Sensitivity Analysis of the Lowest Order Cladding Mode of Long Period Fiber Gratings

Tanoy Kumar Dey[1*], Sara Tombelli[2], Palas Biswas[1], Ambra Giannetti[2], Nandini Basumallick[1], Francesco Baldini[2], Somnath Bandyopadhyay[1], Cosimo Trono[2]

1 CSIR- Central Glass & Ceramic research institute, 196 Raja S.C. Mullick Road, Kolkata - 700032, India
2 Institute of Applied Physics "Nello Carrara", CNR- IFAC, Via Madonna del Piano 10, 50019 Sesto Fiorentino, Italy

**tanoykumardey@gmail.com*

A long period fiber grating (LPFG) has been designed and fabricated in order to couple the $LP_{0,2}$ cladding mode near turn around point (TAP), with the effect of maximum enhancement of the evanescent field of the sensor. The achieved sensitivity was 8751 nm/SRIU within an RI range of 1.333-1.3335, with a resolution of the order of 10^{-5} RIU.

Keywords: Optical fiber sensor, Long period fiber grating.

1. Introduction

Long period fiber gratings (LPFGs) are turning out to be promising bio-chemical sensors for their ability to sense the surrounding refractive index (RI) [1]. In most of the bio-chemical applications, the surrounding RI is ~ 1.333. However, the sensitivity of the sensor in this RI range is not very high. In this work, enhancement of sensitivity of the LPFG is achieved by combination of two methodologies: 1) enhancement of the evanescent field and 2) working near the turn-around point (TAP) of a cladding mode. For the first time, to the best of our knowledge, the cladding diameter is reduced until obtaining the lowest order cladding mode ($LP_{0,2}$) to attain the maximum enhancement of the evanescent field and the TAP of the $LP_{0,2}$ cladding mode. Sensitivity of the sensor is analysed inside a closed flow cell within the RI range 1.333-1.3335 and it is found out to be, for the dual peak resonance of $LP_{0,2}$ cladding mode, 8751 nm/SRIU.

2. Fabrication of sensor

The LPFG, with a period of 246 µm and 123 grating planes, was fabricated in a single mode optical fiber (PS 1250/1500 FIbercore) by using a point by point inscription technique with a KrF excimer laser (Lambda Physics Compex 110). The spectrum after inscription is shown in Fig.1, where $LP_{0,9}$ cladding mode is obtained at ~1370 nm. The period is chosen in such a way that the left peak of the dual resonance of the $LP_{0,2}$ can be obtained in C band in water medium after cladding diameter reduction. The cladding diameter was reduced up to ~ 20 µm by means of hydrofluoric acid chemical etching. The corresponding spectrum is shown in Fig.1.

3. Sensitivity analysis

The etched sensor was sealed inside a PMMA closed flow cell by using optical adhesive (NOA 60). This closed cell reduces the cross sensitivity due to the external temperature fluctuation and allows the easy handling of the etched sensor which has a very low mechanical strength.

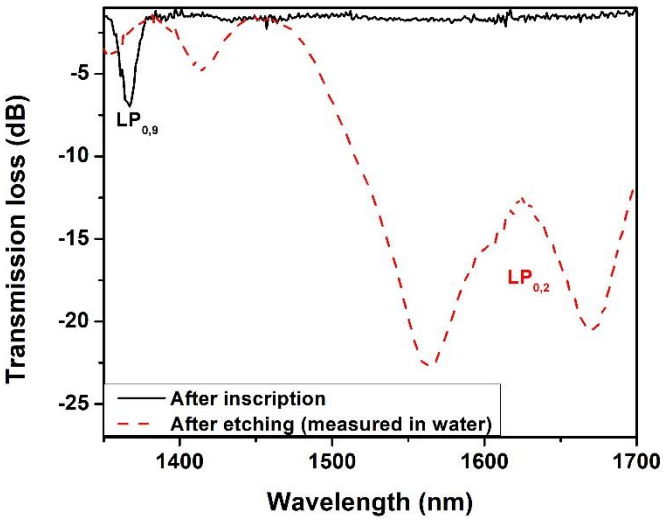

Fig. 1 Measured spectra of the LPFG after inscription and after cladding diameter reduction.

The RI characterization was performed within the range 1.333-1.3335 by using NaCl water solutions at different concentrations. For the dual peak resonance, the sensitivity was found out to be 8751 nm/ SRIU with a resolution of 5×10^{-5} RIU. Sensitivity details are shown in the Table 1.

Table 1 (Sensitivity chart)

Peak of $LP_{0,2}$ cladding mode	SRI sensitivity (nm/SRIU)
Left peak	3342
Right peak	5409
Dual peak	8751

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