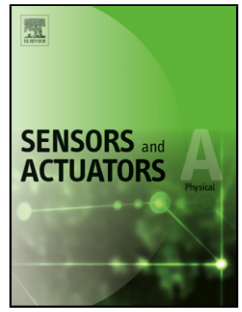

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In-fiber integrated gas pressure sensor based on a hollow optical fiber with two cores

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Highlights

- A kind of special hollow optical fiber with two cores was first fabricated.
- This optical fiber simultaneously provides a micro-channel for the gas and two cores for constructing an in-fiber interferometer.
- In-fiber integrated optical fiber interferometer for gas detection with trace samples is first demonstrated.
- This optical fiber gas sensor can be integrated with the devices without extra chamber.

Abstract

We demonstrate an in-fiber integrated highly-sensitive gas pressure sensor based on a special designed hollow eccentric twin-core optical fiber (HTCF). In this design, the core in the hole and the core in the annular cladding of the HTCF are separately used as sensing arm and reference arm. Then, in-fiber gas pressure detection can be first realized in the long hole of the HTCF. The experimental results show that the sensor exhibits a gas pressure sensitivity of 0.42 nm/bar, with low temperature sensitivity of -51 pm/℃, and a maximum bending sensitivity of 98 pm/μm. Comparing with traditional optical fiber gas pressure sensors, this device first realizes in-fiber gas pressure detecting through the special designed optical fiber with a compact size which can be easily connected and integrated in practical applications.

Keywords Microstructured optical fiber; Hollow optical fiber; Optical fiber sensor; In-fiber integrated

1. Introduction

In recent years, microstructured optical fibers (MOFs) with microholes in the scale of micrometers are widely explored for the components of the sensor devices [1-4]. The holey structure in the MOFs can hold fluids such as liquid and gas samples with small volumes. That is to say, the sensing devices based on MOFs are ideal choice of microanalysis in many fields such as biology, chemistry and environment [5-10]. Simultaneously, the integration of waveguide and the cavity structures of MOFs can significantly simplify the setups of sensors based on optical fibers. The long microholes in the MOFs provide enough surface area for the interaction between the core and the materials in the holes. Then, highly effective light coupling between the core and the samples through the evanescent field can be obtained in the optical fibers. Especially, the low consumption of reagents can also minimize the size of the devices and realize on-line detection [11, 12].

On the other hand, gas sensors have gained popularity because they play an important role in the fields of industry, chemical, and environmental monitoring [13-15]. In particular, optical fiber gas pressure sensors are widely investigated due to their unique advantages such as structure integration, electromagnetic immunity, stable in operation and easy signal detection. They are widely used to detect harmful and flammable gases. Various structures such as Fabry-Perot interferometer [16], long period optical fiber grating (LPFG) [17] and fiber tip [18] have been developed to measure gas pressure. However, although some of them exhibit higher spectral features [19, 20], most of these sensors are built with opened structures such as the cavities and microstructures etched with lasers on the surface or the end of the fibers [21]. Unfortunately, these machined structures have weak mechanical strength and