TOP3–00207

High-Temperature Thin Film Multifunctional Sensor

Technology

A microfabricated thin-film sensor to measure multiple parameters in high-temperature aerospace environments that is minimally intrusive to the system.

Benefits

Provides a more accurate knowledge of the thermal and aerodynamic loads on critical propulsion system components

- Measure multiple physical parameters at high temperatures—up to 1100 °C
- Minimally intrusive in engines: sensor thickness is approximately 0.01 mm and can be fabricated directly on parts
- Of negligible mass so high-frequency measurements can be made

Commercial Applications

- Verification of cooling system integrity including surface temperature, heat flux, and deformation
- An increased understanding of operating conditions and capabilities, leading to improved system safety and reduced development costs
- Validation of design codes through simultaneous measurement of temperature, strain, heat flux, and vibration

Technology Description

Sensors developed for aeronautic and aerospace research applications must be able to operate in environments where stress and temperature gradients are high and the aerodynamic effects or the sensors need to be minimized. The thin film multifunctional sensor developed at NASA Glenn Research Center integrates into one "smart" sensor the designs of individual gauges that measure

- Strain magnitudes and direction
- Heat flux
- Surface temperature
- Flow speed and direction

The entire gauge is microfabricated, enclosing a triangular area approximately 1.5 cm on a side with 50-µm-wide features. Designed for applications in material systems and engine components testing, the sensor can provide minimally intrusive characterization of advanced propulsion materials and components in hostile, high-temperature environments, validation of propulsion system design codes, and experimental verification of computational models.

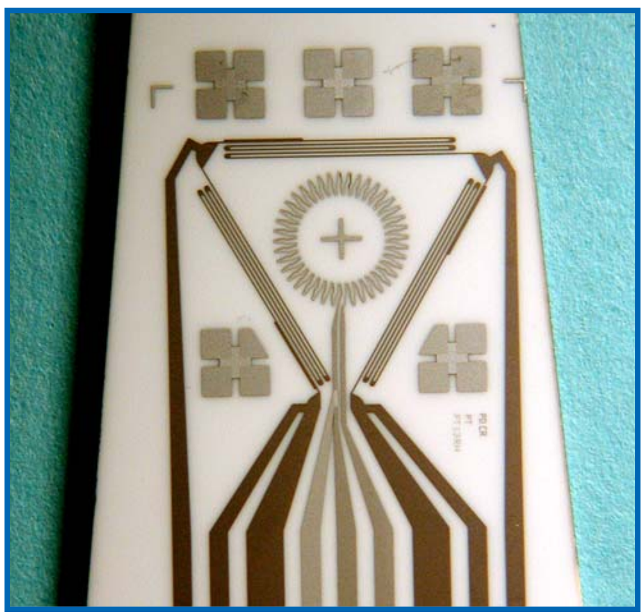

Figure 1.—A thin film multifunctional sensor in the geometry of an off-axis platinum rosette with a type R thermopile heat flux sensor and thermocouple in the center.

Figure 2.—A thin-film multifunctional sensor in the geometry of an on-axis palladium-chromium alloy rosette with type R thermocouple in the shape of a NASA logo.

Unlike conventional wire sensors, thin films do not require machining the surface and therefore leave intact the structural integrity of the engine component being measured. The thin films are vacuum deposited directly onto the surface and have thicknesses on the order of a few micrometers, which are orders of magnitude less than wire sensors. As a result, thin-film sensors add negligible mass to the surface and cause minimal disturbance to the gas flow over the surface. Thin-film sensors, therefore, have minimal impact on the thermal, strain, and vibration patterns that exist in the operating environment.

Integrating NASA GRC thin-film sensor technology into a single gauge for simultaneous measurement of surface temperature, strain, and heat flux is the first step toward smart sensors with integrated signal conditioning and the capability to provide feed back to an operating system in real time. Various prototypes of the gauge have been bench tested on alumina substrates (see figs. 1 and 2). Future testing will include measuring all of the parameters simultaneously on an engine component to be tested in the lab as well as in harsh environments.

Alternate materials for the sensor elements will be explored for ruse in higher temperature applications. Ceramic thermocouple and strain gauge materials are being investigated to replace the metals currently being used. An electronics package will be developed to allow the sensor to become "smart". Additionally, the sensor is to be developed as a transferable gauge, similar to a weldable strain gauge.

Options for Commercialization

The NASA Glenn Research Center is interested in partnering with industry for testing in aerospace and non-aerospace applications. Sensor was developed directly for U.S. Patent 5,979,243.

Contact

Technology Transfer & Partnership Office
NASA John H. Glenn Research Center
at Lewis Field
Mail Stop 4–2
Cleveland, OH 44135–3191
Phone: 216–433–3484
Fax: 216–433–5012
E-mail: ttp@grc.nasa.gov
http://technology.grc.nasa.gov

References

Wrbanek, John D., et al.: A Thin Film Multifunction Sensor for Harsh Environments. NASA/TM—2001-211075, 2001.

Lei, J.F.; Fralick, G.C.; and Krasowski, M.J.: Microfabricated Multifunction Strain-Temperature Gauge. U.S. Patent 5,979,243, Nov. 1999.

LEW–17306–1

Key Words

Thin-film sensor
Strain
Heat flux
High temperature
Harsh environment
Vacuum sputtering
Photolithography

M–1406–32
Jul 04