

Enabling the Development of Power Electronics Applications through Advancements in SiC Power Devices

The U.S. Army Research Laboratory (ARL) has had an active interest in the development of silicon carbide (SiC) power devices since its inception in 1992, and has been at the forefront in the development of this wide bandgap technology since the early 2000s. Led by Mr. Skip Scozzie, ARL became a key supporter in the successful development of SiC power MOSFETs, which were first commercialized in 2011. ARL has also supported the successful development of high-voltage SGTOs and PiN diodes for pulse power applications. This support has included a joint ManTech with the Navy and OSD, which led to the successful development of low-defect, high-quality six-inch SiC wafers, along with significant improvements in SiC power device performance and reliability at both the 650-V to 1,200-V range, as well as at high voltages above 10 kV—for both continuous and pulse-power applications. Although ARL's support initially was focused on Cree as the low-risk path to prove out SiC power device technology, in more recent years ARL's support has broadened to include other, smaller device companies as well in an attempt to widen the U.S. SiC industrial technology base. Most of these smaller companies employ a fabless model, wherein the actual device manufacturing is done at automotive-quality silicon (Si) fabs with excess capacity, such as X-Fab in Lubbock, TX, giving the hope of dramatically reducing manufacturing costs, thereby leading to dramatic decreases in the average cost per ampere of these power devices. These device developmental programs with ARL's key industrial partners have resulted not only in widening the SiC technology base, but also in significantly improved performance, along with the successful scaling of devices to higher voltages and currents to meet the power-density requirements for existing and future Army power systems. This paper will provide an update of advances in the development of various SiC power devices, such as MOSFETs, diodes, IGBTs, and SGTOs, with blocking voltage ratings from 650 V to over 20 kV, and discuss their utility for relevant Army applications.