Silicon Carbide, SiC

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Silicon carbide, SiC, is a wide-bandgap semiconductor material which is steadily growing into position of a key player on the semiconductor arena. As seen in the table below SiC displays characteristics which are overall superior to both Si and GaAs. Specifically, wider bandgap and higher thermal conductivity on one hand, and higher saturated electron drift velocity and higher breakdown field on the other make this material particularly suitable for high temperature-high power device applications. They also assure superior frequency characteristics of SiC devices under high electric field stress. Furthermore, SiC is less than Si sensitive to high energy radiation. At the same time, combination of factors makes SiC an important materials in photonic device manufacturing as well. With SiC wafers 75 mm in diameter available commercially, and larger wafers likely to be available in the future, SiC device technology has become a viable contender in the variety of electronic and photonic applications.

Key parameters for Si, GaAs, and SiC*

	Si	**GaAs**	**6H-SiC**
Bandgap (eV)	1.12	1.43	3.03
Bandgap type	indirect	direct	indirect
Electron mobility (cm^2/V sec)	1500	8500	500
Breakdown field ($x10^5$ V/cm)	2.5	3	24
Thermal conductivity (W/cm K)	1.5	0.5	3
Saturated electron drift velocity ($x10^7$ cm/sec)	1	1	2

** Based partially on www.cree.com*

Silicon carbide exists in well over 100 different polytypes which vary in the details of long-range stacking order within the crystal, and which feature somewhat different properties. In terms of device performance, overall superior results are obtained with hexagonal SiC films in the form of either 4H or 6H polytypes. Both 4H-SiC and 6H-SiC substrates are commercially available.

Significant advances have been made in both crystal growth and epitaxial growth of H-SiC. Undoped SiC wafers have n-type background doping. P-type doping and n-type conductivity control can be obtained by doping with aluminum and nitrogen respectively. Contact properties of H-SiC with various metals are sufficiently well understood to make Schottky diode a common SiC commercial electronic device. Successful attempts to build high-power, high-frequency MESFETs and HBTs on SiC substrates were made. Moreover, silicon carbide MOSFETs operable at temperatures even above 500 ^oC and featuring very high saturation drain current may become commercially available after some problems with a formation of high quality gate oxide on SiC substrates will be resolved. Finally, due to its high thermal conductivity SiC is a n attractive substrate in the wide range of heterostructure electronic devices.

Besides an impact on electronic device technology, SiC also plays significant role in the engineering of photonic devices. A bandgap of 3 eV allows SiC device to generate blue radiation but because of indirect bandgap efficiency of the process, and hence, intensity of emitted light is in this case very low. However, SiC is closely lattice matched to GaN, features thermal expansion coefficient close to GaN, and is available in both conductive and semi-insulating substrates. With all this characteristic SiC is commonly used as a substrate in the manufacture of the variety of GaN based LEDs and lasers.