Working Principle of Fiber Optic Methane Sensor



Overview

To take full advantage of lab-on-fiber gas sensing technology, this paper presents an optical fiber CH 4 sensor based on a functionalized Fabry-Perot interferometer (FPI).

Key Takeaways

Fiber optic methane sensors detect methane by monitoring changes in light properties, such as phase, intensity, or refractive index, caused by interactions with a methane-sensitive coating on the fiber. Working Mechanisms1. Interferometric Sensors: These sensors use single-mode or multimode fibers coated with a methane-sensitive material, such as ZIF-8/PDMS.

Methane molecules interact with the coating, altering the refractive index of the fiber cladding. This change modifies the propagation of light modes within the fiber, producing a shift in the interference spectrum. By measuring this spectral shift, the methane concentration can be quantified.

Sensitivity depends on fiber length, coating thickness, and fiber diameter, with detection limits reaching a few hundred ppm and response times around 30 seconds. 2. Refractometric Sensors: In refractometry-based sensors, a section of the fiber is de-cladded and functionalized with a polymeric film containing methane-binding molecules, such as cryptophane-A.

Methane absorption changes the refractive index of the film, which alters the transmitted optical power along the fiber. Comparing the transmitted power to a reference fiber allows precise methane concentration measurement. These sensors are low-cost, fast, and suitable for in situ monitoring without electrical hazards.

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3. Surface Plasmon Resonance (SPR) Sensors: SPR-based fiber optic sensors employ a metal-coated fiber (e.g., gold) with a methane-sensitive layer. Incident light excites surface plasmons on the metal surface, and methane-induced refractive index changes in the sensitive layer shift the resonance wavelength.

Monitoring this shift enables accurate methane detection.

SP

R sensors offer high sensitivity, self-calibration, and resistance to electromagnetic interference, making them suitable for industrial applications. Key AdvantagesNon-electrical sensing: Safe for explosive environments. High sensitivity: Capable of detecting methane at ppm levels.

Compact and robust: Resistant to corrosion and electromagnetic interference. Fast response and recovery: Typically within tens of seconds.

Summary

Fiber optic methane sensors operate by transducing chemical interactions between methane and a sensitive coating into measurable optical signals, using mechanisms such as interference, refractometry, or SPR. The choice of sensor type depends on the required sensitivity, environmental conditions, and application constraints.

Article Content

Lab-on-fiber: Highly sensitive methane sensor based on ZIF-8/PDMS ...

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Optical Fiber Methane Sensor Based on Mach–Zehnder

The optical fiber device is not selective to methane, but the sensitive film coated on the optical fiber surface is selective to methane. Therefore, the design and fabrication of a suitable methane-sensitive

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Fiber-optic SPR methane sensors excite free electrons on metal surfaces by swift waves on the surface of the fiber. The interaction of free electrons and electromagnetic waves generates surface plasma

Sensitization of an optical fiber methane sensor with graphene

We analyze the mechanism by which tin oxide can be utilized for the optical sensing of methane gas via surface adsorption and electromagnetic theory. Single-mode optical fibers with core

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Optical Fiber Methane Sensor Based on Mach Zehnder Interferometer ...

Optical fiber methane sensors primarily operate on optical principles, detecting methane concentration through variations in light absorption and refractive index induced by methane [16–18]. These

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Fiber optic VOC gas sensors are classified and discussed based on different principles. In addition, this paper extensively reviews the recent advances in fiber optic VOC gas sensors and

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Optical fibre gas sensors are capable of remote sensing, working in various environments, and have the potential to outperform conventional metal oxide semiconductor (MOS)

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Fiber Optic Shape Sensors: A comprehensive review

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A Fiber Optic Shape Sensor (FOSS) can be defined as fiber optic cable with multiple cores and embedded strain sensors. The working principle is the following: in each instrumented section

Optical Fiber Methane Sensor Based on Mach–Zehnder ...

Optical fiber methane sensors primarily operate on optical principles, detecting methane concentration through variations in light absorption and refractive index induced by methane [16, 17,

Gas detection with micro

Abstract This paper overviews recent development in gas detection with micro- and nano-engineered optical fibers, including hollow-core fibers, suspended-core fibers, tapered optical

Highly Sensitive and Self-Calibrating Fiber Optic SPR Methane Sensor ...

According to the detection principle, fiber-optic methane sensors are mainly divided into two types. One is surface plasmon resonance (SPR)–based sensors, which can detect the concentration of methane

Sensitization of an optical fiber methane sensor with graphene

Optical fiber-based methane sensors are suitable for use in harsh and dangerous environments due to their excellent electric insulation, strong anti-electromagnetic interference

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