How is air pressure measured using fiber optic gratings

Article Overview

Fiber Bragg grating (FBG) sensors measure air pressure by converting pressure-induced strain into shifts in reflected light wavelength.

Principle of FBG Pressure Sensing

FBG sensors operate by reflecting specific wavelengths of light that shift when the fiber experiences strain. In pressure measurement, external air pressure is applied to a mechanical structure--such as a diaphragm, capillary, or elastic membrane--that transmits axial strain to the FBG embedded in the fiber. This strain changes the grating period and refractive index, causing a measurable shift in the Bragg wavelength, which is proportional to the applied pressure .

Sensor Design and Sensitivity Enhancement

Bare FBGs have low intrinsic pressure sensitivity (around 3.04 pm/MPa), so mechanical amplification structures are commonly used:

o Diaphragms: Thin metal or polymer membranes deform under pressure, transferring strain to the FBG. Sensitivity can range from 43.7 to 175.5 pm/kPa depending on diaphragm thickness .
o Levers or Coaxial Tubes: Mechanical levers or steel tube structures amplify the strain on the FBG, increasing sensitivity above 20 pm/MPa .
o Epoxy-embedded FBGs: Embedding the FBG in a compliant diaphragm material can further enhance response and durability .

Interferometric Integration

FBG sensors can be combined with Fabry-Perot interferometers (FPI) to improve measurement resolution and allow simultaneous detection of multiple parameters like pressure, temperature, and curvature. In such designs, the FBG reflects specific wavelengths while the FPI cavity provides high-resolution phase-based measurements .

Advantages of FBG-Based Pressure Sensors

o High sensitivity and miniaturization: Suitable for small-scale or biomedical applications.
o Electromagnetic immunity: Ideal for environments with high EMI.
o Multiplexing capability: Multiple FBGs can be inscribed along a single fiber for distributed sensing .
o Durability in harsh environments: With proper packaging, FBG sensors can operate under extreme

temperatures and pressures .

Practical Applications

FBG pressure sensors are used in:

o Aerospace and industrial monitoring: Measuring cabin pressure, fuel systems, or pipeline pressures.
o Biomedical devices: Miniaturized sensors for blood pressure or respiratory monitoring.
o Structural health monitoring: Detecting pressure changes in critical infrastructure .

Summary

To measure air pressure with fiber optic gratings, an FBG is embedded in a mechanical structure that converts pressure into strain. The resulting Bragg wavelength shift is detected optically, providing a precise, EMI-immune, and highly sensitive measurement. Sensitivity can be enhanced using diaphragms, levers, or hybrid FBG-FPI designs, making this method suitable for a wide range of industrial, biomedical, and aerospace applications .

In the vast realm of optical fiber sensing, where precision and innovation converge, Fiber Bragg Gratings (FBGs)

Single- and two-phase flow characterization using optical fiber Bragg gratings (FBGs) is presented. The sensor unit

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

Concise answers to the most frequently asked questions about optical strain gages and fiber bragg grating technology.

In conclusion, this comprehensive review paper provides a panoramic view of the recent advancements in Fiber

Interferometric fiber-optic pressure sensor converts pressure signals into optical phase

Abstract An array of three long period gratings (LPGs) fabricated in a single optical fibre and multiplexed in the

How is air pressure measured using fiber optic gratings

A novel fiber-optic based earth pressure sensor (FPS) with an adjustable measurement range and high sensitivity is

We report on sensitivity control of fiber optic sensors using microbend long-period fiber gratings. By tuning the phase

Conventional fiber-optic pressure sensors employ single-mode fibers (SMFs), which are commercially available and

Abstract In-fiber Bragg grating filters continue to proliferate, and their applications expand with the rapid advancement of

FBG sensors can be successfully employed in structural monitoring for seismic applications and damaging diagnostics. Proper

There are different types of fiber optic sensors, viz. intensity-based, polarization-based, grating-based, scattering

Optical fiber Bragg grating (FBG) sensors have advanced significantly in the last several years. The use of innovative

Abstract-- Distributed pressure sensing arrays fabricated from fibre Bragg gratings have been demonstrated for real time monitoring

Mainly three technologies are presently commercially available for pressure measurement with fiber-optic sensors:

Web: https://bssoda.pl