HL 66: ZnO-based Devices

Time: Friday 10:15–11:15 Location: H17

HL 66.1 Fri 10:15 H17

Properties of transparent ZnO-based electronics — •Alexander Lajn, Heiko Frenzel, Holger von Wenckstern, and Marius Grundmann — Universität Leipzig, Fakultät für Physik und Geowissenschaften, Institut für Experimentelle Physik II, Linnéstr. 5, 04103 Leipzig, Germany

In combination with transparent light emitters, transparent electronics permit the fabrication of fully transparent displays. Thus, new designs allowing higher information content, better ergonomics and new aesthetic aspects are feasible; e.g. in car wind shields, windows, monitors or cell phones. We report on the fabrication of transparent rectifying contacts (TRC) on ZnO thin films and their application in photodetectors, field-effect transistors and inverters. Our TRC can be described as Schottky-diodes and exhibit maximum effective barrier heights of 0.87 eV, ideality factors of 1.47 and rectification ratios of 5×10^6. Visible-blind UV photodetectors with an external quantum efficiency of 32% at 375 nm and an UV-VIS rejection ratio in excess of 10^3 are demonstrated. Metal-semiconductor field-effect transistors (MESFET) with a channel mobility of 11.4 cm^2/Vs and on/off-ratios of 10^6 were fabricated. An average transmission of 70 % in the visible spectral range was achieved for the Ag_xO-based gate electrodes. Furthermore the MESFETs operate at low voltages, only about $\Delta U = 2.5\,V$ are required to switch between on- and off-state. This advantage of MESFETs (compared to MISFETs) was successfully transferred to integrated inverters, yielding a maximum gain of 200 at a supply voltage of 4 V and a low uncertainty level of 0.3 V.

HL 66.2 Fri 10:30 H17

Properties of transparent ZnO inverters under the influence of light and elevated temperature — •Tobias Diez, Alexander Lajn, Heiko Frenzel, Holger von Wenckstern, and Marius Grundmann — Universität Leipzig, Fakultät für Physik und Geowissenschaften, Institut für Experimentelle Physik II, Linnéstr. 5, 04103 Leipzig

Transparent electronics is an ambitious technology, which can be applied in transparent displays, e.g., as car wind-shield displays, in cell phones and electronic paper. In order to be able to manufacture these devices, transparent wide band-gap semiconductors, such as ZnO, have to be used. We fabricate normally-on metal-semiconductor field-effect transistors (MESFET) with reactive dc-sputtered Schottky-gate contacts and combine these to transparent inverters. They exhibit a transparency of about 69 % averaged over the device area and the visible spectrum. To explore the application relevant performance we investigate the change of the electrical properties of our transparent ZnO inverters under illumination with visible light. The uncertainty level, indicating the range of the input voltage with a ambiguous logical output, remains constant at about 0.3 V. Also the peak gain value is mainly unaffected by the incident light, except for blue light, for which a reduction of the gain is observed. Furthermore we investigate the temperature dependence of the inverter characteristics.

HL 66.3 Fri 10:45 H17

ZnO-based On-Chip Devices for Cell Potential Measurement — •F. Klüpfel, A. Lajn, H. Frenzel, H. von Wenckstern, G. Biehne, H. Hochmuth, M. Lorenz, and M. Grundmann — Universität Leipzig, Fakultät für Physik und Geowissenschaften, Abteilung Halbleiterphysik, Linnéstr. 5, 04103 Leipzig

External stimulation causes nerve cells to change their membrane potential. Measuring these electric cell activities is important to improve the understanding of nerve cell communication and has been demonstrated using multi-transistor arrays based on silicon technology [1]. However these devices do not allow transmission microscopy and thus complicate the determination of the cell locations during electric measurements. The development of such structures on transparent substrates like glass or sapphire promises simultaneous recording of cell potential changes and visual observation. We use a chip with transistors based on the transparent semiconductor ZnO grown by pulsed laser deposition and gold electrodes to contact the cells. Our metal-semiconductor field effect transistors (MESFETs) with reactively sputtered AgO Schottky gate contacts are already described in [2] and outperform the amplification properties of ZnO-based metal-insulator-semiconductor field effect transistors by far, making them most suitable for this purpose. In this talk the electrical properties of the MESFETs as well as their applicability for cell potential measurements will be discussed.

[1] A. Lambacher et al., Appl. Phys. A 79, 1607-1611 (2004)
[2] H. Frenzel et al., Appl. Phys. Lett. 92, 192108 (2008)

HL 66.4 Fri 11:00 H17

Appropriate choice of channel ratio in thin-film transistors for the exact determination of field-effect mobility — •Koshi Okamura, Donna Nikolova, Norman Mechau, and Horst Hahn — Institute of Nanotechnology, Karlsruhe Institute of Technology (KIT), Eggenstein-Leopoldshafen, Germany

For the evaluation of any kind of semiconducting materials for thin-film transistors (TFTs), the most important figure of merit is field-effect mobility. It is, however, sometimes extracted from the TFTs with the active semiconductor area undefined (unpatterned) and in the geometry of the small channel ratio; the effect of the fringing electric field at ends of source/drain electrodes are not taken into account. In this study, therefore, the effect of the fringing electric field on the field-effect mobility is systematically investigated. TFTs in the bottom gate configuration were fabricated by spin-coating a suspension of ZnO nanoparticles, as a function of different channel ratios, such as 2.5, 5.5, 12, 32 and 70. The field-effect mobility extracted from TFTs, with the active ZnO area undefined, at the small channel ratio of 2.5 showed the value by 418 % overestimated. In contrast, the field-effect mobility extracted from TFTs, with the active area defined, at the large channel ratio of 70 was nearly equivalent to the real value. These results reveal that the active semiconductor area of TFTs should be defined for the exact determination of the field-effect mobility; otherwise, the channel ratio should be chosen to be large enough to neglect the effect of the fringing electric field.