Low-temperature performance of fiber Bragg gratings

Article Overview

Fiber Bragg gratings maintain reliable performance at cryogenic temperatures, with nonlinear thermal sensitivity and high resolution achievable down to liquid nitrogen temperatures.

Performance Characteristics

Fiber Bragg gratings (FBGs) can operate effectively from ambient conditions down to liquid nitrogen temperatures (~77 K) without requiring auxiliary embedding structures . At these low temperatures, FBGs exhibit nonlinear thermal sensitivity, which arises from the combined effects of the thermo-optic coefficient and the thermal expansion coefficient of the fiber material . This nonlinearity must be accounted for in precise temperature measurements, but it allows consistent modeling of FBG behavior across a wide temperature range.

Resolution and Sensitivity

o Pure-silica-core FBGs can achieve a temperature resolution of approximately 0.5 K at 77 K.
o Boron-doped and germanium-doped standard fibers can reach a finer resolution of 0.25 K at the same temperature . These values demonstrate that FBGs remain highly sensitive even at cryogenic temperatures, making them suitable for applications in aerospace, cryogenics, and low-temperature physics experiments.

Material and Design Considerations

The low-temperature performance depends on the fiber composition:

o Pure silica fibers: lower sensitivity but stable and minimal hysteresis.
o Doped fibers (B_2O_3, GeO_2): higher sensitivity due to enhanced thermo-optic effects . Embedding FBGs in materials with different thermal expansion coefficients can artificially increase sensitivity, but this may introduce nonlinearities, hysteresis, or delamination risks, and can mask the intrinsic response of the FBG itself . For monolithic FBGs, avoiding embedding preserves a small footprint, low thermal mass, and accurate intrinsic measurement.

Practical Implications

FBGs are suitable for cryogenic temperature sensing without complex packaging. Their performance is predictable and can be modeled accurately by considering the nonlinear contributions of both thermal expansion and refractive index changes. This makes them ideal for high-precision, low-temperature monitoring in scientific and industrial applications . In summary, FBGs demonstrate robust, high-resolution performance at low temperatures, with careful consideration of fiber type and thermal modeling enabling reliable cryogenic sensing.

The grating temperature sensitivity was evaluated from room temperature down to -120 °C, before and after irradiation.

In this paper, we studied the spectral response properties of TFBGs with combined strain and subzero temperature

Fiber Bragg gratings (FBGs) sensor has been widely used in all kinds of detection spaces. Nonlinear effects of the

Low-loss FBGs are microfabricated in standard single-mode fiber, with wide control over their temperature coefficient

Eccentric fiber Bragg grating (EFBG) is inscribed in standard communication single-mode fiber using femtosecond

In this paper, our objective is to review the various techniques to measure the temperature and strain using FBGs in

2.1.1 Fibre Bragg Grating Optical Fibre Bragg Grating (FBG) sensors are extensively investigated and used in measuring local static

Regenerated fiber Bragg gratings (RFBGs) have been created in large mode area (LMA) fibers, and their key properties for their

Fiber Bragg gratings (FBG) are important for controlling transmitted light wavelengths in optical sensing systems due to

R. Mamidi et al., "Fiber Bragg grating-based high temperature sensor and its low cost interrogation system with enhanced

Fibre Bragg grating (FBG) strain sensors are not only a very well-established research field, but they are also

Because of its various advantages over its counterparts, fiber Bragg grating (FBG) is a potential device for cryogenic

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The temperature-dependent properties of optical fiber are micro-engineered by creating microchannels within the

Abstract: We demonstrate the use of fiber Bragg gratings (FBGs) as a monolithic temperature sensor from ambient to liquid nitrogen

Structural health monitoring (SHM) is essential for ensuring the safety and longevity of civil engineering structures,

In this paper, a simulation model of surface-adhesive Fiber Bragg grating with the substrate is established for low

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