Enabling Next-Generation Power Electronics With Wide Band-Gap Semiconductors

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Tuesday, November 1, 2022, 11:00am
WANG 1004

Abstract

During the last ten years, the maturity of wide band-gap (WBG) semiconductor technology has advanced rapidly. The most mature WBG semiconductor available today is the Silicon Carbide (SiC) MOSFET, which is now being deployed in commercial applications on a broad scale. SiC devices offer substantial performance advantages over traditional Silicon devices in terms of reduced losses, increased switching speed, and increased thermal capability. When this technology is properly implemented, these device-level performance advantages translate into converter-level and system-level benefits, such as increased efficiency and power density. For example, WBG converters have been demonstrated at ten times higher power density than legacy Silicon converters, without sacrificing conversion efficiency.

In order to achieve such performance gains, SiC-based converters must be carefully optimized to take full advantage of the underlying semiconductor capabilities. Implementation of SiC-based converters using design principles developed for Silicon devices will yield sub-optimal performance. In some cases, this may produce converters that perform worse than legacy Silicon systems. Understanding the key design principles used to optimize converters for SiC devices is critical to attaining the performance entitlement of such systems.

This talk will provide an overview of the concepts that must be understood to unlock the performance advantages of SiC semiconductors at the converter level. First, the characteristics of SiC devices will be explained, along with the procedures used to evaluate and quantify device-level performance. Second, guidance for implementing these devices in practical application circuits will be presented. Third, the metrology and instrumentation requirements for properly evaluating WBG converter implementations will be discussed. Fourth, future trends will be analyzed, including the challenges and opportunities associated with the implementation of medium-voltage (MV) SiC semiconductors. Case studies will be presented throughout this talk to demonstrate the concepts discussed, and to illustrate the presence of knowledge gaps that call for further investigation.

Biography

Andrew N. Lemmon received the B.S. degree in electrical engineering from Christian Brothers University, Memphis, TN, USA, in 2000; the M.S. degree in electrical and computer engineering from The University of Memphis, Memphis, TN, USA, in 2009; and the Ph.D. degree in electrical engineering from Mississippi State University, Starkville, MS, USA, in 2013. From 2000 to 2010, he was an Embedded Systems Design Engineer at FedEx Corporation in Memphis, TN, USA. From 2010 to 2013, he was a graduate research assistant in the Center for Advanced Vehicular Systems (CAVS) at Mississippi State University. He is currently an Associate Professor with the department of electrical and computer engineering at the University of Alabama, Tuscaloosa, AL, USA. His research interests include design and optimization of Silicon Carbide applications; development of compact behavioral models for power semiconductor devices; analysis, modeling, and design of power semiconductor packaging; and analysis, modeling, and mitigation of electromagnetic interference in power electronic systems. Dr. Lemmon is a Registered Professional Engineer and has been awarded four patents.

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