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RELIABILITY ASSESSMENT OF SIC AND GAN POWER DEVICES: CHALLENGES, DEGRADATION MECHANISMS, AND MITIGATION STRATEGIES

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Summary: Reliability has become a crucial concern in the adoption of Wide Bandgap (WBG) power electronic devices, particularly in demanding applications such as industrial systems, automotive powertrains, aerospace, and railway electrification. Silicon Carbide (SiC) MOSFETs and Gallium Nitride (GaN) High Electron Mobility Transistors (HEMTs) offer significant advantages over conventional silicon devices, including higher efficiency, increased power density, and improved thermal performance. However, their long-term reliability remains a key challenge due to unique failure mechanisms and degradation phenomena. This paper presents a state-of-the-art review on the reliability of WBG power devices, examining critical failure modes such as gate oxide degradation, bond wire fatigue, and defect-induced breakdown under electrical, thermal, and environmental stress conditions. Advances in packaging technologies, reliability modeling, and accelerated lifetime testing methodologies are also discussed. A comparative analysis between SiC and GaN devices is provided, highlighting their respective reliability challenges and potential mitigation strategies. The paper concludes by identifying emerging trends and future research directions aimed at enhancing the robustness and operational lifespan of WBG power devices in high-performance applications.

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