HL 72: Nitrides: Devices

Time: Thursday 9:30–11:45 Location: POT 06

HL 72.1 Thu 9:30 POT 06

Fabrication and characterization of hybrid n-GaN/p-PEDOT structures for optoelectronic applications — •Linus Krieg[1], Priya Moni[2], Karen Gleason[2], and Tobias Voss[1] — [1]Institute of Semiconductor Technology and Laboratory for Emerging Nanometrology, Braunschweig University of Technology, 38092 Braunschweig — [2]Department of Chemical Engineering, Massachusetts Institute of Technology, 02139 Cambridge, USA

Hybrid structures consisting of an inorganic and organic layer are promising for the development of cheap, versatile and tailored electronic and optoelectronic devices. The structures are supposed to combine the advantages of inorganic and organic components such as a high structural stability whilst maintaining a high flexibility. One method to conformally deposit polymer layers even on both, planar and 3D-structured substrates, is the oxidative chemical vapor deposition (oCVD). The oCVD process is dry and solventless as the polymer is deposited from the gas phase. Therefore, etching of fragile surfaces can be minimized. On the way towards a hybrid GaN/PEDOT LED, the oCVD of PEDOT on n-type GaN substrates is studied. In particular, the effect of different substrate temperatures on the resulting hybrid layer structures is investigated. The IV-characteristics of the hybrid p-n-junctions are analyzed and compared to that of structures containing an additional insulating tunnel barrier of poly(divinylbenzene) (pDVB) between the GaN and PEDOT. First results show pronounced diode characteristics of the hybrid devices and allow us to determine the relevant conduction mechanism at the inorganic/organic interface.

HL 72.2 Thu 9:45 POT 06

Optoelectronic Characterization of AlGaN-based MSM-UV-Photodetectors — •Sebastian Walde, Moritz Brendel, Sylvia Hagedorn, Frank Brunner, Ute Zeimer, and Markus Weyers — Ferdinand-Braun-Institut, Leibniz-Institut fuer Hoechstfrequenztechnik, Gustav-Kirchhoff-Straße 4, 12489 Berlin, Germany

The alloy $Al_xGa_{1-x}N$ used as absorber material in photodetectors (PD) offers a high sensitivity in the UV with cut-off wavelength between 200 nm (AlN) and 365 nm (GaN), adjustable by the Al-content x. A metal-semiconductor-metal (MSM) design has the advantage of a relatively simple layout, which makes it easy to fabricate and suitable for analyzing material properties of the underlying epitaxial layers.

We present results of bottom-illuminated MSM-UV-PD with $Al_{0.5}Ga_{0.5}N$ absorber layers of different thicknesses t_{abs}. The structures grown on AlN/sapphire exhibit a saturation of the external quantum efficiency (EQE) above specific saturation voltages. Two different carrier collection mechanisms can be observed and they are distinguished by different saturation regimes. The first is dependent on t_{abs} and can be explained by the extension of the space charge region below the biased electrode. In that case, EQE at a wavelength of 250 nm saturates above 40 V for $t_{abs} = 500$ nm. The second mechanism is independent of the absorber thickness showing EQE saturation already above 15 V. This is most likely related to crystal defects penetrating through the absorber layer and forming electrically active channels between the electrodes and the carrier collection volume.

HL 72.3 Thu 10:00 POT 06

Beyond classical band offsets: Employing multiquantum barriers for electron blocking in group III-nitride devices — •Anton Muhin[1], Martin Guttmann[1], Christoph Reich[1], Konrad Bellmann[1], Johannes Enslin[1], Norman Susilo[1], Luca Sulmoni[1], Tim Wernicke[1] und Michael Kneissl[1,2] — [1]Technische Universität Berlin , Institute of Solid State Physics — [2]Ferdinand-Braun-Institut, Leibniz-Institut für Höchstfrequenztechnik, Berlin

Electron leakage current is one of the major loss mechanisms in AlGaN-based light emitting devices (UV LEDs). This can be reduced by inserting a layer with a larger band gap into the heterostructure, an electron blocking layer (EBL), with a conduction band offset of typically 0.3-0.8 eV. By stocking multiple EBLs on a nanometer scale, an additional virtual barrier (VB) can be created by a so-called multiquantum barrier (MQB) structure. Numerical calculations were performed of AlGaN-MQBs in order to quantify the VB, the optimal structure parameters and their robustness to fluctuations. Polarization fields and the band profile have been modeled by solving the Poisson's equation. Transfer matrix method and the Esaki-Tsu current formula were applied to compute the reflection probabilities and the current-voltage-characteristics, respectively. The simulations show an increase of the effective barrier height of 66% when employing on optimized $Al_{0.2}Ga_{0.8}N$/GaN-MQB compared to a $Al_{0.2}Ga_{0.8}N$ EBL of the same thickness on GaN. Approaches to verify the VB experimentally will be discussed in this talk.

HL 72.4 Thu 10:15 POT 06

Enhanced light extraction and internal quantum efficiency for UVB LEDs with UV-transparent p-AlGaN superlattices — •Martin Guttmann[1], Martin Hermann[1], Johannes Enslin[1], Sarina Graupeter[1], Luca Sulmoni[1], Christian Kuhn[1], Tim Wernicke[1], and Michael Kneissl[1,2] — [1]Technische Universität Berlin, Institute of Solid State Physics — [2]Ferdinand-Braun-Institut, Leibniz-Institut für Höchstfrequenztechnik, Berlin

Light emitting diodes (LEDs) in the UVB spectral range (280 nm - 315 nm) are of particular interest for applications such as plant growth lighting and phototherapy. State-of-the-art devices utilize highly absorbing p-GaN contacts and low aluminum mole fraction p-AlGaN layers to enable low operating voltages. The exploitation of UV-transparent p-AlGaN layers together with highly UV-reflective metal contacts may significantly increase the light extraction efficiency (LEE). In this paper, the light output of LEDs emitting around 310 nm with UV-transparent and absorbing Mg-doped AlGaN superlattices is compared. A three-fold increase of the external quantum efficiency (EQE) was observed for LEDs with UV-transparent p-AlGaN layers. To investigate these findings, LEDs with low-reflectivity Ni/Au and high-reflectivity Al contacts were fabricated, characterized, and ray tracing simulations were performed. The increased EQE can be partially ascribed to an two-fold improved LEE in combination with a 50% increase of the injection and internal quantum efficiency when using a UV-transparent p-$Al_{0.4}Ga_{0.6}N$/$Al_{0.6}Ga_{0.4}N$-superlattice.

Coffee Break

HL 72.5 Thu 11:00 POT 06

Influence of the GaN:Mg contact layer on the electro-optical properties of UVB LEDs — •Norman Susilo[1], Johannes Enslin[1], Luca Sulmoni[1], Martin Guttmann[1], Ute Zeimer[2], Tim Wernicke[1], Markus Weyers[2], and Michael Kneissl[1,2] — [1]Institute of Solid State Physics, Technische Universität Berlin — [2]Ferdinand-Braun-Institut, Leibniz-Institut für Höchstfrequenztechnik, Berlin

Light emitting diodes (LEDs) in the UVB spectral range (280 nm - 320 nm) are ideally suited for applications such as phototherapy and plant growth lighting. In order to improve the external quantum efficiency of UVB LEDs GaN:Mg contact layers were investigated to achieve UV-reflective and low resistance ohmic contacts. UVB LED heterostructures were grown by metal organic vapour phase epitaxy and fabricated into LED devices by standard lithography and metalization techniques. From transmission line measurements (TLM) we found that the p-contact resistivity increases rapidly with decreasing GaN:Mg thickness and exhibits a clear Schottky behaviour for layer thicknesses below 40 nm. At the same time, the emission power increases from 0.1 to 1.5 mW at 20 mA with decreasing GaN:Mg thickness. The electro-optical and the structural properties of the LEDs show that a 40 nm thick GaN:Mg cap layer is the best compromise due to the low p-contact resistivity ($3.5 \cdot 10^{-4}$ Ωcm^2) and low absorption resulting in UVB-LEDs with external quantum efficiencies of more than 2 %, measured on-wafer.

HL 72.6 Thu 11:15 POT 06

Time-resolved spectral characterization of white LEDs for car-to-x communication — •Vanessa Simon, Matthias Wachs, and Ulrich T. Schwarz — Chemnitz University of Technology, Experimental Sensor Science, Reichenhainer Str. 70, 09126 Chemnitz

Sensor development, car-to-car and car-to-environment (car-to-x) communication became a fast growing research area over the last years. A new approach could be car-to-x communication by means of white LEDs. This principle of data transmission was demonstrated by H.L. Minh et al. [1] in their Visible Light Communication (VLC) System. They achieved a bandwidth of about 50 MHz.

The aim of our attempt is to examine this system for different LEDs of their suitability for car-to-x communication. Therefore we investigate the switching behavior of gallium nitride and the phosphor converter with a time-resolved spectroscopy setup using a streak camera as detector. This measurement setup allows to determine the rise and fall time of the blue LED and the phosphor converter separately. The studied devices are warm-white and cold-white LEDs from Osram and Nichia. The measured rise and fall time of gallium nitride and the phosphor converter are compared to measurements similar to the experiment from H.L. Minh et al. [1] using a photodiode and band pass filters.

References: [1] H.L. Minh et al., IEEE Photonic Tech L. 21, 1063 (2009).

HL 72.7 Thu 11:30 POT 06

Molecular control over Ni/GaN Schottky barrier diode using Thiol Porphyrin — •Manjari Garg[1], Tejas R. Naik[2], Subramaniyam Nagarajan[3], V. Ramgopal Rao[1], and Rajendra Singh[1] — [1]Wide Bandgap Semiconductor Lab, Department of Physics, Indian Institute of Technology Delhi, Hauz Khas, New Delhi-110016 — [2]Indian Institute of Technology Bombay — [3]Aalto University Finland

The present work aims to investigate the control of self-assembled monolayers SAM of Thiol- Porphyrin on the electrical characteristics of GaN based Schottky barrier diode. In this work, SAM of Thiol-Porphyrin TTPSH organic molecules were sandwiched between Nickel metal and GaN semiconductor to tune the work function. The chemisorption of TTPSH SAM on GaN surface was confirmed by using Water contact angle measurements, XPS and AFM. KPFM revealed that the GaN surface potential was reduced from 950 mV to 750 mV after the adsorption of SAM on GaN. A decrease in the surface potential of semiconductor side of the metal-semiconductor interface implies decrease in workfunction of semiconductor which may lead to an increase in Schottky barrier height. Ni metal was deposited on the molecularly modified GaN surface and was electrically characterized by current-voltage measurements. A significant increase in Schottky barrier height and a decrease in reverse bias leakage current by four orders of magnitude was obtained. An increase in the photoluminescence intensity of GaN at 365 nm wavelength shows that surface passivation of GaN is occurring, which leads to the improvement of electrical characteristics of the diodes.