National Aeronautics and Space Administration

technology opportunity

High-Temperature Optical Sensor Allows Testing Up to 1,000°C

Novel package and process increases thermal stability for aerospace and commercial applications

Innovators at NASA's Glenn Research Center have developed a high-temperature optical sensor that can operate in environments up to 1,000°C. The technology employs a novel method to package and process fiber Bragg gratings (FBGs), which are short segments of optical fiber designed to reflect a particular wavelength. This method drastically increases FBG thermal stability and operability. The resulting thermally stable chemical composition gratings (CCGs) in communication grade fibers are a key component of the sensor, which can accurately monitor the performance of advanced engines, furnaces, and reactors. This technology significantly extends applicability of optical sensors to high-temperature environments where other measurement techniques are unreliable, dangerous, or unavailable.

Benefits

- **Accurate:** Provides performance measures at higher temperatures than previously attainable
- **Robust:** Features a durable housing element that protects sensitive optic fibers
- **Stable:** Allows for both continuous sensing operation for hundreds of hours at high temperatures as well as temperature monitoring during thermal cycles
- **Cost-Effective:** Requires little additional material costs beyond commercially available fiber optic gratings and housings
- **Simple:** Employs a straightforward processing method and a known conversion phenomenon

Applications

High-temperature measurement, such as that needed for:

- **High-efficiency turbine engines**
- **Nuclear reactors**
- **High-temperature furnaces**
- **Tapblocks for extraction of molten products**
- **Chemical processes**
- **Oil and gas exploration and retrieval**

Technology Details

In numerous aerospace, industrial, and research applications, there is a need for sensors with high-temperature sensing capability and durability. For example, such sensors can be placed in extremely hot portions of advanced turbine engines to accurately measure engine performance. The Glenn innovation uses a two-part packaging and processing method to construct optical sensors that protect the sensitive optical fiber component and increase its thermal stability and operability.

How It Works

First, FBGs are encapsulated into a housing tube or "jacket" that shields the optical fibers from heat or other harmful conditions (see Figure 1). The housing can be made of ceramic or any material that has a low thermal conductivity and exhibits thermal stability at temperatures beyond 1,000°C. The device then undergoes an annealing process whereby it is slowly heated to 1,000°C and held at that temperature for 20-50 hours then cooled to room temperature, transforming the original FBGs to more thermally stable CCGs. The entire process is controlled and recorded using LabVIEW™ software. Glenn has demonstrated operability of the device at 1,000°C for up to 1,000 hours and during numerous thermal cycles of temperatures between 400°C to 800°C with different heating rates. Furthermore, the packaged sensor units showed their operability at heating rates up to 400°C/min.

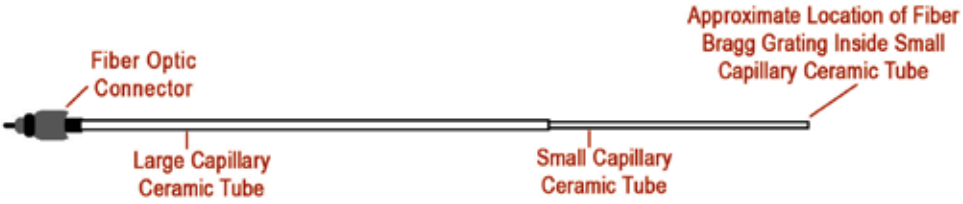

Figure 1: Encapsulated and Connectorized High Temperature Sensor
The optical fiber is inside and shielded by the ceramic tube.

Why It Is Better

Conventional in-situ temperature sensors, such as thermocouples, resistance thermometers, and thermistors, are not suited for high-temperature applications, particularly those with sustained high temperatures. These devices in most cases require compensating and measuring circuits with current carrying leads, which are also subjected to elevated temperatures that may alter their performance. As a result, conventional sensors cannot provide continuous measures in high temperature environments and their use is limited to spot checks, restricting their reliability. Similarly, conventional silica-based FBGs do not withstand high temperatures due to the dissipation of dopants that form those gratings. Various protective coatings for optical fibers evaporate at high temperatures, leaving fibers exposed, brittle, and subject to damage. The Glenn innovation, through use of its novel packaging and processing technique, protects sensitive components in extreme environments in which other sensors would fail. This technology may enable temperature sensing in ever more hostile environments, such as those found in and near turbine engines, nuclear reactors, and oil and gas equipment. Next steps involve modifying the sensor design so that it can withstand vibration levels characteristic to an aircraft engine or space vehicle as well as exposure to heating rates typical to engine environments.

Licensing & Partnering Opportunities

Glenn's Office of Technology Partnerships and Planning seeks to transfer technology into and out of NASA to benefit the space program and U.S. industry. NASA invites companies to consider licensing the High Temperature Optical Sensor (LEW 18381-1) for commercial applications.

For More Information

For more information about this and other technology licensing opportunities, please visit:

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