Guest Editorial: Special Issue on Wide and Ultrawide Band Gap Semiconductor Devices for RF and Power Applications

ON BEHALF of myself and the other guest editors for the Special Issue on "Wide and Ultrawide Band Gap Semiconductor Devices for RF and Power Applications" featured in this month's IEEE Transactions on Electron Devices, we are pleased to offer readers a selection of papers that span the contemporary landscape of wide and ultrawide bandgap semiconductor devices.

The global economy is currently facing two significant challenges that demand crucial technological contributions from the RF and power electronic industries. First, there is a swift digitization of industry, jobs, and daily life, necessitating advanced and efficient RF communication systems. Second, there is a push for the decarbonization of human activities, coupled with fluctuations in energy costs, emphasizing the importance of energy efficiency in electrical power conversion.

The resolution of both challenges can be accelerated by the evolution of cutting-edge electronic devices based on wide and ultrawide bandgap semiconductor materials. Within this context, the ongoing development of high-speed RF transistors is underway, to tackle the demands of 5G and the anticipated 6G networks, requiring elevated values of f_t, $f_{\max}$, and efficiency. In addition, efforts are being directed toward the creation of fast, high-breakdown voltage transistors tailored for use in power conversion. This is particularly crucial in expanding markets such as electric/hybrid cars, data centers, renewable energy generation and conversion, and smart grids.

A variety of materials is currently under exploration, ranging from the largely studied SiC and GaN to highly innovative ultrawide bandgap semiconductors such as Ga_20_3, Al(Ga)N, BN, and diamond. Despite remarkable progress in recent years, several scientific challenges still require resolution to make these technologies readily accessible.

This Special Issue presents a selection of papers covering the current state of the art and the most recent advancements in the field of wide and ultrawide bandgap semiconductors and devices for RF applications and power conversion. The contributions include both experimental results and theoretical developments.

Several topics are covered, from advanced GaN device design to novel SiC transistor architectures, to the design and challenges of Ga_2O_3 devices, and to the properties of diamond transistors. Characterization, reliability, and modeling are also discussed in detail, and challenges related to the integration of wide bandgap devices are explored.

My fellow editors and I sincerely wish that you derive as much enjoyment from reading this collection of papers as we have.

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Dr. Ng is a member of the IEEE Electron Device Society Board of Governors, an Editor of the IEEE Journal of the Electron Devices Society (JEDS), and an Editorial Board Member of the open-access journal *Electronics*.

Farid Medjdoub received the Ph.D. degree in electrical engineering from the University of Lille, Lille, France, in 2004.

He is a CNRS Senior Scientist and leads the research group WIND focused on wide bandgap material and devices at the Institute of Electronics, Microelectronics and Nanotechnology (IEMN), Villeneuve-d'Ascq, France. Then, he moved to Ulm University, Ulm, Germany, as a Research Associate before joining IMEC, Heverlee, Belgium, as a Senior Scientist in 2008. His research interests are the design, fabrication, characterization, and simulation of innovative wide bandgap devices. Multiple state-of-the-art results have been realized in the frame of his work. Among others, world record thermal stability up to 1000 °C for a field-effect transistor, the best combination of cut-off frequency/breakdown voltage or highest lateral gallium nitride (GaN)-on-silicon breakdown voltage using a local substrate removal has been achieved. He is the author and coauthor of more than 250 articles in this field. He holds several patents deriving from his research. He has been leading the nitride power electronic activities within the French national network called GaNexT starting since 2019.

Matteo Buffolo received the Ph.D. degree from the Department of Information Engineering, University of Padova, Padua, Italy, in March 2018.

He is currently with the University of Padova as an Assistant Professor. His research interests focus on the characterization and modeling of the physical mechanisms that limit the performance and reliability of electronic and optoelectronic semiconductor devices, such as LEDs, LDs, solar cells, diodes, and high-electron-mobility transistors (HEMTs). The main families of investigated semiconductor materials include nitrides (gallium nitride (GaN) and its alloys) and arsenides (GaAs and its alloys), as well as gallium oxide, copper indium gallium selenides (CIGS), antimony selenide (ASe), and GaAsBi. Within these activities, he has published more than 150 journal articles and conference proceedings papers.

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Dr. Warnock currently serves on the Wide Bandgap subcommittee and the Management Committee for the IEEE International Reliability Physics Symposium.

Digbijoy Nath received the Ph.D. degree from Ohio State University, Columbus, OH, USA, in 2013, with a focus on molecular-beam epitaxy (MBE) growth III-nitride heterostructures, N-polar LEDs, and gallium nitride (GaN)-based tunnel-injection transistors.

Since 2014, he has been at the Indian Institute of Science (IISc), Bengaluru, India, where is currently an Associate Professor at Centre for Nano Science and Engineering (CeNSE). His group works on wide bandgap devices, especially GaN-based high-electron-mobility transistors (HEMTs) for microwave and power switching applications, Ga_2O_3-based devices, and deep-UV photodetectors.

Jun Suda received the B.E., M.E., and Ph.D. degrees from Kyoto University, Kyoto, Japan, in 1992, 1994, and 1997, respectively.

From 1992 to 1997, he worked on molecular-beam epitaxy (MBE) and structural and optical characterization of ZnMgSSe strained quantum well structures for short-wavelength optoelectronics. In 1997, he began research on group-III nitrides (III-Ns) and SiC for electron device applications as a Research Associate at Kyoto University. Since 2017, he has been a Professor at the Department of Electronics, Nagoya University, Nagoya, Japan. He is the Director of Transformative Electronics Facilities (C-TEFs) at Nagoya University. He has authored or coauthored over 300 publications in peer-reviewed journals and international conferences. His research interests include growth, characterization, process technologies, power devices and high-frequency devices of group-III nitrides, and related materials.

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Shyh-Chiang Shen (Senior Member, IEEE) received the B.S. and M.S.E.E. degrees in electrical engineering (E.E.) from the National Taiwan University, Taipei, Taiwan, in 1993 and 1995, respectively, and the Ph.D. degree in E.E. from the University of Illinois at Urbana–Champaign (UIUC), Champain, IL, USA, in 2001.

He joined the Georgia Institute of Technology (GT), Atlanta, GA, USA, in 2005, where he is currently a Full Professor with the School of Electrical and Computer Engineering (ECE). His expertise has been in the development of compound semiconductor devices and integrated circuits. He was a key contributor in the development of low-voltage RF microelectromechanical system (MEMS) switches and ion-implanted GaAs metal–semiconductor field-effect transistors (MESFETs) for millimeter-wave integrated circuits (MMICs) during his Ph.D. study at the UIUC. In 2001, he joined Xindium Technologies, Crystal Lake, IL, USA, where he developed a commercial-grade InP single-heterojunction bipolar transistor (SHBT) technology that resulted in one of the first demonstrations of monolithically integrated 40 Gb/s PIN+TIA differential-output optical receivers. At GT, he conducts focused research on wide bandgap semiconductor devices, including high-power III-nitride (III-N) transistors, III-N ultraviolet avalanche photodiodes, III-N diode lasers, and III-N vertical power switches. His research has yielded nine awarded U.S. patents, more than 220 publications in refereed journals and technical conferences, five book chapters, and many invited seminars in industries and academia to date.

Dr. Shen is a fellow of the Optical Society (OSA). He has been a member of the Technical Program Committee for the International Compound Semiconductor Manufacturing Technology (CSMANTECH) Conference since 2006. Within the IEEE, he served as a Steering Committee Member of the 2008 IEEE International Microwave Symposium, a member of the Power Devices and Compound Semiconductor subcommittee in the IEEE International Electron Device Meetings (IEDM) (2017–2018), and the Publication Chair of the IEEE Workshop on Wide Bandgap Power Devices & Applications (WiPDA) (2018, 2019). He was a member of the Optoelectronic Devices Technical Committee (2017–2020) and the Compound Semiconductor Devices & Circuit Committee (2021–2022) in the Electron Device Society (EDS). He also serves as an Officer for the Atlanta Chapter of the EDS/Photonics Society. He was a Guest Editor of *Physica Status Solidi (b)* in 2016. He has been a member of the Editorial Board for *Applied Physics A* (Springer) since 2018. He is also an Editor of a book titled *Nitride Semiconductor LEDs* (Woodridge, 2nd edition, 2018).