Ultra-high-voltage Silicon Carbide (SiC) Thyristors

Sandia National Laboratories, DOE Energy Storage Program, GeneSiC Semiconductor, Inc., and U.S. Army Armament Research, Development, and Engineering Center (ARDEC)

Problem

Increasing demand for power creates numerous challenges for ensuring reliable power for consumers. Because the current electricity grid is aging, updating it is essential to improving the nation's energy security. Greater use of renewable energies, such as wind or solar, will help to provide safer, more secure electricity for customers and will reduce our nation's dependence on fossil fuels. Many energy technologies, particularly renewables, generate direct current (DC) power which must be converted to alternating current (AC) before use. Power switches, known as thyristors, perform this conversion and are crucial to a reliable electrical grid. Current switches have been inefficient and require cooling efforts to ensure proper function. New silicon carbide (SiC) thyristors developed by Sandia and GeneSiC improve performance over traditional silicon-based units by offering high temperature, high frequency operation that increases power system efficiency and reliability.

Innovative Edge

These packaged power devices are the world's first commercially available high voltage, high frequency, high current, high temperature, single-chip SiC-based thyristors. They can reduce the size and weight of existing next-generation smart grid power electronics systems, allowing greater application in such areas as weapons systems and pulsed power. SiC-based thyristors offer 10x higher voltage, 100x faster switching frequencies, and higher temperature operation when compared to conventional silicon-based thyristors, leading to improved system efficiency for both economic and environmental benefits.

Creation of the SiC-based thyristors led the Sandia team to develop, implement, and integrate a number of new technologies. Developers implemented new design and fabrication techniques to support increased voltage ratings. They developed novel gate-anode designs for high current devices and improved the SiC fabrication processes. In order to accurately characterize devices with ultra-high operating ratings, researchers established advanced measurement techniques, circuits, and components and created a new soldering technology to allow wire-bondless packaging.

Commercialization & Industry Impact

This leading-edge device is the world's first commercially available high voltage SiC-based power device. Targeted research applications include grid-tied solar inverters, wind-power inverters, and trigger control for pulsed power weapon systems. In a 2010 press release, Dr. Ranbir Singh, President of GeneSiC stated, "GeneSiC has recently completed delivery of [a family of] thyristors to multiple customers conducting research in renewable energy, Army and Naval power system applications."

High frequency, silicon carbide thyristors are expected to revolutionize grid infrastructure.