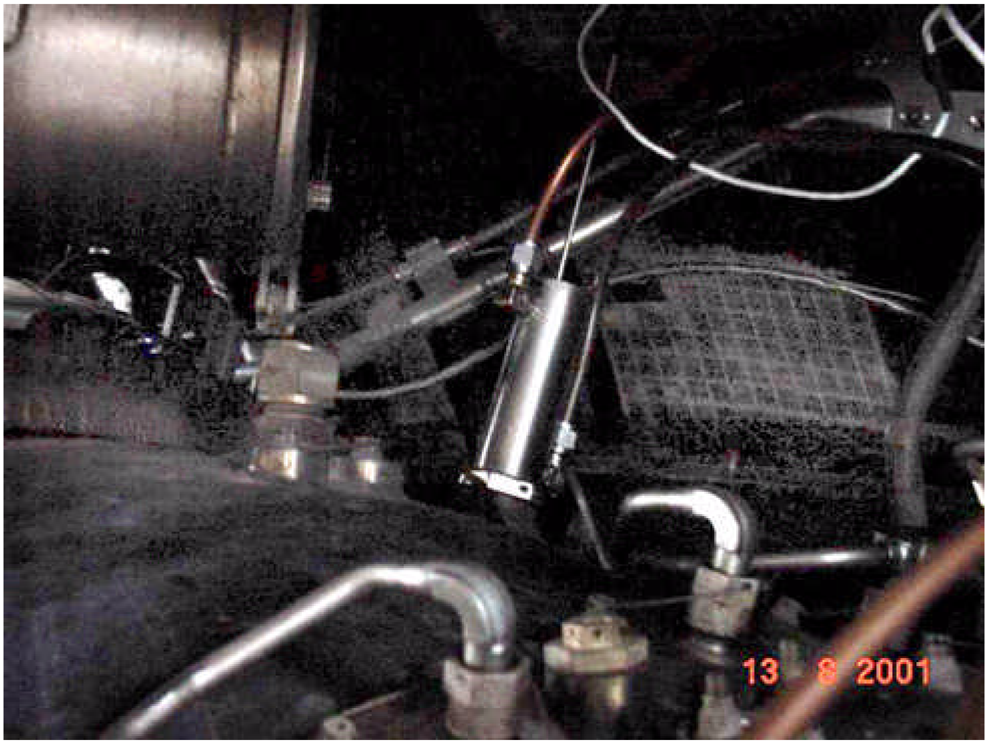
Advanced Packaging Technology Used in Fabricating a High-Temperature Silicon Carbide Pressure Sensor

The development of new aircraft engines requires the measurement of pressures in hot areas such as the combustor and the final stages of the compressor. The needs of the aircraft engine industry are not fully met by commercially available high-temperature pressure sensors, which are fabricated using silicon. Kulite Semiconductor Products and the NASA Glenn Research Center have been working together to develop silicon carbide (SiC) pressure sensors for use at high temperatures. At temperatures above 850 °F, silicon begins to lose its nearly ideal elastic properties, so the output of a silicon pressure sensor will drift. SiC, however, maintains its nearly ideal mechanical properties to extremely high temperatures. Given a suitable sensor material, a key to the development of a practical high-temperature pressure sensor is the package. A SiC pressure sensor capable of operating at 930 °F was fabricated using a newly developed package. The durability of this sensor was demonstrated in an on-engine test.

The SiC pressure sensor uses a SiC diaphragm, which is fabricated using deep reactive ion etching. SiC strain gauges on the surface of the diaphragm sense the pressure difference across the diaphragm. Conventionally, the SiC chip is mounted to the package with the strain gauges outward, which exposes the sensitive metal contacts on the chip to the hostile measurement environment. In the new Kulite leadless package, the SiC chip is flipped over so that the metal contacts are protected from oxidation by a hermetic seal around the perimeter of the chip. In the leadless package, a conductive glass provides the electrical connection between the pins of the package and the chip, which eliminates the fragile gold wires used previously.



SiC pressure sensor installed in the combustor of an aircraft engine. The sensor is mounted in a water-cooled jacket.

The durability of the leadless SiC pressure sensor was demonstrated when two 930 °F sensors were tested in the combustor of a Pratt & Whitney PW4000 series engine. Since the gas temperatures in these locations reach 1200 to 1300 °F, the sensors were installed in water-cooled jackets, as shown in the photograph. This was a severe test because the pressure-sensing chips were exposed to the hot combustion gases. Prior to the installation of the SiC pressure sensors, two high-temperature silicon sensors, installed in the same locations, did not survive a single engine run. The durability of the leadless SiC pressure sensor was demonstrated when both SiC sensors operated properly throughout the two runs that were conducted.

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