

Session 19 (Focus): Power Devices - Challenges for Wide Bandgap Device Adoption in Power Electronics

Tuesday, December 4, 2:15 PM

Continental Ballroom 1-3

Co- Chairs: D.S. Lee, Texas Instruments

G. Meneghesso, University of Padova

2:20 PM - 2:45 PM

19.1 SiC Devices for Mainstream Adoption (Invited), P. Friedrichs, Infineon Technologies AG

SiC power devices enter more and more applications today. This process is supported by a couple of factors. Maturity levels and cost/performance of diodes and transistors are interesting enough for many users to consider the new components. Furthermore, devices are more and more fine-tuned to target application requirements which make it easier to enter the most promising target applications. The contribution will sketch on various examples how this philosophy can be rolled out. A new generation of power diodes will be discussed as well as corresponding more powerful package technologies. Finally, a similar assessment for SiC power MOSFETs will be presented.

2:45 PM - 3:10 PM

19.2 The current status and future prospects of SiC high voltage technology (Invited), A. Mihaila, L. Knoll, E. Bianda, M. Bellini, S. Wirths, G. Alfieri, L. Kranz, F. Canales, and M. Rahimo, ABB Switzerland, Ltd.

This paper reviews the recent progress of SiC MOSFETs rated above 3.3kV. The static and dynamic performance of 3.3 and 6.5kV-rated MOSFETs will be evaluated and benchmarked against similarly rated state-of-the-art Si IGBTs. A numerical comparison between high voltage (15kV) SiC MOSFETs and IGBTs will also be provided. The paper will also attempt to comment on the future challenges facing high voltage (HV) devices in SiC technology.

3:10 PM - 3:35 PM

19.3 Progress in High and Ultrahigh Voltage Silicon Carbide Device Technology (Invited), Y. Yonezawa, K. Nakayama, R. Kosugi, S. Harada, K. Koseki, K. Sakamoto, T. Kimoto*, H. Okumura, Advanced Power Electronics Research Center, National Institute of Advanced Industrial Science and Technology (AIST), *Kyoto University

The current developments in silicon carbide (SiC) device technology in various voltage ranges are introduced. These developments correspond to, in particular, next-generation high to ultrahigh-voltage devices, SiC super-junction metal oxide semiconductor field effect transistors, SiC insulated gate bipolar transistors, and the fundamental bipolar degradation suppression technology. We expect that these next generation devices will trigger a paradigm shift in power electronics.

3:35 PM - 4:00 PM

19.4 Effects of Basal Plane Dislocations on SiC Power Device Reliability (Invited), R. E. Stahlbush, K. N. A. Mahakik, A. J. Lelis* and R. Green*, U.S. Naval Research Laboratory, *U.S. Army Research Laboratory

As silicon carbide power devices enter the commercial power electronics market there is a strong interest in all aspects of their reliability. This work discusses the degradation of MOSFETs due to basal plane dislocations (BPDs). During the forward bias of the MOSFET body diode, electron-hole recombination causes BPDs to fault and the resulting stacking faults in the drift layer degrade the MOSFET. As the stacking faults grow, the on-state conductivity of the MOSFET drift layer decreases, the off-state leakage

of the drift layer increases, and the forward voltage of the body diode increases. Commercial 1200 V MOSFETs were stressed with a body current of 5 A or 10 A. The first generation of commercial MOSFETs showed significant degradation within minutes of stress time, whereas more recent MOSFETs did not show degradation for over 5 hours of stress time.

4:00 PM *Coffee Break*

4:25 PM - 4:50 PM

19.5 GaN devices for automotive application and their challenges in adoption (Invited), *T. Kachi, Nagoya University*

Currently, electrification of automobiles is an urgent task. Electrification requires high performance power devices to achieve high efficiency. Wide bandgap semiconductors are powerful candidates for power devices used in the near future electric vehicles (EV) and fuel cell vehicles (FCV). Recent advances in GaN power devices are prominent. Lateral GaN power devices on Si substrates are beginning to be commercialized and are moving on to the system development. Research and development of vertical GaN power devices is also accelerating, and there are reports that exceed the performance of SiC-MOSFETs. Such high-performance devices are expected to greatly contribute to the electrification of automobiles, then interest in GaN power devices is increasing.

4:50 PM - 5:15 PM

19.6 Barriers to the Adoption of Wide-Bandgap Semiconductors for Power Electronics (Invited), *I.C. Kizilyalli, E.P. Carlson*, and D.W. Cunningham, U.S. Department of Energy, *Booz Allen Hamilton*

Wide-bandgap power semiconductor devices offer enormous energy efficiency gains in a wide range of potential applications. As silicon-based semiconductors are fast approaching their performance limits for high power requirements, wide-bandgap semiconductors such as gallium nitride and silicon carbide with their superior electrical properties are likely candidates to replace silicon in the near future. Along with higher blocking voltages wide-bandgap semiconductors offer break-through relative circuit performance enabling low losses, high switching frequencies, and high temperature operation. However, even with the considerable materials advantages, a number of challenges are preventing widespread adoption of power electronics using WBG semiconductors.

5:15 PM - 5:40 PM

19.7 GaN Power Commercialization with Highest Quality-Highest Reliability 650V HEMTs-Requirements, Successes and Challenges (Invited), *P. Parikha, Y. Wua, L. Shena, R. Barra, S. Chowdhury, J. Grittersa, S. Yea a, P. Smitha, L. McCarthy, R. Birkhahna, M. Moorea, J. McKaya, H. Clementa, U. Mishra, R. Lala, P. Zuka, T. Hosodab, K. Shonob, K. Imanishib, Y. Asaib. Transphorm Inc.*

Gallium Nitride (GaN) is now a popular choice for power conversion. High voltage (HV) GaN HEMTs (GaN FETs) in the range of 650-900 volts are emerging as the next standard for power conversion. This paper highlights key successes in efficient and compact converters/inverters ranging from high performance gaming/crypto-mining power supplies, titanium class server power, servo drives, PV inverters, and automotive OBCs, dc-dc converters, pole charges. The reasons for market success including unmatched quality & reliability, high volume GaN on Si manufacturing, robust performance in applications as well as challenges to achieve the full potential of GaN FETs are presented.