ELECTRICAL, ELECTRONICS AND COMMUNICATIONS ENGINEERING

DENERG - Characterization of Automotive-class Wide-Bandgap Semiconductors and Modular Packaging Design

Funded By	Dipartimento DENERG
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Context of the research activity	This Ph.D. will focus on the characterization of Wide-bandgap semiconductors for automotive applications, including reliability under abnormal conditions, with the aim of proposing innovative module concepts for high-efficiency power electronics.
	Ph.D. Project Description Characterization of Automotive-class Wide-Bandgap Semiconductors and Modular Packaging Design 1. Overview Wide bandgap (WBG) semiconductors—such as SiC MOSFETs and GaN HEMTs—are transforming automotive power electronics thanks to their high efficiency, fast switching capability, and ability to operate at elevated temperatures. Their integration into safety-critical automotive systems, however, requires a deep understanding of device behavior under abnormal and fault conditions, as well as the development of advanced packaging solutions capable of withstanding extreme electrical, thermal, and mechanical stresses. This Ph.D. project addresses these challenges by combining reliability testing, failure analysis, and packaging innovation to enable robust, high-performance WBG power modules for next-generation electric and hybrid vehicles. 2. Research Objectives 2.1 Characterization Under Abnormal and Fault Conditions • Develop experimental setups to evaluate SiC and GaN devices under: o Overvoltage and surge events o Short circuit and avalanche stress o High dV/dt and dI/dt switching transients o Thermal runaway and high temperature operation • Identify degradation signatures, precursors to failure, and catastrophic failure modes. • Create physics-based models linking stress conditions to long-term

Objectives	reliability. 2.2 Reliability-Oriented Packaging Innovation • Investigate advanced packaging materials and architectures, including: o Advanced additive manufacturing, including mixed metal/insulator 3D-printing o Low inductance module layouts o Double-sided cooling structures o High frequency optimized interconnects • Assess thermo-mechanical robustness under automotive mission profiles (thermal cycling, vibration, humidity, power cycling). • Explore embedded sensing or monitoring features for predictive maintenance. 2.3 Co-Design of Device, Package, and System • Develop multi-physics simulation frameworks combining electrical, thermal, and mechanical domains. • Optimize module design for: o Fast switching o EMI mitigation o Thermal spreading o Fault tolerance • Validate optimized designs through prototype fabrication and accelerated stress testing. 3. Expected Contributions The Ph.D. candidate will deliver: • A comprehensive reliability map of WBG devices under abnormal conditions. • Novel packaging concepts tailored for harsh automotive environments. • Experimentally validated models and prototype modules. • Publications in leading journals and conferences in power electronics and reliability engineering. 4. Candidate Profile The ideal candidate has a background in electrical engineering, materials science, or applied physics, with a strong interest in power electronics, semiconductor devices, reliability testing, and multi-physics simulation. Hands-on laboratory experience is highly desirable. English proficiency is mandatory.

Skills and competencies for the development of the activity	The ideal candidate has a background in electrical engineering, materials science, or applied physics, with a strong interest in power electronics, semiconductor devices, reliability testing, and multi-physics simulation. Hands-on laboratory experience is highly desirable. English proficiency is mandatory.