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SiC Based Miniaturized Devices

Edited by

Stephen Edward Saddow, Daniel Alquier, Jing Wang, Francesco LaVia and Mariana Fraga

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About the Special Issue Editors

Stephen Edward Saddow started his involvement in SiC technology in 1992 when he started to develop optically-activated switching of 6H-SiC. He spent nearly 20 years focusing on epitaxial growth of SiC along with the development of porous SiC and novel defect reduction techniques specifically aimed at improving the material quality of 3C-SiC grown on Si substrates. For the past decade he has focused his efforts on the development of SiC for biomedical devices, first via materials studies (in-vitro and in-vivo) and more recently device prototyping. Currently he is focusing on the development of robust, implantable SiC devices for long-term operation as well as SiC-based nanostructures for the treatment of deep-tissue cancer. He is also leading a Bioelectronics Rapid Prototyping Laboratory at USF with the specific purpose of allowing for rapid translation of biomedical device research to commercial products.

Daniel Alquier is Professor and Research Vice-President at Université de Tours, doing his research in GREMAN (UMR CNRS 7347). He prepared his PhD. at the LAAS-CNRS on ultra-shallow junctions in 1998. He occupied then a position in Taiwan for PixTech-UNIPAC. Since 2000, he is working at the University of Tours and became professor in 2005. Pr. D. Alquier is the author and co-author of more than 140 papers and 6 patents. He has participated to several European and national projects. His fields of interest are wide band gap semiconductors (SiC & GaN), MEMS & NEMS and engineering for power and medical applications.

Jing Wang is a Professor and Co-Director of Center for Wireless and Microwave Information Systems (WAMI) at the University of South Florida. He got dual B.S. degrees in Electrical and Mechanical Engineering from Tsinghua University in 1999. He received two M.S. degrees in Electrical and Mechanical Engineering, and an Electrical Engineering Ph.D. from the University of Michigan in 2000, 2002, 2006, respectively. His research interests include micromachined transducers, RF/Bio-MEMS, microwave/mmWave devices, RF additive manufacturing, lab-on-a-chip/microfluidics, and functional nanomaterials. His work has been funded by grants from federal agencies (NSF, DTRA, US Army, US Air Force) and contracts from many companies totaling over $14 M. He has published more than 180 peer-reviewed papers and holds 11 US patents. He serves as the chair for IEEE MTT/AP/EDS Florida West Coast Section and he acted as the general chair or TPC chair for IEEE WAMICON Conferences in 2011, 2012, 2013, 2014 and 2020.

Francesco LaVia was born in Catania (Italy) in 1961. He graduated in Physics at the University of Catania in 1985. From 1985 to 1990 he had a scholarship at the STMicroelectronics in Catania. In 1990 he joined the CNR-IMM of Catania. In 2001 he became senior researcher and became head of the research team working on epitaxy and hetero-epitaxy of silicon carbide. He was responsible of several industrial projects and contracts and actually coordinates two European projects. In his career he has published more than 300 papers in JCR journals, 11 patents, two articles on invitation, three chapters in books and he was editor of four books. He presented several invited talks at international conferences and has co-organized several conferences and tutorials. He has been the Co-Chair of the ICSCRM2015 and Chair of the Technical Program Committee. He is member of the Steering Committee of the ICSCRM conference.

Mariana Fraga obtained her PhD in Aeronautics and Mechanical Engineering (with concentration on materials science) from the Technological Institute of Aeronautics and master's degree in electrical engineering (with concentration in Microelectronics) from the University of São Paulo (USP), Brazil. Her major research efforts are in the fields of materials science and engineering, and can be briefly summarized as follows: (i) synthesis and characterization of thin films and nanostructures, more specifically those based on silicon carbide (SiC), CVD diamond, diamond-like carbon (DLC), aluminium nitride (AlN) and titanium dioxide (TiO2), and (ii) development of micro-electro-mechanical (MEMS) sensors, microelectronic devices, solar energy conversion devices, biomedical devices, and coatings for technological applications. Currently, she is a visiting professor at the Institute of Science and Technology, ICT-UNIFESP. She also serves as Member of the Editorial Board for five international journals. She is the co-editor of the book Emerging Materials for Energy Conversion and Storage.

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Editorial

Editorial for the Special Issue on SiC Based Miniaturized Devices

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The MEMS devices are found in many of today's electronic devices and systems, from air-bag sensors in cars to smart phones, embedded systems, etc. Increasingly, the reduction in dimensions has led to nanometer-scale devices, called NEMS (Nano-Electrical-Mechanical Systems). The plethora of applications on the commercial market speaks for itself, and especially for the highly precise manufacturing of silicon-based MEMS and NEMS. While this is a tremendous achievement, silicon (Si) as a material has some drawbacks, mainly in the area of mechanical fatigue and thermal properties. Silicon carbide (SiC) is a well known wide-bandgap semiconductor whose adoption in commercial products is experiencing exponential growth, especially in the power electronics arena. While SiC MEMS have been around for decades, in this Special Issue we sought to capture both an overview of the devices that have been demonstrated to date, as well as bring new technologies and progress in the MEMS processing area to the forefront. This Special Issue contains one review paper and nine original research papers, with both experimental and theoretical investigations, reporting the recent progress of SiC materials, processing, modeling and device technology.

The review paper of this Special Issue provides an overview of high-temperature SiC power electronics, with a focus on high-temperature converters and MEMS devices [1]. This paper mainly surveyed the research and development of SiC-based high-temperature converters as well as the existing technical challenges facing high-temperature power electronics, including gate drives, current measurements, parameters matching between each component and packaging technology.

The discussion on the original research published in this Special Issue opens with the paper on the development of a 1200V/200A full-SiC half-bridge power module by Zhang et al [2]. Their study focused on the influences of output power on the turn-on Vgs characteristics for high-power and high-frequency application. There is also a paper addressing the design and simulation of an improved 4H-SiC metal semiconductor field effect transistor (MESFET) based on the double-recessed MESFET (DR-MESFET) [3].

The use of SiC in radiation detection is the subject of two papers in this issue. Mandal et al. investigated the development of miniature 4H-SiC-based radiation detectors for harsh environment application [4], whereas Puglisi et al. reported the electrical and spectroscopic performance of an innovative position-sensitive semiconductor radiation detector in epitaxial 4H-SiC [5].

The mechanical properties of hexagonal SiC (4H- and 6H-SiC) are also discussed in this Special Issue. Ben Messaoud et al. reported the Young's modulus and the residual stress of 4H-SiC