DS 6: Focus Session: Innovative GaN-based High-power Devices: Growth, Characterization, Simulation, Application 2

Organizers:
Bernd Witzigmann, University Erlangen-Nürnberg
Frank Bertram, Magdeburg University

Synopsis (see part I)

Time: Monday 15:00–16:45 Location: H17

Invited Talk DS 6.1 Mon 15:00 H17

Novel high power device structures: Enabling compact and integrated power ICs — •Elison Matioli — EPFL, Lausanne, Switzerland

This talk will discuss new technologies to drastically reduce the sheet resistance in these semiconductors. Combined with a judicious design of the electric field distribution, based on nanostructures, this approach enables to concurrently reduce the on-resistance and increase the breakdown voltage of power devices, leading to figures of merit far beyond the state-of-the-art. To manage the large heat fluxes in power devices, I will present new technologies based on integrated microfluidic cooling inside the device. By co-designing microfluidics and electronics within the same semiconductor substrate, a monolithically integrated manifold microchannel cooling structure was produced with efficiency beyond what is currently available. Our results show that heat fluxes exceeding 1.7 kW/cm2 could be extracted using only 0.57 W/cm2 of pumping power. The proposed cooling technology should enable further miniaturization of electronics, and greatly reduce the energy consumption in cooling of electronics. Furthermore, by removing the need for large external heat sinks, this approach enables the realization of very compact power converters integrated on a single chip.

Invited Talk DS 6.2 Mon 15:30 H17

Ab-initio investigations of V-pits and nanopipes in GaN — •Liverios Lymperakis[1,2], Su-Hyun Yoo[2], and Jörg Neugebauer[2] — [1]Department of Physics, University of Crete, Heraklion, Greece — [2]Computational Materials Design Department, Max-Planck-Institut für Eisenforschung GmbH, Düsseldorf, Germany

Dislocations in nitrides constitute a long-standing and controversial topic. Nevertheless, screw dislocations in GaN have recently attracted considerable interest due to their potential effect on power electronic devices' performance. An intriguing feature of these dislocations is that they trigger the formation of V-pits and nanopipes in GaN. However, a full understanding of their origin, size, and shape is still lacking. The nucleation and properties of these defects are governed by the complex interplay between dislocation's strain and core energies, surface energies, and oversaturation. In the present work, we combine density functional theory calculations with elasticity theory and we shed light on the aforementioned interplay. Based on these calculations we derive phase diagrams that describe the equilibrium size and shape of V-pits and nanopipes as a function of the ambient growth conditions, i.e., the Ga and H chemical potentials as well as the oversaturation. Our calculations indicate that under H-rich conditions, V-pits and nanopipes can spontaneously form due to the preferential decoration of the bounding surfaces by hydrogen. Based on these results we will further discuss their electronic properties as well as their potential to preferentially accommodate impurities/dopants.

DS 6.3 Mon 16:00 H17

Metal micro-contacts deposited by focused electron and ion beam: impact on electrical properties — •Konstantin Wein, Gordon Schmidt, Frank Bertram, Silke Petzold, Peter Veit, Christoph Berger, André Strittmatter, and Jürgen Christen — Otto-von-Guericke-University Magdeburg, Magdeburg, Germany

In this study, we want to concentrate on the local deposition of platinum and tungsten as metal micro-contacts by electron- as well as ion-beam in a focused ion beam microscope (FIB). We are using a Thermo Fisher Scientific Scios 2 HighVac dual-beam with liquid gallium ion source. Either the focused electron beam or the ion beam are used to crack the precursor molecule bonds and induce the complex metal deposition process.

For the investigation of the electrical properties Pt/W stripes were deposited between macroscopic lithographic Au pads on top of insulating SiO_2/Si template. Parameters like Ga- and e-beam current, acceleration voltage, dwell time and pixel overlap were systematically investigated and optimized with regard to best electrical properties. The trade-off between efficient incorporation of conductive material and sputtering has to be determined. We observe almost insulating properties for layers deposited by electron beam radiation. On the other hand, the ion beam induced deposition layers behave ohmic and exhibit electrical conductivity up to $4.6\frac{10^5}{\Omega * m}$ for tungsten.

Invited Talk DS 6.4 Mon 16:15 H17

Lateral and Vertical β-Ga_2O_3 Power Transistors for High-Voltage Applications — •Kornelius Tetzner[1], Michael Klupsch[1], Karina Ickert[1], Ralph-Stephan Unger[1], Zbigniew Galazka[2], Ta-Shun Chou[2], Saud Bin Anooz[2], Andreas Popp[2], Joachim Würfl[1], and Oliver Hilt[1] — [1]Ferdinand-Braun-Institut, Leibniz-Institut für Höchstfrequenztechnik (FBH), Gustav-Kirchhoff-Straße 4, 12489 Berlin, Germany — [2]Leibniz-Institut für Kristallzüchtung (IKZ), Max-Born-Straße 2, 12489 Berlin, Germany

Beta gallium oxide (β-Ga_2O_3) with its ultra-wide bandgap of 4.8 eV has emerged as a promising semiconducting material for the fabrication of next-generation power electronic devices. The estimated dielectric strength of 8 MV/cm in combination with the expected Baliga's figure of merit are promising indicators to pave the way for the realization of power devices with even higher breakdown voltages and efficiencies than their SiC and GaN counterparts. This presentation will give an overview on the current status of lateral and vertical β-Ga_2O_3 power transistor devices with a special emphasis on results obtained at FBH and IKZ. For both cases different concepts for bulk crystal growth, epitaxial layer structures and device designs suitable for reaching the targeted performance will be discussed especially in terms of breakdown voltage and channel current density. In this regard, certain material and device related challenges are identified which need to be addressed perspectively in order to overcome current breakdown limitations.