DS 13: Oxide Semiconductors for Novel Devices (Focussed Session): Session III

The class of semiconducting oxides includes low temperature processed amorphous thin films for bendable electronics and display technology as well as highly crystalline materials such as the wide band group-III sesquioxides being interesting for UV and DUV photo sensors, power electronics and even memristors. This session sets a focus on physical properties of such oxides, their growth methods and heterostructures for demonstrator devices. This focus session is supported by the Leibniz ScienceCampus GraFOx.

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Time: Tuesday 9:30–11:30 Location: E 020

Invited Talk DS 13.1 Tue 9:30 E 020

Electron transport in beta-gallium oxide — •Rebecca L. Peterson[1], Zumrad Kabilova[1], and Cagliyan Kurdak[2] — [1]Department of Electrical Engineering and Computer Science, University of Michigan, Ann Arbor, Michigan, USA — [2]Department of Physics, University of Michigan, Ann Arbor, Michigan, USA

The sesquioxide semiconductor gallium oxide is currently drawing attention for power electronics and deep ultraviolet optoelectronics applications, due to its ultra-wide bandgap. Gallium oxide has several crystal polytypes. The stable beta-phase has a bandgap of approximately $4.8\,eV$, a monoclinic crystalline structure, and bulk substrates are commercially available. Here, we present our experimental and theoretical work on charge transport in bulk (010) $\beta-Ga_2O_3$, in which the extrinsic tin doping of $10^{18}\,cm^{-3}$ is close to the Mott metal-insulator transition point. A peak electron mobility of $95\,cm^2V^{-1}s^{-1}$ was measured at 185K. Across a wide temperature range, a two-band conduction model applies, consisting of a impurity band in parallel with the conduction band, as was observed previously for n^{++} $(\bar{2}01)\,\beta-Ga_2O_3$ [1]. At low temperature, we find that conduction is via variable-range hopping through the impurity band. At high temperatures, phonon scattering of conduction band electrons dominates, similar to lightly-doped $(100)\,\beta-Ga_2O_3$ [2]. This work was supported by DARPA/SPAWAR under award N66001-14-1-4046. [1] T. Oishi, K. Harada, Y. Koga, and M. Kasu: Japan. J. Appl. Phys. 55, (2016) 030305; [2] A. Parisini and R. Fornari, Semicond. Sci. Technol. 31, (2016) 035023.

Invited Talk DS 13.2 Tue 10:00 E 020

Deep level defects in bulk and epi-grown β-Ga2O3 — •Lasse Vines — University of Oslo, Norway

After the early work on gallium oxide (Ga2O3) in the mid-1900s, a renewed interest has recently emerged on behalf of its prospects in power electronics and UV devices. Particularly, the monoclinic β-Ga2O3 phase attracts interest due to its band gap of ~ 4.8 eV and n-type conductivity, and where promising MOSFET devices have already been demonstrated. However, while controlling charge carrier and defect concentrations is essential for high power and high temperature devices, the understanding of the electrically active defects and dopants is still in its infancy. Here, the present status of controlling electrical properties of β-Ga2O3 will be reviewed, and recent progress in understanding electrically active defects and dopants will be discussed. In particular, recent results combining deep level transient spectroscopy with secondary ion mass spectrometry and ion irradiation on a range of different samples will be shown. The results reveal both intrinsic and extrinsic defects present in the samples, and give insight into the nature new and previously reported energy levels. For example, iron is shown to be an important impurity in bulk samples with an energy level position around 0.78 eV below the conduction band edge, acting as a deep compensating center, while irradiation demonstrate the appearance of a nearby intrinsic defect level, and the results are further supported by density functional calculations

Invited Talk DS 13.3 Tue 10:30 E 020

Indium Oxide and its surface electrons – a model system to study gas interaction and metal/semiconductor junctions — •Marcel Himmerlich, Theresa Berthold, Jonas Michel, Simeon Katzer, and Stefan Krischok — Institut für Physik & IMN Macro Nano, Technische Universität Ilmenau, Germany

The electron accumulation at Indium Oxide surfaces is beneficial for electronic devices that rely on adsorption processes such as gas sensors. However, it is a drawback for electron transport devices since it hinders the fabrication of rectifying metal contacts. In both cases, the manipulation of the electron density by surface reactions is one approach to optimize performance. We analyze the underlying mechanisms of adsorption processes and the formation of metal/semiconductor contacts using model in-situ experiments. For the interaction with O_2, O_3, H_2O, CO and NO_x, a clear correlation exists between adsorbate-semiconductor charge transfer, density of surface charge carriers, and the conductivity of the material. If In_2O_3 is treated by a reactive oxygen plasma, the surface electron layer is fully depleted generating a barrier for interface transport. Photoelectron spectroscopy measurements reveal that adsorption of Pt on these modified surfaces results in sufficient Schottky barriers for rectifying contacts, but fabricated devices fail. It will be demonstrated that the oxygen-rich Pt/In_2O_3 interface is critical in stability and that oxidation of Pt-based contacts is beneficial to enhance electronic barriers and to exploit the effect of electron depletion via oxygen plasma modification. Combining both processes enables performance improvement of In_2O_3 Schottky diodes.

Invited Talk DS 13.4 Tue 11:00 E 020

Phonons and excitons in Ga_2O_3 polytypes — •Markus R. Wagner — Institut für Festkörperphysik, Technische Universität Berlin, Hardenbergstr. 36, 10623 Berlin

We present a comparative experimental study of the optical, vibrational and thermal properties of Ga_2O_3 in the alpha-, beta-, gamma-, and epsilon-modification. The anisotropic band gap energies are probed by the observation of deep UV excitation channels using temperature-dependent, polychromatic photoluminescence excitation spectroscopy (PLE). Based on these experiments, we establish an order of the bandgap for the different polymorph of Ga_2O_3. In addition, we investigate the optical phonon modes of the different structural configurations of Ga_2O_3 by polarized and angular resolve micro-Raman spectroscopy. Finally, we compare the temperature-dependent thermal conductivity of the four different Ga_2O_3 polytypes as obtained by 3-omega measurements. The results are discussed considering phonon boundary scattering and size effects due to structural imperfections and reduced dimensionality in ultra-thin films.