

Principle of Concentration Measurement by Fiber Optic Sensors

Article Overview

Fiber optic sensors measure concentration by detecting changes in light intensity, reflection, or transmission caused by the interaction of the optical signal with the liquid or mixture.

Working Principle

Fiber optic concentration sensors operate by monitoring how light propagates through or reflects from a medium. The basic principle relies on the fact that the optical properties of a solution--such as refractive index, turbidity, viscosity, and surface tension--change with concentration. These changes affect the intensity, phase, or wavelength of light traveling through the fiber, which can then be correlated to the concentration of the substance being measured .

Types of Fiber Optic Sensors

- o Intrinsic Sensors: The fiber itself acts as the sensing element. Changes in the surrounding medium directly affect the light traveling within the fiber, such as through absorption or scattering .
- o Extrinsic Sensors: The fiber transmits light to an external sensing element. The modulation occurs outside the fiber, and the fiber primarily guides the light to and from the sensor .
- o Hybrid Sensors: Combine intrinsic and extrinsic principles, allowing light to interact with both the fiber and an external sensing element .

Reflection Intensity Method

A common approach for concentration measurement is the reflection intensity method. The sensor head, often at the end of a polymer optical fiber, is immersed in the liquid. The Fresnel reflection at the interface between the fiber and the liquid depends on the refractive index, which varies with concentration. The reflected light is captured and converted into an electrical signal, which can be processed to determine the concentration .

Light Loss in Fiber Curvatures

Another method involves light losses in curved or polished fiber regions. For example, a U-shaped fiber with lateral polishing increases sensitivity to changes in the surrounding liquid. Variations in concentration alter the light loss due to scattering or absorption, which is then measured to quantify the concentration .

Signal Processing and Neural Networks

Advanced fiber optic concentration sensors often include opto-electronic interfaces and neural networks to process the measured signals. The neural network can generalize from training data to improve accuracy,

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compensating for factors like turbidity, viscosity, and surface tension . The sensor resolution depends on the efficiency of the coupler, precision of signal conversion, and the quality of the neural network training.

Applications

These sensors are widely used in wastewater treatment, chemical processing, and biomedical applications, where precise and real-time concentration monitoring is critical . Their advantages include remote sensing capability, immunity to electromagnetic interference, and high sensitivity. In summary, fiber optic sensors measure concentration by detecting optical changes caused by the interaction of light with the liquid, using reflection, transmission, or light loss mechanisms, often enhanced with signal processing techniques for accurate quantification.

While Brillouin scattering is an excellent strain sensor technology, the response time is about 1 second; and therefore, is not suitable

In this work, we report on the fabrication and testing of a fiber optics sensor based on multimodal interference (MMI)

The utilization of optical fibers in measuring concentration is a necessity to many industries since it is safe to be applied in volatile

The measurement principle of optical absorbance-based optical fiber heavy metal ion sensor is that the light intensity

A fiber optic sensor measures a physical quantity by modulating the intensity, spectrum, phase, or polarization of light traveling

Fibre optics makes use of the total internal reflection (TIR) concept, which allows for a correlation between the light intensity

An optical fibre sensor has been developed to measure particle concentration in water. The principle of operation is based on light

This work reviews the fiber-optic sensors based on Bragg gratings, long period gratings, interferometers, surface

2. Principles of operation and optical fiber measurement systems The operation of optical fiber sensors requires a light

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This paper reports the use of fiber optic sensor consists of two-fiber probe and reflector for the measurement of

Abstract A high sensitivity optical fiber Surface Plasmon Resonance (SPR) sensor which based on coreless optical fiber,

Radiation absorption creates electronic excited states that are trapped by localized defects for extended periods of time. Heating the

The current state of the art of optical fiber technology is reviewed, namely based on its main characteristics and sensing advantages.

Explore fiber optic sensors: their working principles, types (intrinsic, extrinsic, hybrid), and diverse

communication system via using fiber optics there was a great demand to measure and sense the rate of data transmission, change

Measuring pH is a critical parameter in environmental monitoring, biomedical diagnostics, food safety, and industrial

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