COMMERCIALIZATION OF SILICON CARBIDE POWER MODULES FOR HIGH-PERFORMANCE ENERGY APPLICATIONS

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ABSTRACT

Over the past ten years, Arkansas Power Electronics International (APEI), Inc., has been developing advanced next-generation power electronics capabilities through the design and implementation of silicon carbide (SiC)-based systems and platforms. SIC has the capability to reduce electrical energy waste by more than 90% and simultaneously reduce power electronics system size and weights by up to an order of magnitude, and it is poised to completely revolutionize the power electronics industry and reduce our dependence on foreign energy. The demands of modern high-performance power electronics systems are rapidly surpassing the power density, efficiency, and reliability limitations defined by the intrinsic properties of silicon-based semiconductors. The advantages of SiC are well known, including high temperature operation, high-voltage blocking capability, high-speed switching, and high-energy efficiency.

The high-performance power modules presented within this discussion are new commercial products, employing the design techniques, advanced materials, and manufacturing processes developed by Arkansas Power Electronics International (APEI), Inc., to meet the demands of current and upcoming power electronic systems. This power module is rated to 1200 volts, is operational at currents greater than 150 amperes, can perform at temperatures in excess of 225 °C, and is designed to house various silicon carbide (SiC) devices, including metal-oxide-semiconductor field-effect transistors (MOSFETs), junction field-effect transistors (JFETs), or bipolar junction transistors (BJTs). The module is designed for high-performance commercial and industrial systems such as hybrid electric vehicles or renewable energy applications, implements a novel ultra-low parasitic packaging approach that enables high switching frequencies in excess of 100 kilohertz, and weighs in at just over 130 grams (offering ~5× mass reduction and ~3× size reduction in comparison with industry standard power brick packaging technology). It is configurable as either a half- or full-bridge converter.

The main goal for this module is to introduce to the market a commercial SiC module product (HT-2000 series) that can be used in the mentioned applications. A big credit to the success of this commercialization activity is the funding provided by the U.S. Department of Energy Energy Storage Program through the Small Business of Innovative Research Phase I, II, and III programs. An image of the newly developed HT-2000 module is shown in Figure 1.

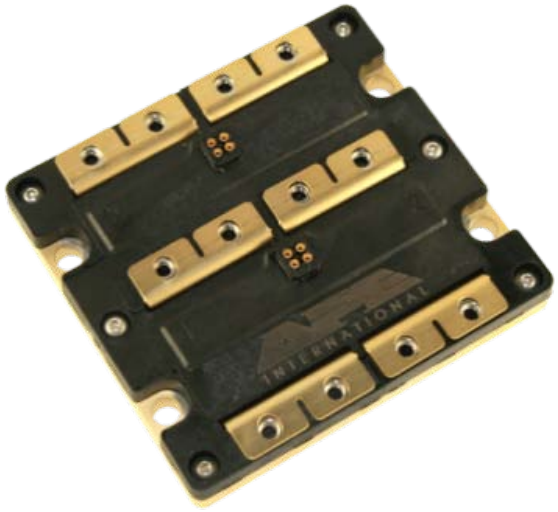

Fig. 1. HT-2000 series SiC power module with operating conditions of 1200 volts, >150 amperes, and 225 °C operations temperature.