HL 44: ZnO and its relatives: Devices

Time: Tuesday 10:45–12:45 Location: POT 151

HL 44.1 Tue 10:45 POT 151

Energy-selective monolithic multichannel ultraviolet photodiodes based on (Mg,Zn)O thin films — •Zhipeng Zhang, Holger von Wenckstern, Jörg Lenzner, and Marius Grundmann — Universität Leipzig, Fakultät für Physik und Geowissenschaften, Institut für Experimentelle Physik II, Linnéstraße 5, 04103, Leipzig

We report on the fabrication of photodiodes employing Schottky contacts based on ternary (Mg,Zn)O thin films in wurtzite modification [1]. We utilize a new concept for forming a continuous composition spread (CCS) [2] within the active layer allowing the design of energy-selective, monolithic and multichannel ultraviolet metal-semiconductor-metal photodiodes [3]. The CCS of (Mg,Zn)O thin film was realized by pulsed-laser deposition on a 2 inch double-sided polished a-plane sapphire wafer using a single segmented target. The Mg-content and with that the bandgap change linearly along the compositional gradient [2].

The photo response of the photodiodes with a defined spectral bandwidth is enabled by an integrated optical filter layer providing a high energy cutoff. Further, we also have fabricated photodiodes from a wafer with separated active and filter layer with lateral graded CCS. By that the onset of absorption was tuned over 330 meV and the bandwidth of the photodiodes can be controlled from 270 meV down to about 30 meV.

[1]: Z. Zhang et al., Appl. Phys. Lett. **99**, 083502 (2011)
[2]: H. von Wenckstern et al., CrystEngComm. **15**, 10020 (2013)
[3]: Z. Zhang et al., Appl. Phys. Lett. **103**, 171111 (2013)

HL 44.2 Tue 11:00 POT 151

MOCVD-growth and characterisation of AZO-contacts for p-doped GaAs nanowire structures — •Christian Koppka[1], Alexander Koch[1], Andreas Nägelein[1], Sana Muhammad Ullah[1], Matthias Steidl[1], Katja Tonisch[1], Peter Kleinschmidt[1,2], Sabine Nieland[2], Uta Stürzebecher[2], Claudia Schmidt[3], Werner Prost[3], and Thomas Hannappel[1,2] — [1]TU Ilmenau, Germany — [2]CiS Forschungsinstitut, Erfurt, Germany — [3]Universität Duisburg-Essen, Germany

A key part in the development of nanowire-based solar cells is based on the production of appropriate front side contacts. In this regard, the application of transparent conductive oxides (TCOs) for the production of tunnel junctions on p-doped III-V semiconductors is investigated. To obtain homogeneous coating of non-planar surfaces, such as core-shell nanowire structures, an ALD type process has been established in a standard MOCVD reactor (Aixtron). Deposition parameters such as growth temperature, carrier gas flow and percursor concentrations were adjusted using planar sapphire and p-GaAs substrates in a first step to achieve highly conductive and transparent films. The deposited films were characterized by scanning electron micrsocopy (SEM), X-ray diffraction (XRD) and X-ray photoelectron spectroscopy (XPS) as well as various methods for determining the optical and electrical properties. Current-voltage measurements reveal an ohmic behaviour of the AZO contact on planar p-doped GaAs. In a next step, this contact system is implemented on nanowire structures.

HL 44.3 Tue 11:15 POT 151

Controlled fabrication of ZnO/ZnS core-shell nanotube arrays prepared on anodic aluminum oxide with enhanced photoluminces and electronic properties — •Samar Tarish[1,2], Chengliang Wang[1], Ahmed Al-Haddad[1,2], Zhijie Wang[1], Zhibing Zhan[1], and Yong Lei[1] — [1]Institute for Physics and IMN MacroNano (ZIK), Ilmenau University of Technology, Prof. Schmidt Str. 26, 98693 Ilmenau, Germany. — [2]Department of Physics, College of Science, The University of Mustansiryah, Baghdad, Iraq.

Heterostructured ZnO/ZnS core-shell nanotube arrays on the AAO template were fabricated by a two-step growth process. The ZnO nanotubes were first synthesized by atomic layer deposition ,and the ZnO/ZnS composite arrays can be successfully obtained afterwards through sulfartion reaction. The optical properties of the composite nanotubes change as a function of the ZnS shell thickness , and it was found that the UV emission intensity of ZnO/ZnS core-shell nanotubes is stronger than that of ZnO nanotubes. Besides, ZnO/ZnS core shell shows better electric properties than ZnO nanotubes . With the enhanced electrical conductivity comparing with the bare ZnO arrays the intriguing improvement implies the promising utilization of this special ZnO/ZnS heterstuctured nanotubes array configuration in the applications, such as gas and chemical sensing and optical switching applications.

HL 44.4 Tue 11:30 POT 151

Electrical characteristics of functionalized and bare ZnO nanowire Schottky diodes — •Alejandra Castro-Carranza, Stephanie Bley, Olesea Volciuc, Tobias Voss, and Jürgen Gutowski — Institute of Solid State Physics, University of Bremen, Bremen, Germany

Zinc oxide nanowires (ZnO NW) have shown to be promising nanoscale building blocks for optoelectronic applications due to their unique semiconductor, optical, piezoelectric, and chemical characteristics. An interesting approach to tailor the optoelectronic properties of ZnO nanostructures is to form hybrid assemblies with other materials. Previously, it has been shown that the photoluminescence (PL) spectrum of the ZnO NW arrays is modified when applying other materials, e.g. polymers and metals. This has been attributed to variations of the internal electric field and trap states at the interface. To gain further insight into these physical phenomena, we explore the electrical characteristics by means of Schottky diodes based on bare and coated ZnO NW arrays. Specifically, the internal electric field and charge carrier density of our devices are determined using capacitance-voltage characterization, the quality of the interfaces is examined using current-voltage characteristics, and the density of states is explored using capacitance-frequency characteristics.

HL 44.5 Tue 11:45 POT 151

Influence of antimony doping on optical and structural properties of ZnO nanowires — •Sarah Schlichting[1], Thomas Kure[1], Alexander Franke[1], Emanuele Poliani[1], Eswaran Senthil Kumar[2], Faezeh Mohammadbeigi[2], Simon Watkins[2], and Axel Hoffmann[1] — [1]Technische Universität Berlin, Institut für Festkörperphysik, Berlin, Germany — [2]Simon Fraser University, Department of Physics, Burnaby, Canada

Antimony (Sb) is a canditate to obtain p-conductivity in ZnO. First-principles calculations indicate that a complex with induced Zn vacancies and low formation energy would lead to a shallow acceptor.[1] However, there is also evidence that Sb acts as a shallow donor in ZnO so that the doping mechanism remains controversial.[2]
We investigated the optical and structural properties of Sb-doped ZnO nanowires (NW) by low temperature photoluminescence (PL) under the influence of an external magnetic field, Raman measurements on ensemble and single NW as well as TEM-CL.
We concluded that the Sb emission at 3.3639 eV with a FWHM of approx. 200 μeV originates from a donor bound exciton. Our measurements confirm the observed donor behavior of Sb by the formation of a composed Sb and Zn vacancy complex.

[1] S. Limpijumnong et al., Phys. Rev. Lett. 92, 155504 (2004); [2] E. Senthil Kumar et al., Appl. Phys. Lett. 102, 132105 (2013)

HL 44.6 Tue 12:00 POT 151

XPS investigations of selective surface passivation for highly stable metal oxide TFTs — •Yulia Trostyanskaya, Marlis Ortel, Torsten Balster, and Veit Wagner — Campus Ring 1, 28759 Bremen, Germany

Zinc oxide thin film transistors (TFTs) showing high electron mobilities (7 cm2/Vs in air) were prepared by spray pyrolysis. In air the transistors showed considerable hysteresis and shift in threshold voltage during operation. After selective surface passivation with benzoyl-1,1,1-trifluoroacetone (BTA) the hysteresis and operational stability improved significantly. Analysis of chemical composition and binding properties of the passivation material is crucial to develop a microscopic model of the semiconductor-passivation interaction. By means of X-ray photoelectron spectroscopy (XPS) was found that a monolayer of BTA bond to Zn can be achieved by desorption of weakly bonded multilayers at 30°C only. The BTA-Zn bond withstands high temperatures but decomposition of the compound was observed at 170°C. This is far above the operation temperature of TFTs. The decomposition was monitored by XPS, the F-peak was split from the original one at

688.5 eV to a second one at 685.3eV. This indicates the formation of Zn-F bonds by decomposing the CF3-group. The analysis shows the excellent suitability of BTA as passivation layer due to strong bonding properties of BTA to Zn and high chemical stability under standard operation conditions of TFTs.

HL 44.7 Tue 12:15 POT 151

ZnO nanowires for gas sensing applications — •Manfred Madel, Julian Jakob, Martin Dickel, Florian Huber, Bruno Amann, and Klaus Thonke — Institute of Quantum Matter / Semiconductor Physics Group, University of Ulm

ZnO nanowires with average diameter of $50 - 100$ nm were grown by chemical vapour deposition. Due to the large surface to volume ratio the nanowires show very good sensing behaviour to adsorbed molecules in different gas atmospheres. Besides conventional electrical measurements, micro-photoluminescence (μPL) and photoconductivity read out is used for the detection of oxygen atmosphere.
To adress single nanowires in μPL measurements, these were aligned by the simple and low cost dielectrophoresis method. In our experiments, we find a relationship between sensing behaviour and nanowire form and diameter.
Electrical photoconductivity measurements on dense ensembles of aligned ZnO nanowires on gold contacts show that the decay time of the electrical current after switching off UV illumination depends stronlgy on the ambient gas atmosphere.
For both methods the detection limit for oxygen was found to be in the lower ppm range.

HL 44.8 Tue 12:30 POT 151

Influence of pH and ions on the transistor performance and topography of solution processed ZnO nanoparticles — •Paul Mundt[1,3], Nicole Anderl[2,3], Stefan Vogel[1], and Heinz von Seggern[1] — [1]Electronic Materials Division, Institute of Materials Science, Technische Universität Darmstadt, Alarich-Weiss-Str. 2, 64287 Darmstadt, Germany — [2]Ernst-Berl-Institut für Technische und Makromolekulare Chemie, Technische Universität Darmstadt, Alarich-Weiss-Str. 4, D-64287 Darmstadt, Germany — [3]Merck TU Darmstadt-Lab, Eduard-Zintl-Institut für Anorganische und Physikalische Chemie, Alarich-Weiss-Str. 12, 64287 Darmstadt, Germany

Recently, zinc oxide nanoparticles (ZnO-NP) have become a subject of considerable interest due to their high potential for developing solution processed, low cost, low temperature semiconducting devices. The present work utilizes sol gel processed ZnO-NPs without an additional steric stabilization. Thin ZnO-NP films were produced by spin coating using post-treatment temperatures of 250°C only being therefore suitable for applications on flexible substrates. By using different doping agents, the electronic behaviour of the devices can be influenced in a wide range from semiconducting thin film transistors yielding electron mobilities of 10-2 cm*/Vs up to conducting devices with currents in the order of mA. We investigate these changes in device behaviour for different doping agents using photoelectron spectroscopy and UV/VIS spectroscopy and correlate the results with the change in morphology using scanning electron microscopy and atomic force microscopy.