HL 53: GaN: Devices

Time: Wednesday 10:00–11:45 Location: H15

HL 53.1 Wed 10:00 H15

Magnetoresistance of GaN-based High Electron Mobility Transistors (HEMT) — •Sebastian Roensch[1], Victor Sizov[2], Takuma Yagi[2], Saad Murad[2], Lars Groh[2], Stephan Lutgen[2], Markus Sickmoeller[2], Michael Krieger[1], and Heiko B. Weber[1] — [1]University of Erlangen-Nuremberg, Erlangen, Germany — [2]AZZURRO Semiconductors AG

GaN-based heterostructures are well-suited for the application in high-power electronics. In particular, epitaxially grown AlGaN/GaN heterojunctions can be utilised in high electron mobility transistors (HEMT) targeted on high-power application. The intrinsic material properties of AlGaN and GaN generate a two dimensional electron gas with a high electron mobility at the interface of the heterojunction. In order to gain a comprehensive understanding of the two dimensional electron gas we carried out temperature dependent magnetoresistance measurements in the temperature range from 1.5 K to 300 K. We report on quantum correction to the classical conductance, in particular weak localization, electron-electron-interaction, and Shubnikov-de Haas oscillations.

HL 53.2 Wed 10:15 H15

Strukturelle Charakterisierung von AlInN/AlN/GaN FET Strukturen — •Andreas Lesnik, Jürgen Bläsing, Jonas Hennig, Armin Dadgar und Alois Krost — Institut für Experimentelle Physik, Otto-von-Guericke Universität Magdeburg, Universitätsplatz 2, 39106 Magdeburg

FETs auf Basis von AlInN/GaN Heterostrukturen weisen eine weitaus höhere Leitfähigkeit im Vergleich zu den üblichen FETs mit AlGaN/GaN auf. Wir haben daher Serien von AlInN(~5nm)/AlN(~1nm)/GaN FETs mittels MOCVD hergestellt und mit Hilfe der Röntgenreflektometrie (XRR), hochauflösenden Röntgenbeugung (HRXRD) und Röntgenfluoreszenzanalyse unter streifendem Einfall (GIXRF) untersucht. Durch die alleinige Untersuchung der Schichtstruktur mittels XRR und HRXRD konnte die Schichtstruktur nicht vollständig charakterisiert werden. Erst eine weitergehende Untersuchung der Proben durch GIXRF und der Kombination mit den anderen Messverfahren ermöglichte es, die Struktur quantitativ zu bestimmen. Insbesondere das Vorhandensein des AlN Spacers und dessen Komposition konnte erst durch weiterführende GIXRF Untersuchungen verifiziert werden.

HL 53.3 Wed 10:30 H15

AlInN/GaN based FETs with 3DEGs — •Jonas Hennig, Oliver Krumm, Hartmut Witte, Jürgen Bläsing, Peter Veit, Annette Diez, Armin Dadgar, and Alois Krost — Institut für Experimentelle Physik, Otto-von Guericke-Universität Magdeburg, Universitätsplatz 2, 39106 Magdeburg

AlGaN/GaN heterostructures are the common active layer structure applied for FET devices. In contrast to AlGaN/GaN FETs a much higher conductivity can be achieved by AlInN/GaN. Common for both device types is high current operation, with higher values for AlInN/GaN, but a varying transconductance at different applied gate voltages originating in the 2DEG at the heterointerface. We have applied the concept of 3DEGs to AlInN/GaN FETs on Si to combine high conductivity with a plateau like transconductance behavior. To achieve this a GaN-AlGaN gradient was grown prior to the AlInN heterointerface. We will present calculations and first results on the structures and devices characterized by XRD, Hall-effect, C-V and I-V measurements.

HL 53.4 Wed 10:45 H15

Toward light-emitting diodes based on homogenous III-N nanowire ensembles on Si substrates — •Mattia Musolino, Christian Hauswald, Friederich Limbach, Martin Wölz, Tobias Gotschke, Oliver Brandt, Lutz Geelhaar, and Henning Riechert — Paul-Drude-Institut für Festkörperelektronik, Berlin

Light-emitting diodes (LEDs) based on III-N nanowires (NWs) are an attractive alternative to conventional planar layers, since the NW geometry enables the growth of (In,Ga)N/GaN heterostructures with high crystal quality on cost-effective Si substrates. However, (In,Ga)N/GaN NW ensembles grown by self-assembly processes suffer from multicolour emission. Homogeneous emission can be achieved by controlling the diameter of the NWs by selective-area growth (SAG). LEDs based on such NW ensembles have so far been fabricated only on expensive and not very versatile GaN templates.

Our approach for the SAG of NWs on Si substrates by molecular beam epitaxy exploits the longer incubation time of GaN NWs on the patterned SiOx mask than in openings to an AlN buffer layer. We optimized the growth of the AlN buffer in order to attain a thickness low enough to allow LED operation and at the same time preserve the requirements necessary for SAG. In order to prove the feasibility of operating devices on such an AlN buffer we fabricated functional (In,Ga)N/GaN LEDs based on NWs grown by self-assembly processes on this thin buffer layer. In addition, we demonstrated the SAG of GaN NW on such buffers, thus paving the way towards homogeneous NW LEDs on Si substrates.

HL 53.5 Wed 11:00 H15

Influence of waveguide layer composition and doping on the performance of blue-violet laser diodes — •Martin Martens[1], Martin Frentrup[1], Luca Redaelli[2], Jörg Jeschke[2], Carsten Netzel[2], Mark-Antonius Rothe[1], Sven Einfeldt[2], Jens Rass[1], Tim Wernicke[1], and Michael Kneissl[1,2] — [1]Technische Universität Berlin, Institut für Festkörperphysik, Hardenbergstr. 36, EW 6-1, 10623 Berlin — [2]Ferdinand-Braun-Institut, Leibniz-Institut für Höchstfrequenztechnik, Gustav-Kirchhoff-Str. 4, 12489 Berlin

A crucial aspect about designing highly efficient laser diodes is the mode guiding structure surrounding the multiple quantum well (MQW) active region. In order to investigate the impact of composition and doping of the waveguiding layers (WG) on the laser threshold of the devices, we have fabricated broad area laser diodes emitting at around 410 nm with AlGaN cladding layers, InGaN/InGaN MQWs and different WG structures consisting of GaN and $In_{0.02}Ga_{0.98}N$ layers grown by MOVPE on free standing (0001) GaN substrates. Vertical far-field measurements, electro- and photoluminescence measurements as well as device simulations were performed to investigate the effect of the WG design on the optical confinement, injection efficiency and internal quantum efficiency in the different device structures. The lowest threshold current density of $2.4\,kA/cm^2$ was achieved with a symmetric InGaN WG and additional Si-doping in the lower WG.

HL 53.6 Wed 11:15 H15

Comparison of different carrier injection mechanisms in 290 nm LEDs — •C. Kuhn[1], F. Mehnke[1], T. Wernicke[1], J. Stellmach[1], T. Kolbe[1], C. Reich[1], M. Guttmann[1], V. Kueller[2], A. Knauer[2], M. Weyers[2], and M. Kneissl[1,2] — [1]Technische Universität Berlin, Institut für Festkörperphysik, Hardenbergstr. 36, 10623 Berlin, Germany — [2]Ferdinand Braun Institut, Leibniz-Institut für Höchstfrequenztechnik, Gustav-Kirchhoff-Str. 4, 12489 Berlin, Germany

To achieve high external quantum efficiency in UV-B LEDs a high injection efficiency for electrons and holes is necessary. The injection efficiency is reduced by electron leakage into the p-doped side of the LED. Previous examinations of LEDs with varied emission wavelength between 285 nm and 345 nm, including an $Al_{0.7}Ga_{0.3}N$:Mg electron blocking layer have shown a strong p-side luminescence which is dominating the emission especially at shorter wavelengths. To overcome this problem of electron leakage an additional interlayer consisting of undoped AlN or $Al_xGa_{1-x}N$ ($x > 0.8$) was introduced. This interlayer blocks electrons while allowing a hole current to the active region by tunneling. Electroluminescence spectra of 290 nm LEDs grown by MOVPE with AlN interlayers with a thickness from zero to 6 nm show reduced p-side luminescence due to reduced electron leakage. The optimal interlayer thickness was found to be 4 nm which is consistent with simulations. For thicker interlayers the hole injection is reduced. Further investigations of the influence of a varied aluminum content of an AlGaN interlayer will be presented.

HL 53.7 Wed 11:30 H15

Investigation of extraction efficiency and internal quantum efficiency of GaN-based LEDs — •Ailun Zhao, Uwe Rossow, Heiko Bremers, and Andreas Hangleiter — Institut für Angewandte Physik, TU Braunschweig

In order to better understand the real physical mechanism of efficiency

droop for GaN-based light emitting diodes (LEDs), it is very important to know the internal quantum efficiency under electroluminescence conditions since it plays a crucial role. In our study, we calculate the extraction efficiency of our LEDs and subsequently calibrated the results using a systematic variation of the LED structure. In our calculation we consider polarization-dependent partial reflections at interfaces as well as reflections at the metal contact and their interface. Both the dispersion of the refractive indices as well as the complex refraction index of the metal mirror are taken into account. We compare the result of the calculation with experimental data from a series of LEDs with varied distance between the quantum well and the mirror. This procedure allows us to obtain an absolute calibration of the extraction efficiency. Using the result for the extraction efficiency we have determined the internal efficiency from the measured efficiencies for LEDs with various modifications of the active region in order to assess their impact on the droop.