller[2], Frank Brunner[2], Arne Knauer[2], Markus Weyers[2], and Axel Hoffmann[1] — [1]Institut für Festkörperphysik, TU Berlin, Hardenbergstr. 36, 10623 Berlin — [2]Ferdinand-Braun-Institut für Höchstfrequenztechnik (FBH) in Berlin, Germany

The direct transition energy of the ternary semiconductor AlGaN system can be adjusted between 6.2 eV (AlN) and 3.4 eV (GaN). The preferences of AlGaN/GaN multiple quantum wells (MQW) are the large bandgap, large longitudinal phonon energy, good carrier confinement and ultra fast carrier and intersubband relaxation. These properties make AlGaN/GaN and AlGaN/AlN MQWs a possible material for optoelectronic devices like ultra violet light emitting diodes, laser diodes or photodetectors. AlGaN MQWs were grown on [0001]-oriented sapphire substrates (c-plane) by metal organic vapour phase epitaxy at high temperatures around 1500°C. In this contribution we analyse $Al_{28}Ga_{72}N$:nid and $Al_{28}Ga_{72}N$:Si samples with super lattice structures consisting of 10 - 80 layers with 1 - 11nm thickness. The samples were investigated by Raman spectroscopy and temperature-dependent photoluminescence. The Raman spectra show a shift of the strain-sensitive E_2 (high) mode, which can be attributed to the doping of the sample. The temperature-dependent photoluminescence spectra demonstrate different exciton energies and defect luminescences of the samples. Thereby the strength of the defect luminescence depends on the structure and doping of the samples.

15 min. break

HL 16.6 Tue 11:00 POT 151

Electrical conductivity in InN nanowires — •Florian Werner[1], Friederich Limbach[2], Michael Carsten[1], Christian Denker[1], Joerg Malindretos[1], and Angela Rizzi[1] — [1]IV. Physikalisches Institut, Georg-August-Universität Göttingen, Germany — [2]Institut für Bio- und Nanosysteme (IBN-1), Forschungszentrum Jülich GmbH, Germany

Electrical conductance through InN nanowires strongly depends on their geometry and on the carrier distribution inside them. By measuring wires of different radii and lengths in a four-point probe geometry, quadratic contributions from the bulk and linear contributions from the surface can be distinguished. The linear contribution is attributed to a high density electron accumulation layer which had previously been confirmed by Raman and photoluminescence spectroscopy. The electron accumulation layer is demonstrated to dominate the conduc-

tance through wires with less than 55 nm in diameter, although the influence of the bulk conductance cannot be neglected even for small wires. Evidence of a thin surface layer of indium oxide is provided by X-ray core level photoemission spectroscopy. Therefore the electron accumulation layer is expected to form at the InN/In_2O_3 interface. The surface oxide forms a tunneling barrier between the contacts and the electron accumulation layer and therefore has a strong impact on the contact resistance.

HL 16.7 Tue 11:15 POT 151

Optimization of AlN-based seeding and superlattice buffer layers to grow high-quality AlxGa1-xN with Al content up to x=0.66 on Si (111) substrates — •P. Saengkaew, A. Dadgar, J. Blaesing, B. Bastek, F. Bertram, T. Hempel, P. Veit, J. Christen, and A. Krost — AHE/IEP/FNW,Otto-von-Guericke-Universität Magdeburg, Universitätsplatz 2, 39106 Magdeburg

AlxGa1-xN is one of the most attractive materials to develop UV optoelectronic devices due to its direct wide-bandgap energy from 3.4 to 6.2 eV. Here we present MOVPE-grown high-quality AlxGa1-xN layers with Al content up to x=0.66 on Si (111) substrates. With optimized AlN-based seeding and superlattice buffer, crack-free layers with smooth surface and low defect density were obtained. Initially, the impact of the AlN seeding layer was investigated by varying growth parameters as growth temperature, time, pressure and V/III ratio. To optimize high- and low-temperature AlN-based superlattices, the growth temperature, growth time, and number of SL periods were varied. These optimized AlN seeding and SL layers are efficient in reducing the dislocation density and in-plane strain. By HR-XRD, the crystalline quality of AlxGa1-xN was characterized. The finite thickness fringes of AlxGa1-xN have been observed in theta/2theta-scans of the (0002) reflections showing their excellent crystalline quality and abrupt smooth surface. AFM and FE-SEM measurements were used to observe the surface morphology and TEM measurements to determine the dislocation behaviour. The optical properties were investigated by CL measurements.

HL 16.8 Tue 11:30 POT 151

Pulsed Growth of AlN by MOVPE — •Hanno Kröncke, Stephan Figge, and Detlef Hommel — Institute for Solid State Physics (IFP), University of Bremen, Otto-Hahn-Allee 1, 28359 Bremen

The growth of AlN is of interest because of it's special features like high thermal conductivity and large bandgap. These provide applications like high power- or opto-electronic devices in the UV. However the production of high quality AlN templates is challenging because of the low diffusivity of Al, which inhibits lateral overgrowth and demands high growth temperatures over $1300\,^{\circ}C$ to decrease the defect density. A second approach is the pulsed or flow modulation MOVPE growth [1], where an alternating supply of the precursors TMA and NH_3 increases the surface mobility of the atoms. This allows for growing AlN even at temperatures of $800\,^{\circ}C$ [2].

In our study we grew thick AlN layers on c-plane sapphire in a closed coupled showerhead MOVPE at temperatures of $1000\,^{\circ}C$. We investigated the influence of nitridation, different seed layers and length of precursor pulses on the surface roughness, cracking and crystal quality by AFM, SEM and XRD. Especially a nitridation and low temperature AlN buffer lead to a rough surface, so that we developed a process starting with pure TMA supply. By this method we achieved more than $1\,\mu$m thick AlN layers with an RMS roughness below 1 nm, which show no cracks and high crystal quality.

[1] M. Asif Kahn, Appl. Phys Lett. **61** (1992), 2539
[2] Jung-Seung Yang, Jap. J. App. Phys. **46**, 38, (2007), L927

HL 16.9 Tue 11:45 POT 151

Pseudosymmetrische (11-20)-Reflexe bei a-planarem GaN auf r-planarem Saphir — •Matthias Wieneke, Jürgen Bläsing, Armin Dadgar und Alois Krost — Otto-von-Guericke-Universität Magdeburg, Postfach 4120, 39016 Magdeburg

Unter der Variation von Wachstumsbedingungen, z.B. des V-III-Verhältnisses oder der Wachstumstemperatur wurden unterschiedliche Serien von a-planaren GaN-Schichten mittels metallorganischer Gasphasenepitaxie auf r-planarem Saphir gewachsen. Weiterhin wurde der Einfluss von Zwischenschichten, wie z.B. die Dicke oder die vertikale Position von SiN_x-Nanomasken auf die Mikrostruktur der GaN-Schicht analysiert. Die Untersuchung der mikrostrukturellen Eigenschaften der gewachsenen Schichten erfolgte mittels hochauflösender Röntgenbeugung am symmetrischen (11-20)- und den in der Wachstumsebene liegenden (10-10)- und (0002)-Reflexen. Dabei zeigte diese und die Abhängigkeit von einigen Wachstumsparametern eine eindeutige Anisotropie in Bezug auf die m- und c-Richtung in der Wachstumsebene. So wiesen die ω-Scans des symmetrischen (11-20)-Reflexes eine deutliche Abhängigkeit von der Einfallsrichtung der Röntgenstrahlung bezüglich des Azimutwinkels auf. Genauere Untersuchungen mittels (11-20)-Polfiguren ergaben für einige Wachtumsbedingungen zwei annähernd symmetrische Texturkomponenten, die um wenige Grad zu einander und zur Oberflächennormalen verkippt sind. Der Einfluss beider Komponenten auf die Messungen unter Standardeinstellungen und Annahme eines symmetrischen Reflexes wird diskutiert.