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Technology Opportunity

Technology Transfer & Partnership Office

TOP3-00206

Thin-Film Heat Flux Sensor (Improved Design)

Technology

A new design for a thin film heat flux sensor utilizing a Wheatstone bridge is easier to fabricate, has a larger signal, and is more easily scalable than previous designs.

Benefits

- Can measure that heat flux at high temperatures—up to 1000 °C
- Can be fabricated directly on parts without cutting into the part
- Are minimally intrusive in engines (sensor thickness is approximately 0.01 mm) for more accurate knowledge of heat loading
- Are of small mass, therefore high-frequency measurements

Commercial Applications

Ideal in engine and furnace components for

- Process control
- Modeling validation
- Determination of cooling requirements
- General calorimetry

in rocketry, aerospace, and automotive environments

Technology Description

Heat flux is one of a number of parameters, together with pressure, temperature, flow, etc., of interest to engine designers and fluid dynamicists. There are various designs of heat flux sensors, such as Gardon gauges, plug gauges, and thin-film thermocouple arrays. All heat flux sensors operate by measuring the temperature difference across a thermal resistance. Existing designs use thermocouples to

measure this temperature difference. The signal level of these designs are low, typically a few mV/(Watt/cm²). In addition, the precise alignment required to place each thermocouple element correctly makes fabrication difficult for small gauges, and restricts the minimum size to about 6 mm in diameter.

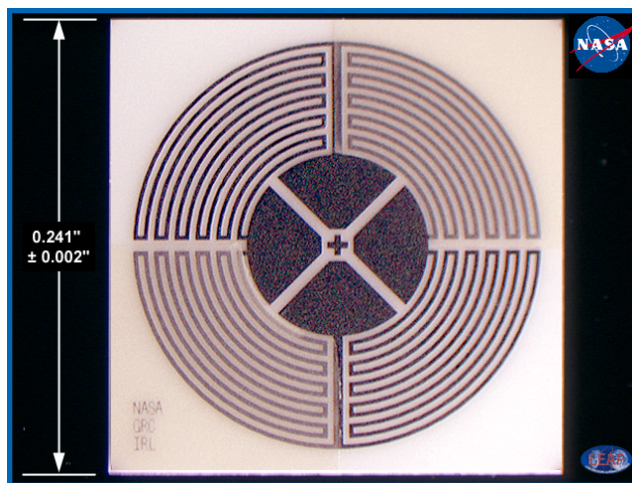


Figure 1.—The single-sided Wheatstone bridge heat flux sensor.



Figure 2.—The single-sided Wheatstone bridge heat flux sensor in a mounting bolt.

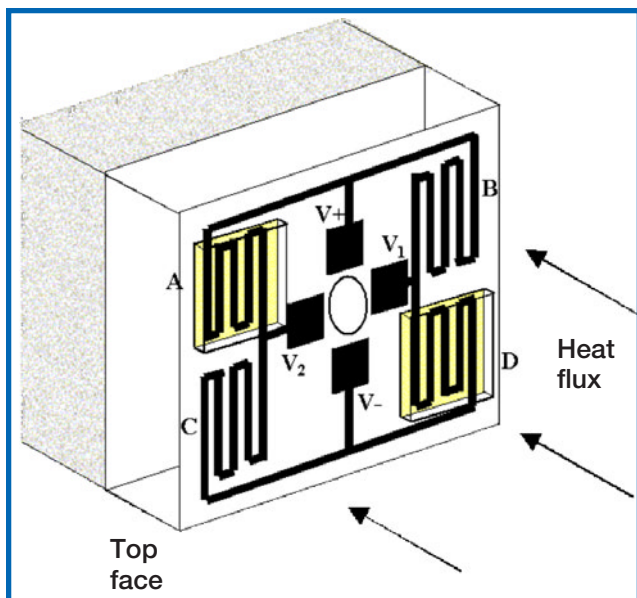


Figure 3.—Schematic of the heat flux sensor.

The response of the single-sided gauge can be calculated using a numerical one-dimensional finite volume technique, and the transient response is shown in figure 4. The resulting signal is approximately eight times that of commercial gauges. The temporal response is comparable to that of the fastest commercial gauges, with a time constant of roughly 7 μsec , corresponding to a frequency response of 23 kHz.

All the components are made as thin films, so the total sensor thickness is in the 0.001 to 0.01 mm range. A two-sided design was also developed, where the substrate upon which the sensor is mounted acts as the extra thermal resistance, shown in figure 5.

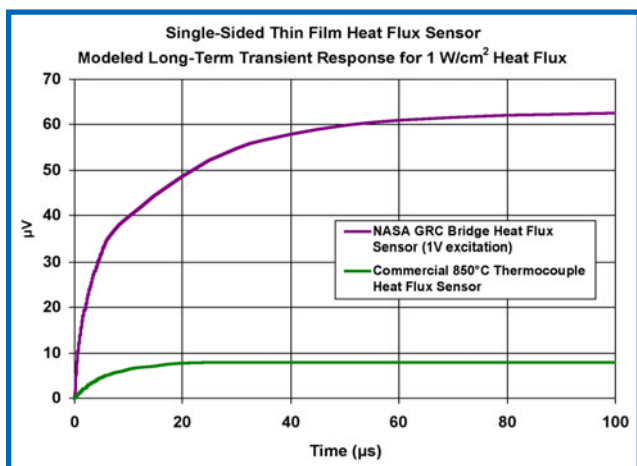


Figure 4.—Calculated response for a single-sided Wheatstone bridge heat flux sensor.



Figure 5.—Double-sided Wheatstone bridge heat flux sensor elements.

Options for Commercialization

The NASA Glenn Research Center is interested in partnering with industry for aerospace and non-aerospace applications. Patent is applied for.

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References

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Key Words

Heat flux
Thin films
Ceramic
High temperature
Vacuum sputtering
Photolithography