Thickness detection using fiber optic sensor

Article Overview

Fiber optic sensors can detect material thickness by measuring changes in light propagation, refractive index, or surface interactions, with high sensitivity and real-time capability.

Principles of Thickness Detection

Fiber optic sensors operate by guiding light through a core surrounded by cladding, where changes in the surrounding medium or material properties modulate the light signal. Intrinsic sensors detect changes directly along the fiber, while extrinsic sensors relay light to an external sensing element for measurement . Thickness detection often relies on refractive index variations, evanescent field interactions, or surface plasmon resonance (SPR) effects, which are highly sensitive to small changes in material thickness .

Sensor Types and Configurations

o Single-mode-multimode-single-mode (SMS) fibers: These structures enhance sensitivity by controlling modal interference. Adjusting the cladding thickness of the multimode fiber segment can optimize performance, balancing sensitivity, quality factor, and energy loss .
o Surface plasmon resonance (FOSPR) sensors: These sensors use a metal-coated fiber to detect thickness changes at interfaces, such as oil-water or air-oil layers. They provide real-time measurements with high repeatability and can detect thickness in the millimeter range with sensitivities like -1.373%/mm at the water-oil interface .
o Fiber Bragg grating (FBG) sensors: By monitoring shifts in reflected wavelengths, FBG sensors can detect strain or thickness changes in coatings or thin films .

Performance Considerations

o Sensitivity: Determined by the interaction between the guided light and the material. Thinner cladding or tapered fibers increase evanescent field exposure, improving sensitivity .
o Resolution and Limit of Detection (LOD): High-quality sensors can detect sub-millimeter thickness changes, depending on the optical configuration and signal processing.
o Environmental Stability: Temperature, salinity, or other environmental factors can affect readings, but well-designed sensors, such as FOSPR, minimize these effects .

Applications

Fiber optic thickness sensors are used in:

o Industrial monitoring: Measuring coatings, films, or liquid layers.
o Environmental monitoring: Real-time detection of oil slick thickness in marine environments .
o Biomedical diagnostics: Detecting thin biological layers or fluid films.
o High-voltage or hazardous environments: Where electrical sensors are unsafe .

Summary

Fiber optic sensors detect thickness by exploiting light-matter interactions, with configurations like SMS fibers, FOSPR, and FBG providing tailored sensitivity and real-time monitoring. Cladding thickness, fiber type, and surface modifications are key factors in optimizing performance, enabling precise measurements in industrial, environmental, and biomedical applications .

A fiber optic sensor operates with an optical fiber cable connected to a dedicated light source. These sensors offer great mounting

Fig. 7. Fiber optic sensor configurations in biomedical engineering applications: intensity modulation using (a) fiber microbending

Light Injection into the Optical Fiber Source (Laser, LED etc.) Transmission of Modulated Light to a Monitoring Point Detector (PIN

Fiber optic sensors and fiber optics - limitless and customized The perfect solution with the fiber optics sensor toolbox Over 350

By using a single optical source and detection unit, it is possible to operate large arrays of distributed sensors without active

A new ray-tracing-based calibration method for an Optical fiber-based Reflective Probe (ORP) was developed. This

The fiber optic sensor working principle is that transducer changes some optical fiber system parameters like

Brief theory of sensing principle, fabrication method, applications, advantages and disadvantages of the different fiber

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

An optical fiber sensing system is basically composed of a light source, optical fiber; a sensing element or transducer and a detector

An ultrahigh resolution thickness measurement sensor was proposed based on a single mode-hollow core-single mode

Abstract: In this paper, a thin film thickness gauge based on the interferometric principle of Y-shaped optical fiber is proposed to

Thickness is measured by passing a target between two sensors. A newly designed optical system and dedicated jig allow for ultra

Optical fibre sensors are an essential subset of optical fibre technology, designed specifically for sensing and measuring several

This paper presents a highly accurate dual-probe thickness measurement method based on interference spectroscopy

Imagine a world where the Internet doesn"t just connect but senses--detecting earthquakes,

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