The Commercialization of the SiC Flame Sensor

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The technical and scientific steps required to produce large quantities of SiC flame sensors is described.

The technical challenges required to understand, fabricate, test and package SiC photodiodes in 1990 were numerous since SiC device know how was embryonic. A sense of urgency for a timely replacement of the Geiger Muller gas discharge tube soon entered the scene. New dual fuel GE Power Systems gas turbines, which were designed to lean burn either natural gas or oil for low NOx emissions required a much higher sensitivity sensor.

Joint work between GE CRD and Cree Research sponsored by the GE Aircraft Engine Division developed the know how for the fabrication of high sensitivity, high yield, reliable SiC photodiodes. Yield issues were uncovered and overcome.

The urgency for system insertion required that SiC diode and sensor circuitry development needed to be carried out simultaneously with power plant field tests of laboratory or prototype sensor assemblies.

The sensor and reliability specifications were stringent since the sensors installed on power plant turbine combustor walls are subjected to high levels of vibration, elevated temperatures, and high pressures. Furthermore a fast recovery time was required to sense flame out in spite of the fact that the amplifier circuit needed have high gain and high dynamic range. SiC diode technical difficulties were encountered and overcome.

The science of hydrocarbon flames will also be described together with the fortunate overlap of the strong OH emission band with the SiC photodiode sensitivity versus wavelength characteristic. The extremely low dark current ($\leq 1 pA/cm^2$) afforded by the wide band gap and the 3eV sensitivity cutoff at 400nm made if possible to produce low amplifier offsets, high sensitivity and high dynamic range along with immunity to black body radiation from combustor walls.

Field tests at power plants that had experienced turbine tripping, whenever oil fuel and/or oil with steam injection for power augmentation, were extremely encouraging. This warrantee problem previously due to the low sensitivity of the Geiger Muller tube was solved using the much higher sensitivity SiC detector. This sensitivity increase is partially due to the fact that the SiC photodiode “sees” the strong OH emission band whereas the Geiger Muller tube can only respond to the shorter wavelength CO emission band. Other successful field tests were observed and acclaimed by power plant operators, which for the first time could track mode switching and power level (flame intensity) because of the high dynamic range (≥5000:1). The demand for this product thereupon rose dramatically.

This success, the first for SiC devices other than that of SiC blue LEDs, is leading GE to implement this technology in other application fields.

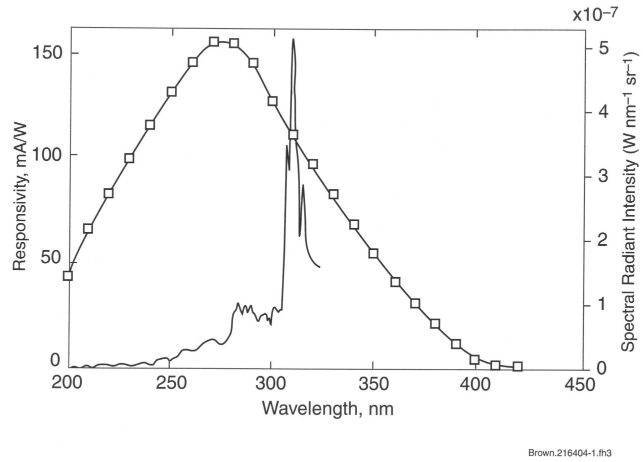

Figure 1: SiC Photodiode UV responsivity and UV flame emission specrum

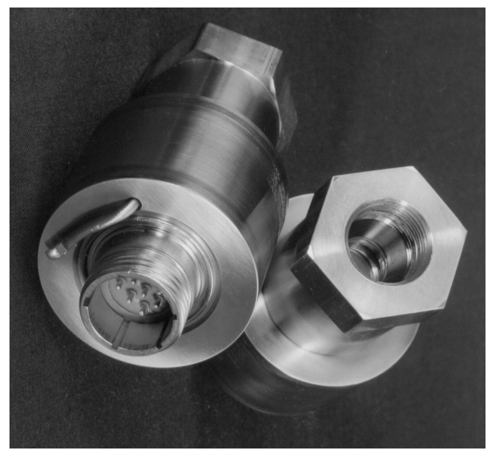

Figure 2: GE SiC Flame Sensor

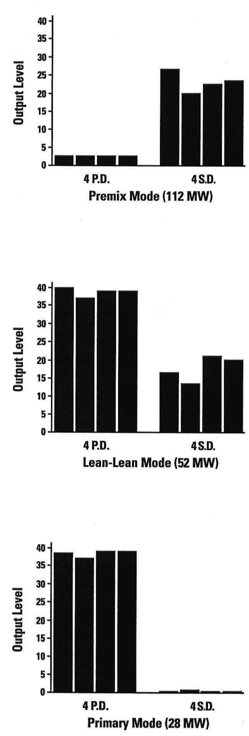

Figure 3: Primary and Secondary Zone Flame Sensor Output Signal Levels for Dry Low NOx Oil Burning Gas Turbine During Power Plant Operation