

Article Overview

Planar fiber optic sensing enables high-resolution, real-time strain and structural monitoring using flat or non-circular optical fibers embedded in composite materials.

Overview

Planar fiber optic sensors (FOFS) are an advanced class of fiber optic sensors designed for real-time, in-situ monitoring of strain, force, torque, and structural integrity in engineering systems . Unlike traditional cylindrical fibers, planar fibers have a rectangular or D-shaped cross-section, which improves strain transfer, reduces interfacial stress concentrations, and conforms better to composite layups . These sensors are particularly useful in aerospace, civil engineering, and renewable energy applications where high spatial resolution and immunity to electromagnetic interference (EMI) are critical .

Working Principles

Planar fiber optic sensors typically employ:

- o Fibre Bragg Gratings (FBGs): Encode strain or temperature variations as spectral shifts in reflected light, allowing precise point-wise measurements .
- o Distributed sensing techniques: Rayleigh or Brillouin scattering enables strain or temperature measurement along the entire fiber length, providing continuous monitoring . In force and torque applications, planar fibers can act as optical strain gauges, where deformation of the host structure induces measurable changes in the optical path length of the fiber . This allows simultaneous measurement of multiple parameters, such as combined force and torque, with high accuracy.

Fabrication and Integration

Planar fiber sensors are manufactured using techniques such as:

- o Precision mechanical polishing
 - o Controlled chemical etching
 - o Additive manufacturing of polymer-based fibers
- Integration strategies include preform embedding, resin transfer molding, and surface bonding, ensuring compatibility with composite layups and maintaining sensor survivability under mechanical loads . These methods enhance strain transfer and reduce the risk of fiber-matrix debonding.

Advantages

Planar fiber optic sensors offer several benefits over traditional electrical or cylindrical fiber sensors:

- o High spatial resolution and multiplexing capability
- o Immunity to EMI and environmental disturbances
- o Minimal cross-sectional footprint for embedding in composites
- o Capability for distributed or localized strain measurement
- o Real-time monitoring enabling predictive maintenance

Applications

- o Aerospace: Wing box structures, aircraft composite components
- o Civil engineering: Bridges, railway infrastructure
- o Renewable energy: Wind turbine blades
- o Robotics and continuum manipulators: Shape sensing using single-fiber OFDR systems for precise control

Challenges and Future Directions

Key challenges include temperature cross-sensitivity, mechanical durability under fatigue, and cost barriers. Solutions involve dual-parameter compensation, nanocomposite-enhanced coatings, and scalable fiber fabrication techniques . Future developments may leverage nanotechnology and machine learning for enhanced signal interpretation and predictive analytics in structural health monitoring . Planar fiber optic sensing represents a transformative approach for high-performance, real-time monitoring in complex engineering systems, combining precision, flexibility, and robustness.

A planar flexible fiber-optic interferometric acoustic sensor is developed by wrapping optimized single-mode fibers in a

A fiber optic sensor array which is structured by four Sagnac fiber optic sensors is proposed to detect and locate a

This paper reviews the fiber optic sensors that have been developed and applied to measure cable forces, including fiber Bragg

This review comprehensively examines the advancements, challenges, and applications of flat optical fibre sensors (FOFS) for real

Although the state-of-the-art fiber optic shape sensing mechanisms can provide sub-millimeter spatial resolution for off

This paper introduces a revolutionary way to interrogate optical fiber sensors based on fiber Bragg gratings (FBGs)

Here, we present a miniature optical fiber PAS gas sensor based on a planar-spiral spring OMR (PSS-OMR) that is in

Planar optical waveguides formed by ion-exchange in glass are sensitive to changes in parameters such as:

To address the challenges associated with shape sensing of continuum manipulators (CMs) using Fiber Bragg Grating (FBG) optical

Smart manufacturing, Industry 4.0, and cyber-physical systems (CPSs) require sensing architectures capable of

Sensing platform based on the integrated optical planar waveguide represents an active research area. The

Key Takeaways Optical sensors can be classified into two main types: fiber optic sensors and planar waveguide sensors. Planar

In this work, we characterize a fiber-coil sensor for high-frequency ultrasonic detection in immersion.

Flexible optical fiber sensors benefit from both technology-merits of optical fiber sensing and flexible materials. They utilize specially

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A fiber-optic sensor is a sensor that uses optical fiber either as the sensing element ("intrinsic sensors"), or as a means of relaying

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