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Application Engineering of Wide Bandgap Semiconductors

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1. ABSTRACT

This paper will address the importance and benefits of WBG semiconductors and provide examples of utilization of these new devices in power electronic circuits. Paper will elaborate the challenges and potential solutions of application of WBG for various power electronic applications. Paper will also present the current power electronic curriculum and education and suggest the changes that can be made to include and promote WBG devices in power engineering education to develop new workforce.

2. APPLICATION ENGINEERING OF WIDEBANDGAP SEMICONDUCTORS

Si-based power devices (e.g. MOSFETs, IGBTs) have dominated power electronic applications for so long that their performance is nearly at theoretical limits [1]. However, there is an increasing need for devices that are capable of faster switching with a higher power rating, lower switching losses, and better high temperature capability due to widespread use of power electronic converters in many applications. There has been attention on WBG semiconductors among which SiC devices have gained the greatest attention in recent years. GaN devices are also being developed. These devices will offer significant advantages in efficiency improvements for power electronic converters.

WBG semiconductors such as silicon carbide and gallium nitride devices are becoming a game changing technology for power electronic converters, but there has been relatively sporadic in-depth study in the context of low to medium power applications to date. This paper will present a systematic approach to explore the full benefits of WBG semiconductor technology and further the research in DC-AC power electronic converters. Specifically, the proposed research will aim to contribute to the efficiency, weight, volume, thermal management, mechanical packaging, and power density of DC-AC converters. For example, efficiency gains that will be attained due to WBG semiconductors will enable power converters to use less electrical energy and increase reliability due to the high temperature capability of the new devices. Any weight and volume reduction, both in DC-AC converters and other cooling systems, will benefit the competitiveness of a product. Certainly, the cost of these new devices is a factor for commercialization. It is expected that WBG semiconductor prices will decrease in the future as advancements are made in manufacturing.

The application of WBG devices will directly benefit to all kinds of power converters used in many applications such as industrial drives, solar and wind energy systems, home appliances, automotive, and marine and aerospace applications. Hence, the scale of economics for the WBG devices for power electronic is significant with potential impact to many important sectors and will achieve large energy savings globally .

Our paper will address the benefits, challenges, and opportunities for the WBG devices and suggest valuable changes in the curriculum to promote and educate the next generation of students and engineers to assimilate this technology in an efficient way.