

Tutorial Title

Reliability and Qualification of Wide Bandgap Automotive Power Semiconductors

Instructor Team

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Abstract

Wide bandgap devices are increasingly penetrating the automotive market and are becoming prime candidates for implementation in applications like traction inverters and battery chargers. The mission profile of the traction inverter is aggressive since the electrothermal and thermo-mechanical stresses on the power devices vary significantly in amplitude and frequency as the motor drive goes through various stages of the drive cycle including acceleration, deceleration, stalling etc. Historically, the traction converter has been implemented using silicon devices where the performance and reliability is well known and understood. Application of WBG devices like SiC MOSFETs and GaN power devices in automotive applications requires understanding of the reliability and qualification procedures especially according to the automotive standard. SiC and GaN power devices have varying internal physics and modes of operation with vastly varying robustness and reliability performance compared to silicon devices. Given the sensitive nature of the application, these devices must pass stringent automotive reliability tests and guidelines defined by the Automotive Electronics Council (AEC), the Joint Electron Device Engineering Council (JEDEC-JC70) and the European Centre of power electronics (AQG). This tutorial is designed to cover the following topics.

- i Introduce the reliability and robustness requirements of automotive power devices.
- ii Understand the role of packaging and how it affects electrothermal and thermo-mechanical performance.
- iii Understand the physics of degradation and failure of power devices.
- iv Understand the peculiarities of robustness and reliability in WBG devices (SiC and GaN).
- v Understand test methods and circuits used in assessing the reliability and robustness of power devices.

Instructor Team Biographies



Layi ALATISE PhD, CEng, FIET, SMIEEE is currently a Professor and Royal Society Industry Fellow in Power Electronics at the University of Warwick. He received the B.Eng. (first class Hons.) degree in Electrical/Electronic Engineering and the Ph.D. degree in Microelectronics and Semiconductor Device Physics from Newcastle University, Newcastle upon Tyne, U.K., in 2005 and 2008, respectively. He has worked at ATMEL North Tyneside as a CMOS Process Integration Engineer (2004 to 2006) and NXP Semiconductors as a Power MOSFET Development Engineer (2008 to 2011). In 2011, he joined the University of Warwick as Research Fellow in advanced power semiconductor materials and devices. Since February 2019, he has been a Professor in Electrical Engineering with the University of Warwick, Coventry, U.K. He has led several research projects in power electronics including EPSRC funded, Innovate UK funded and industry funded projects. He was a recipient of the 2021 best paper award in the IEEE Transactions in Industrial Electronics. He has authored or co-authored more than 150 publications in journals and international conferences as well as supervised 11 PhDs in power electronics. Prof. Alatise has previously delivered tutorials at ECCE 2023.



Jose ORTIZ GONZALEZ is currently an Associate Professor at the University of Warwick (UK). He has worked Research Fellow in several EPSRC and Innovate UK projects at Warwick (UK) and the University of Vigo (Spain). His expertise is in power semiconductor device characterization, reliability and condition monitoring in Power Electronics. He received his PhD from the University of Warwick in December 2017 and is the author of more than 120 journal and conference papers. Jose has developed novel methodologies for assessing the threshold voltage instability of Silicon Carbide and Gallium Nitride power devices and together with professor Alatisé, they were awarded the 2021 IEEE Transactions on Industrial Electronics Outstanding Paper Award for the journal article “Performance and Reliability Review of 650 V and 900 V Silicon and SiC Devices: MOSFETs, Cascade JFETs and IGBTs”. Jose was a Researcher Co-Investigator on a major £1.2M EPSRC project and has worked in several collaborative research projects. He is an associate editor of Elsevier Microelectronics Reliability. Dr Ortiz Gonzalez a member of the Education Committee of the IEEE Transportation Electrification Community, the secretary of IEEE PELS – TC-6: Emerging Power Electronic Technologies and the secretary of the IEEE IAS Power Electronics Devices and Components Committee.

