Optical Fiber Sensor Mach-Zehnder Interferometer Based on TiO_2 Coated Long Period Fiber Grating

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Abstract: The wavelength sensitivity and spectral resolution of Mach-Zehnder fiber interferometers based on uncoated and TiO_2 coated LPFGs is presented and compared with TiO_2 coated single LPFGs optical fiber sensors.
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1. Introduction

Optical fiber sensors based on long period fiber gratings (LPFGs) have been extensively studied in past years due to their advantages relatively to conventional devices [1]. They have been applied to a wide number of applications as, for example, for sensing strain, bending, temperature, and chemical or biologic compounds. See [2] and references therein.

LPFGs are produced by introducing a refractive index (RI) modulation in the fiber core with periods from 100 to 1000 μm and a length of a few centimeters [3]. As a result, several attenuation bands are generated in the transmission spectrum of the optical fiber exhibiting high spectral dependence with the surrounding refractive index (SRI) [4-6].

The highest wavelength shift sensitivity of the LPGFs occurs for SRI values slightly lower that the cladding refractive index, decaying abruptly as the SRI becomes closer to the water RI [4, 7]. Sensing applications in biology, environmental health sciences and life sciences require sensing systems optimized analysis in the refractive index range from ~1.33 to ~1.34. This weakness can be solved by coating the bare LPFG with a material that has a RI higher than the CRI [8]. The properties of LPFGs can be enhanced by coating the grating with metal oxides thin films, such as titanium dioxide (TiO_2) [9, 10].

A RI sensor based on a Mach-Zehnder (MZ) interferometer composed of a pair of LPFGs has been reported, where the sensitivity of the cladding mode to the SRI was utilized, providing a RI resolution of 1.8×10^{-6} [11].

The main objective of the present work is the evaluation of the spectral sensitivity and resolution of optical fiber MZ interferometers based on the combination of 3 dB LPFGs before and after the TiO_2 coating and to compare their sensing characteristics with the single LPFGs before and after the same type of coating.

2. Materials and Methods

The MZ interferometers were implemented in standard single mode fiber (SMF28, Corning, Inc.). The sensing device is composed by two LPFGs inline and a section of a bare optical fiber in between, as illustrated in Fig. 1. The LPFGs were produced by the electric arc technique as described by Rego et al. [12]. The period of the gratings was 396 μm, a value chosen to produce a resonance wavelength at 1.55 μm, corresponding to the asymmetric $LP_{1,6}$ cladding mode. In order to maximize the visibility of the interferometer, an attenuation value of 3 dB for the $LP_{1,6}$ band of each LPFG was targeted, reached for 15±5 mm LPFG length.

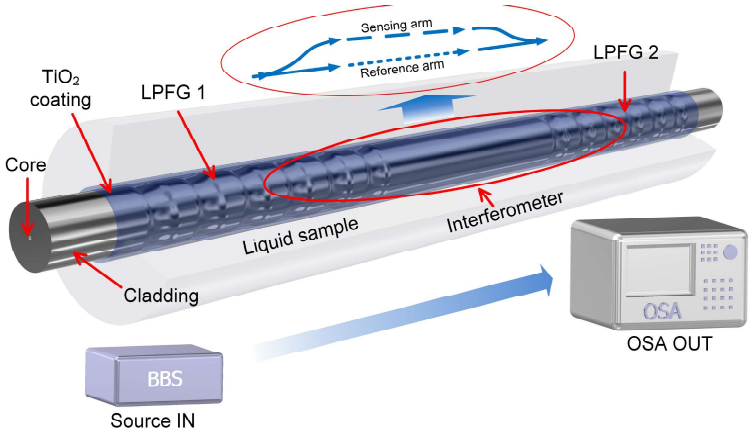

Fig. 1. Setup for the measurement of the optical characteristics of the optical fiber sensors, both MZ interferometers and LPFGs.