Monday Morning, August 14, 2023

Keynote Address
Room Davis Hall 101 - Session KEY-MoM

Keynote Address I

Moderators: Michael Scarpulla, University of Utah, **Uttam Singisetti**, University of Buffalo, SUNY

8:30am **KEY-MoM-1 Welcome and Opening Remarks***,*

8:45am **KEY-MoM-2 Gallium Oxide as a Material for Power Device Applications***, **Akito Kuramata,*** Novel Crystal Technology, Inc., Japan **INVITED**

Ga_2O_3 is expected as a material for next generation power devices. Since it has a large bandgap energy and a large breakdown electric field strength, it is suitable for high breakdown voltage applications. It is a material that can be produced at a lower cost than SiC and GaN because it can be melt-grown and its hardness is not high.

Currently, 100-mm substrates manufactured by the EFG method are commercially available. A 100-mm epitaxial wafer with a carrier concentration of 10^{15}-10^{17} cm^{-3}, grown by the HVPE method, has also been commercialized. There are no commercial Ga_2O_3 devices yet, but research is progressing. So far, SBDs and FETs have been demonstrated with ampere-class currents and breakdown voltages of 1 kV or higher. In the presentation, I will introduce the above and talk about the challenges for commercialization of Ga_2O_3 devices.

Keynote Address
Room Davis Hall 101 - Session KEY-TuM

Keynote Address II

Moderators: Uttam Singisetti, University of Buffalo, SUNY, **Joel Varley**, Lawrence Livermore National Laboratory

8:30am **KEY-TuM-1 Welcome and Opening Remarks***,*

8:45am **KEY-TuM-2 Bulk Single Crystals and Physical Properties of β-($(Al_xGa_{1-x})_2O_3$) Grown by the Czochralski Method***, Zbigniew Galazka,* LEIBNIZ-INSTITUT FÜR KRISTALLZÜCHTUNG, Germany **INVITED**

β-Ga_2O_3 is a transparent semiconducting oxide that attracted a particular attention in the research community with potential applications especially in high power electronics and UV opto-electronics. This is the result of a wide bandgap of 4.85 eV, good electrical properties enabling a wide doping range, high theoretical breakdown field of 8 MV/cm, and a capability of growing large bulk single crystals and thin films of high structural quality [1].

A yet higher critical breakdown field of β-Ga_2O_3 can be achieved by enlarging its bandgap through heavy doping with Al. For homoepitaxial growth of β-$(Al_xGa_{1-x})_2O_3$ films and subsequent device fabrication, wafers from bulk single crystals of similar composition would be highly beneficial. We have already demonstrated the capability of growing bulk β-$(Al_xGa_{1-x})_2O_3$ single crystals by the Czochralski method with x = 0 – 0.35, and provided basic structural, optical, and electrical properties [2].

The present study provides an overview of the growth of bulk β-$(Al_xGa_{1-x})_2O_3$ single crystals by the Czochralski method, including thermodynamics and limits of Al incorporation in the monoclinic β-Ga_2O_3 crystal lattice, as well as limits of Ga incorporation in the trigonal a-Al_2O_3 crystal lattice. In addition to Al doping, the crystals were co-doped either with Si or Mg. The study is accompanied with extended characterization of physical properties of β-$(Al_xGa_{1-x})_2O_3$ as a function of [Al]. It covers structural (lattice constants), electrical (free electron concentration, electron mobility, BOFM), optical (absorption edge, bandgap, static dielectric constants, refractive index), and thermal (thermal conductivity) properties. A high doping level of bulk β-Ga_2O_3 single crystals with [Al] ≤ 35 mol.%, their high structural quality, and a wide spectrum of physical properties might facilitate homoepitaxial growth of β-$(Al_xGa_{1-x})_2O_3$ films and novel device fabrication.

This work was funded by the Deutsche Forschungsgemeinschaft (DFG) project under Grant Nos. GA 2057/5-1 and PO 2659/3-1. It was partly performed in the framework of GraFOx, a Leibniz-Science Campus, partially funded by the Leibniz Association—Germany.

[1] Eds. M. Higashiwaki and S. Fujita; "Gallium Oxide: Crystal Growth, Materials Properties, and Devices"; Springer Nature Switzerland AG (2020).

[2] Z. Galazka, A. Fiedler, A. Popp, S. Ganschow, A. Kwasniewski, P. Seyidov, M. Pietsch, A. Dittmar, S. Bin Anooz, K. Irmscher, M Suendermann, D. Klimm, T.-S. Chou, J. Rehm, T. Schroeder, M. Bickermann; J. Appl. Phys. 133 (2023) 035702.

Wednesday Morning, August 16, 2023

Keynote Address
Room Davis Hall 101 - Session KEY-WeM

Keynote Address III

Moderators: Hari Nair, Cornell University, **Uttam Singisetti**, University of Buffalo, SUNY

8:30am **KEY-WeM-1 Welcome and Opening Remarks***,*

8:45am **KEY-WeM-2 Gallium Oxide Microelectronics for Department of Air Force Applications***, **Kelson Chabak**,* Air Force Research Laboratory **INVITED**

The Department of Air Force (DAF) and DoD are pivoting to decentralized warfare to win future conflicts. The unique warfighting domains of the DAF require multi-function sensing that demand increased power in small volume platforms. Many of these domains have unique challenges such as no active cooling, temperature extremes, and radiation that require efficient wide and ultra-wide semiconductors. AFRL is a global leader in developing Gallium Oxide device technology for lateral and vertical power conversion with promising operation for switching applications. Further, we have found Gallium Oxide a robust high-temperature microelectronics technology. This presentation will highlight the above and other recent progress of AFRL to mature and transition Gallium Oxide for various RF and power switching applications.

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