HL 73: GaN: Preparation and Characterization IV

Time: Thursday 9:30–11:00 Location: ER 270

HL 73.1 Thu 9:30 ER 270

AlInN/GaN-heterostructures for sensing applications — •Malte Fandrich, Timo Aschenbrenner, Stephan Figge, Thorsten Mehrtens, Andreas Rosenauer, and Detlef Hommel — Institute of Solid State Physics, University of Bremen, Otto-Hahn-Allee NW1, 28359 Bremen, Germany

Commonly, $Al_{0.28}Ga_{0.72}N$-based heterostructures are applied as open-gate sensors utilizing the 2-dimensional electron gas (2DEG), which originates from the polarization discontinuity between GaN and a thin AlGaN top layer. Since $Al_{0.82}In_{0.18}N$ exhibits a higher polarization difference and is lattice matched to GaN, AlInN is a promising candidate to replace conventionally used AlGaN and to improve the sensor characteristics.
Both, strained AlGaN and lattice matched AlInN layers were grown by MOVPE on GaN buffer layers using c-plane sapphire substrates. All epitaxial structures were charaterized by HRXRD, SEM, AFM and TEM, particularly with respect to strain, defect density, as well as surface and interface roughness of the structures. In addition, sheet carrier density and mobility of the 2DEG were determined by Hall-measurements. The influence of the growth parameters on the structural quality of AlInN and its impact on the electrical properties will be discussed. Based on the heterostructures open-gate sensors were processed and their sensing behavior regarding polar liquids and gases were investigated. A comparison of the device performances proves the superior capability of AlInN/GaN-heterostructures for sensing applications.

HL 73.2 Thu 9:45 ER 270

Development of $Al_xGa_{1-x}N$ MSM photodetectors — •Moritz Brendel, Andrea Knigge, Sven Einfeldt, Frank Brunner, Arne Knauer, and Markus Weyers — Ferdinand-Braun-Institut, Leibniz-Institut für Höchstfrequenztechnik,Gustav-Kirchhoff-Str. 4, 12489 Berlin, Germany

Photodetectors for the UV spectral region are required to control UV sources, for the usage in UV lithography, disinfection, and also medical applications. Metal semiconductor metal photodetectors (MSM PDs) have a relatively simple layout and can be processed with quick cycle times. This makes them suitable as a tool for the examination of material quality by photocurrent measurements. By varying the Al content x in the $Al_xGa_{1-x}N$ absorber layer the cut-off wavelength can be tuned from 365 nm for $x = 0$ to 200 nm for $x = 1$. With rising Al content the epitaxial growth of $Al_xGa_{1-x}N$ layers on sapphire with a low defect density becomes increasingly challenging. A higher defect density is often associated with enhanced carrier trapping and thus can influence the experimentally accessible responsivity. Traps are also associated with persistent photoconductivity (PPC) after turning off the illumination source. The capture of excess carriers at defect states in either the bulk material, at interfaces or at the semiconductor surface retards the decay of the photoinduced conductivity corresponding to an enhanced recombination lifetime. In this talk MSM photodetectors with different absorber compositions grown by MOVPE are presented. Spectral responsivity, dark current, and switching behavior are discussed in relation to material properties of the absorber layer.

HL 73.3 Thu 10:00 ER 270

Electrical properties of p-type AlGaN/GaN layers on Si substrates — Antje Rohrbeck, •Hartmut Witte, Phannee Sangkaew, Peter Veit, Bernd Garke, Armin Dadgar, Juergen Christen, Ruediger Goldhahn, and Alois Krost — Institute of Experimental Physics, Otto-von-Guericke-University Magdeburg, Universitätsplatz 2, 39106 Magdeburg, Germany

AlGaN/AlN layers on Si-substrates are the base of new UV- LEDs with additional applications in sensoring and information storage. Effective p-type doping of AlGaN is hindered by the increase of the Mg acceptor activation energy with increasing Al content and by an increased defect density using Si substrates. For an enhancement of the hole concentration in p-AlGaN layers a p-type AlGaN:Mg/GaN:Mg superlattice(SL) was grown. The doping properties of this SL were compared with single p-type GaN and p-type AlGaN (x=0.1) layers characterized by CV- and impedance spectroscopy and scanning capacitance microscopy. Furthermore, the impact of the density and the character of structural defects of the surface properties were characterized by atomic force microscopy and scanning surface potential microscopy in correlation with transmission electron microscopy. To investigate electrical surface properties X-ray photoemission spectroscopy and the serial resistance of a lateral Schottky junction were applied. Inversion domains and dislocations were observed in the p-GaN and p-AlGaN layers increasing the serial resistances of the Schottky contacts and reducing the forward current densities. In contrast, the AlGaN/GaN SL surface shows only marginal surface defects.

HL 73.4 Thu 10:15 ER 270

High quality n-GaN with carrier concentrations above 10^{20} cm^{-3} using Germanium doping — •Stephanie Fritze, Antje Rohrbeck, Hartmut Witte, Armin Dadgar, and Alois Krost — Institute of Experimental Physics, Otto-von-Guericke-Universität Magdeburg, Germany

For GaN based semiconductor devices, especially for LED manufacturing, a high n-type conductivity is necessary for homogeneous current spreading. Commonly Si is used as n-type dopant in GaN, but it induces additional tensile stress in the GaN layer possibly leading to cracking. Furthermore, exceeding a critical Si doping level of $n = 5 \cdot 10^{19} cm^{-3}$ the GaN surface becomes rough. We demonstrate successful Ge doping for highly conductive n-GaN using two different Germanium sources, GeH_4 and iso-butyl-germane (IBGe). The GaN structures were grown on c-sapphire substrates by the MOVPE technique using standard growth conditions. We realized Ge-doping levels up to $2.5 \cdot 10^{20} cm^{-3}$ without any tensile stress enhancement. All Ge-doped GaN structures show a smooth and crack-free surface in Nomarski microscopy. Even at carrier concentrations of $n = 2.5 \cdot 10^{20} cm^{-3}$, as determined by Hall effect measurements, no surface morphology degradation was visible. In a doping range between $1 \cdot 10^{18}$ and $5 \cdot 10^{19} cm^{-3}$ the XRD ω-FWHM is similar between Si-doped and Ge-doped GaN. But with further increasing the carrier concentration the crystalline quality abruptly improves at a doping concentration around $1 \cdot 10^{20} cm^{-3}$. In this case both Ge dopant sources show equal characteristics.

HL 73.5 Thu 10:30 ER 270

Reliable defect energetics in GaN:Mg — •Björn Lange[1], Christoph Freysoldt[1], Jörg Neugebauer[1], Qimin Yan[2], John L. Lyons[2], Anderson Janotti[2], and Chris G. Van de Walle[2] — [1]Max-Planck Institut für Eisenforschung GmbH, 40237 Düsseldorf, Deutschland — [2]University of California Santa Barbara, CA 93106-5050, USA

Density-functional theory (DFT) is a widely used method for electronic structure calculations. The modeling of defects within this method allows us to calculate their formation energies and concentrations in dependence of experimental growth parameters. In the plane-wave DFT description there are several approximations for modeling the electron-ion interaction (pseudo potentials or the PAW approach) and the exchange-correlation functional (LDA, GGA, or hybrid functionals such as HSE). Calculated formation energies of defects with respect to standard reference systems (bulk solids or molecules) may strongly depend on these computational details. In this work we show that the differences arise mainly from the varying quality of description between defects and the reference systems. A new reference system which uses defect states allows for a fair comparison, showing a much better agreement between the different approaches. We discuss the remaining differences for various defects related to Mg doped GaN. The obtained formation energies are then used to calculate defect concentrations in dependence of the Mg concentration. Based on this analysis we identify the mechanism behind the experimental observed drop of the relative hydrogen concentration occurring in highly Mg-doped GaN samples.

HL 73.6 Thu 10:45 ER 270

Investigating Highly Doped Marker Layers in GaN on Sapphire using Scanning Microwave Microscopy — •Matthias A. Fenner[1] and Rachel A. Oliver[2] — [1]Agilent Technologies, Lyoner Straße 20, 60528 Frankfurt, Germany — [2]Department of Materials Science and Metallurgy, University of Cambridge, Cambridge, UK

Gallium nitride films grown on sapphire substrate were investigated using Scanning Microwave Microscopy (SMM). During the growth thin, highly doped layers were included to mark the shape of the surface

at regular intervals. The SMM*s capability to measure dopant densities was employed to reconstruct cross sections of these surfaces. An unintentionally doped region was found for the initial stages of the growth. The growth surface at this stage is rough with most parts of the surface tilted out of the substrate plane. This suggests a model in which inclined surfaces promote the unintentional uptake of dopant material. Later stages of the growth result in smooth surfaces without unintentional doping.