

Principle of Fiber Optic Speckle Sensor



Overview

Advances in Optical Fiber Speckle Sensing: A Navigating through diverse sensor technologies, including interferometry, intensity variation, nonlinear effec.

Key Takeaways

Fiber optic speckle sensors operate by analyzing speckle patterns formed at the end of a multimode fiber, which change in response to external perturbations.

Working Principle

Fiber optic speckle sensors (FSSs) utilize multimode optical fibers illuminated by a coherent light source, such as a laser. When coherent light propagates through a multimode fiber, the multiple guided modes interfere with each other, producing a speckle pattern at the fiber's output facet. This speckle pattern is highly sensitive to external fiber perturbations (EFPs), including strain, temperature, pressure, or vibration.

Any mechanical or environmental change along the fiber alters the phase and amplitude of the propagating modes, which in turn modifies the speckle pattern observed at the output.

Specklegram Analysis

The output speckle pattern, often called a specklegram, is captured using a photodetector or camera. By comparing the specklegram before and after a perturbation, the sensor can quantify the magnitude and nature of the external influence. Techniques such as correlation analysis, image processing, or machine learning algorithms are commonly employed to extract meaningful information from the specklegram.

Advantages FSSs are valued for their simplicity, low cost, and compact design. Unlike grating-based sensors, they do not require complex inscription or interrogation equipment. They also offer potential multipoint sensing capabilities by using beams with different angular separations or wavelengths, enabling distributed measurements along a single fiber.

Additionally, FSSs are immune to electromagnetic interference, making them suitable for harsh or sensitive environments.

Applications

Fiber optic speckle sensors are applied in structural health monitoring, robotics, gait analysis, and chemical detection, among other fields. Their high sensitivity to small perturbations allows precise monitoring of mechanical or environmental changes in real time. In summary, the principle of a fiber optic speckle sensor is based on the interference of multiple modes in a multimode fiber, producing a speckle pattern that changes with external perturbations, which can then be analyzed to measure physical quantities accurately and efficiently.

Article Content

Advances in Optical Fiber Speckle Sensing: A

Navigating through diverse sensor technologies, including interferometry, intensity variation, nonlinear effects, and grating-based sensors,

(PDF) Optical Fiber Sensors: Working Principle,

Brief theory of sensing principle, fabrication method, applications, advantages and disadvantages of the different fiber-optic sensors, are addressed.

Advances in Optical Fiber Speckle Sensing: A Comprehensive Review

Navigating through diverse sensor technologies, including interferometry, intensity variation, nonlinear effects, and grating-based sensors, fiber specklegram sensors (FSSs) emerge as promising

Ultra-stable speckle-based optical fiber sensing demonstrated on an ...

Here, we introduce an ultra-stable speckle-based architecture that overcomes these limitations and enables real-time structural health monitoring of uncrewed aerial vehicles.

Optical Fiber Sensors: Working Principle, Applications, and Limitations

Brief theory of sensing principle, fabrication method, applications, advantages and disadvantages of the different fiber-optic sensors, are addressed. Recent progress in numerous sensing fields, including

Fiber-Optic Point-Based Sensor Using Specklegram Measurement

Here, we report a fiber-optic point-based sensor to measure temperature and weight based on correlated specklegrams induced by spatial multimode interference. The device is realized simply by

The Optimization of Multimode Fiber Speckle Sensor for

Fiber specklegram sensors (FSS) are a kind of sensor based on the intermodal interference of multimode optical fibers (MMFs) . When coherent light is incident into a multimode

A low-cost fiber-optic temperature sensor utilizing integrated sensing ...

To address this, an integrated fiber-optic sensing approach is presented. A tapered fiber segment is employed to generate leaky-mode speckle patterns, with geometric parameters and a

Entropy analysis of optical fiber specklegram sensors

Speckle patterns are random intensity distributions resulting from the multiple constructive and destructive interferences of coherent light as it passes a diffuser or scatters in a rough surface

Advances in Optical Fiber Speckle Sensing: A Comprehensive Review

Optical fiber sensors have been studied, developed, and already used in the industry for more than 50 years due to their multiplexing capabilities, lightweight design, compact form factors,

Zhao Ge's research works | Huazhong University of Science and ...

Zhao Ge's 20 research items with 61 citations and 691 reads, including: Efficient Cloud-Edge Framework for Distributed Vibration Event Recognition via Compressed-Sensing-Inspired AI

A fiber optic refractive index sensor with extremely high dynamic range ...

In this paper, a tapered optical fiber sensor with high precision measurement capability in a wide dynamic range has been proposed and experimentally demonstrated. Speckle pattern images

Advances in Optical Fiber Speckle Sensing: A Comprehensive Review

A plethora of optical fiber sensor technologies have been proposed, capitalizing on distinct effects on optical fibers to achieve specific sensing outcomes. These include interferometry , intensity

Yunjiang Rao's research works | University of Electronic Science and ...

Yunjiang Rao's 245 research works with 3,786 citations and 6,634 reads, including: On-chip silicon electro-optical modulator with ultra-high extinction ratio for fiber-optic distributed acoustic ...

Optical fiber speckle spectrometer based on reversed-lens ...

Light is injected into an optical fiber and the emergent speckle patterns are imaged by a reversed-lens smartphone camera.

Deep learning for highly efficient curvature recognition using fiber ...

Abstract A flexible fiber-optic sensor enabled by deep learning is proposed and experimentally demonstrated for highly efficient curvature sensing application. This sensing

Event-based speckle interrogation for high-bandwidth multi-point ...

Speckle-based fiber optic sensors are well-known to offer high sensitivity but are strongly limited on the interrogation side by low camera frame rates and dynamic range. To address this limitation, we

Speckle-based fiber sensor for temperature measurement

The applications of specklegram analysis techniques have been developed recently. In this paper, we represent a fiber-optic method to measure the temperature through the analysis of output

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