

Article Overview

Fiber optic nanosensors detect chemical or biological analytes by converting nanoscale interactions into measurable optical signals using functionalized nanostructures integrated with optical fibers.

Core Principles

Fiber optic nanosensors operate by modifying the properties of light traveling through an optical fiber in response to interactions with target analytes. The key optical parameters affected include intensity, phase, wavelength, refractive index, absorption, and emission spectra. These changes are detected and correlated with the presence or concentration of specific chemical or biological species .

Intrinsic vs Extrinsic Sensing

- o Intrinsic sensors use the fiber itself as the sensing element. Changes in the fiber's internal optical properties, such as refractive index or birefringence, occur when the analyte interacts with the fiber surface or embedded nanomaterials .
- o Extrinsic sensors use the fiber primarily as a light guide, with the sensing interaction occurring outside the fiber, often in a nanoscale functionalized tip or coating .

Nanoscale Enhancement

The integration of nanomaterials--such as nanoparticles, nanotubes, nanorods, quantum dots, graphene, MoS₂, and MXenes--enhances sensitivity due to their high surface-to-volume ratio. These nanostructures are functionalized with chemical or biological receptors that selectively bind target molecules, producing detectable optical changes . This allows detection of trace amounts of analytes with high selectivity and real-time response.

Optical Transduction Mechanisms

Fiber optic nanosensors employ several optical transduction mechanisms:

- o Surface Plasmon Resonance (SPR): Changes in refractive index at the fiber surface alter the resonance conditions of surface plasmons, producing measurable optical shifts .
- o Fluorescence and Luminescence: Binding events or chemical reactions at the nanoscale can induce emission of photons, which are guided through the fiber for detection .
- o Raman Scattering: Surface-enhanced Raman scattering (SERS) at fiber nanotips or nanoarrays amplifies molecular vibrational signals for chemical identification .
- o Interferometry: Mach-Zehnder, Fabry-Perot, and other interferometric setups detect phase or wavelength

shifts caused by analyte interactions .

Chemical and Biological Transducers

- o Chemical transducers include pH-sensitive dyes, ion indicators, or reactive molecules that change optical properties upon interaction with analytes .
- o Biotransducers include antibodies, enzymes, DNA strands, or cells that specifically bind target biomolecules, producing optical signals detectable by the fiber .

Advantages

Fiber optic nanosensors offer:

- o High sensitivity due to nanoscale interactions and enhanced surface area .
- o Selectivity through tailored chemical or biological receptors .
- o Real-time monitoring capabilities for dynamic chemical or biological processes .
- o Remote sensing and EMI immunity, making them suitable for harsh or hazardous environments .

Applications

These sensors are widely used in environmental monitoring, healthcare diagnostics, chemical process control, and safety detection, leveraging their ability to detect minute quantities of analytes with high precision . In summary, fiber optic nanosensors combine the light-guiding properties of optical fibers with functionalized nanostructures to achieve highly sensitive, selective, and real-time detection of chemical and biological species, making them a powerful tool in modern sensing technologies.

4. High Integration Optical Fiber Assisted-Sensing System The optical fiber can be conveniently connected to the high-performance

1. Introduction In the field of optical fiber technology integrated with nanophotonics emerged new avenues for

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

An extensive review of optical fiber sensors and the most beneficial applications is presented in this chapter. Although

Content Outline. The document is organized as follows: Section 2 presents the different types of optical fiber sensors, their main

Fiber-optic nanosensors represent a significant advancement in the realm of chemical detection, offering exceptional sensitivity,

This review paper presents the foundations of fiber-optic chemical sensing or biosensing, including the sensing

Optical fiber sensors present several advantages in relation to other types of sensors. These advantages are

This article presents a concise summary of current advancements in novel nanomaterial-based optical fiber biosensors.

However, a technological gap exists between the sensing materials and optical fibers, i.e., how to efficiently combine

This review aims to provide an exhaustive discussion on the various types of fiber optic tactile sensors, focusing on

Fiber Optic Shape Sensing is an innovative Optical Fiber Sensing Technology that uses a fiber optic cable to

Fiber optics, the science of transmitting data, voice, and images by the passage of light through thin, transparent fibers.

This review deals with all four types of fiber-optic nanosensors and is more focused on FO chemical nanosensors and

Fabrication techniques such as focused non-chemical bonding strategies and self-assembly of nanoparticles are

This article discusses and documents the basic concepts of, and developments in, the field of optical nanosensors and

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