Metal Coating of Fiber Bragg Gratings

Article Overview

Metal coatings on Fiber Bragg Gratings enhance durability, thermal sensitivity, and enable integration into metallic structures.

Overview

Fiber Bragg Gratings (FBGs) are highly sensitive optical sensors but are inherently fragile due to their silica core and cladding. Bare FBGs are prone to microcracking under thermal shock or mechanical strain, and standard polymer jackets degrade above ~150 ?C, limiting their use in harsh environments. Metal coatings provide mechanical protection, improve thermal response, and allow embedding into metal structures for smart sensing applications .

Coating Methods

1. Electroless and Electroplating: A common approach involves a two-step metallization process. First, a thin layer of copper or nickel is deposited on the fiber using electroless plating, creating a conductive and uniform base. Then, a thicker nickel layer is applied via electroplating, resulting in a smooth, compact coating without visible defects. This method enhances thermal sensitivity and protects the FBG during embedding in metal structures, such as 42CrMo steel . 2. Stepped-Metal Coatings: Stepped-metal coatings involve sequential deposition of metals like nickel and copper in layers with different thicknesses. This can restructure the FBG resonance into dual-peak spectra, allowing simultaneous measurement of multiple parameters at a single location. Experimental studies show that different stepped-metal configurations produce varying temperature sensitivities, with some types achieving up to 6.5 pm/?C difference between peaks . 3. Other Techniques: Additional methods include physical vapor deposition (PVD), chemical vapor deposition (CVD), atomic layer deposition (ALD), and hybrid approaches combining PVD with electrodeposition. These techniques allow precise control over coating thickness, microstructure, and adhesion, which are critical for operation across cryogenic to high-temperature regimes .

Benefits of Metal Coating

o Mechanical Protection: Shields the fragile silica fiber from microcracks and mechanical fatigue.
o Thermal Sensitivity Enhancement: Metal layers with high thermal expansion coefficients amplify the FBG's response to temperature changes.
o Integration into Metal Structures: Enables embedding FBGs in metallic components for structural health monitoring.
o Environmental Resistance: Improves performance in high-temperature, cryogenic, or radiation-prone environments .

Practical Considerations

o Surface Preparation: Proper cleaning and activation of the fiber surface are essential for adhesion.
o Coating Thickness: Must balance protection with minimal impact on optical performance.
o Material Selection: Choice of metals (e.g., nickel, copper) affects thermal expansion, sensitivity, and compatibility with host materials.
o Process Control: Electroless plating and electroplating parameters must be optimized to avoid defects and ensure uniformity . Metal-coated FBGs are widely used in smart structures, aerospace, and industrial monitoring, where durability and precise temperature or strain sensing are critical.

A mathematical model for analyzing the temperature sensing properties of a metal-coated long-period fiber grating

In this study, the fiber Bragg grating (FBG) was metallized with a nickel coat using an electroless-electro plating

Effects of the metal coatings on the fiber Bragg grating (FBG) temperature sensing characteristics were simulated and

This study presents a simple method for metal re-coating of silica optical fibre Bragg gratings. No vacuum techniques

High-temperature optical fibres (OF) with fibre Bragg gratings (FBG) arrays written over a long length and in-line metal

In this work, we developed a multilayer metal-coated FBG that can operate in high-temperature cycles of 20-1000 °C.

After using the technology, the optical properties of the metal-coated fiber Bragg gratings have been retained, and their

Abstract Fiber Bragg grating (FBG) sensors have emerged as advanced tools for monitoring a wide range of physical parameters in

Abstract The optical fiber Bragg grating (FBG) sensor has great potential to be used for measuring temperature, strain,

In this study, a copper coating was deposited on the surface of a fiber Bragg grating (FBG) via electroplating. We

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Optical fiber Bragg grating (FBG) sensors have attracted considerable interest due to their special wavelength-encoded

Researchers developing for instance high-temperature fibre optical Bragg-grating sensors will need a simple and cheap method for

In this paper the possibility of improving the temperature sensitivity of FBG sensors by metal coating is investigated.

Compared to conventional adhesive packaging for fiber Bragg grating (FBG) sensors, metal packaging is considered

This paper demonstrates a method for the development of stepped-metal coating on optical

These requirements have driven the integration of functional coatings--metallic, ceramic, or hybrid--to extend FBG

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