

Production of fiber optic temperature sensors



Overview

Optical Fiber Sensors for High-Temperature Monitoring: A Review Fiber-optic high-temperature sensors are gradually replacing traditional electronic sensors.

Key Takeaways

Fiber optic temperature sensors can be fabricated using silicon-tipped Fabry-Perot interferometers bonded to optical fibers via aerogel-assisted glass soldering with precise laser heating.

Sensor Design and Principle

Fiber optic temperature sensors often utilize a Fabry-Perot interferometer (FPI) configuration, where a small silicon diaphragm is attached to the tip of an optical fiber. The silicon diaphragm acts as a reflective cavity, and its thermo-optic properties—high refractive index and large thermo-optic coefficient—enable high-sensitivity temperature measurements. These sensors are compact, immune to electromagnetic interference, and suitable for high-speed and high-precision applications in aerospace, metallurgy, and medical monitoring.

Conventional Fabrication Methods



Traditional fabrication involves vacuum deposition techniques such as e-beam evaporation, sputtering, or chemical vapor deposition to deposit thin polycrystalline silicon films (< a few micrometers) directly onto the fiber end face. While this method provides high-temperature capability, it often results in short cavity lengths, limiting temperature resolution. Other bonding methods like UV epoxy or direct fusion bonding have limitations, including low temperature tolerance or stringent diameter requirements.

Aerogel-

Assisted Glass Soldering Method

A more advanced approach involves bonding a silicon diaphragm to the fiber tip using glass powders with tailored melting points, assisted by an aerogel substrate and 980 nm laser heating. Key steps include: Preparation of the silicon diaphragm (coated or uncoated) and fiber tip. Placement of glass powders between the diaphragm and fiber tip.

Localized laser heating delivered through an optical fiber to melt the glass powders, forming a strong bond. Temperature monitoring using a 1550 nm white-light system to ensure precise control and prevent thermal damage. Use of aerogel substrate to reduce thermal loss and improve heating efficiency, allowing bonding at lower laser power and in open space for convenient optical alignment.

This method allows fabrication of both low-finesse and high-finesse FPI sensors, achieving temperature resolutions as fine as 0.07 mK for high-finesse sensors and 0.35 mK for low-finesse sensors.

The flexibility of glass powders with different melting points enables high-temperature resistance and compatibility with various diaphragm sizes.

Advantages

High precision and sensitivity due to silicon's thermo-optic properties. Compact and robust design, suitable for harsh environments. Reduced thermal perturbation during fabrication thanks to precise laser heating and aerogel insulation.

Flexibility in operating temperature by selecting appropriate glass solder compositions. Open-space fabrication allows easier optical alignment and reduces risk of thermal damage.

Applications

These fiber optic temperature sensors are widely used in: Aerospace and aviation for turbine and combustion chamber monitoring. Metallurgical industry for real-time high-temperature measurements. Medical applications for precise body temperature monitoring.

Nuclear and energy sectors where electromagnetic interference immunity is critical. In summary, aerogel-assisted glass soldering with laser heating represents a breakthrough in the fabrication of silicon-tipped fiber optic temperature sensors, combining high precision, thermal stability, and flexibility for advanced sensing applications.

Article Content

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