Thickness influence on the polarization dependency of tilted fiber Bragg gratings coated with zinc oxide thin films

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Tilted fiber Bragg gratings

present a refractive index modulation blazed by a few degrees in the plane perpendicular to the optical fiber axis. It offers a convenient way to measure surrounding refractive index (SRI) with a sensitivity of $10^4$ refractive index unit (RIU) in the range $1.30 \ldots 1.45$ based on the cladding modes variations in the transmitted spectrum (Fig. 1). The presence of the core mode resonance combined to its small dimensions yields temperature-insensitive in situ refractometers that can be used in many industrial processes.

We investigate the effect of a high refractive index coating on the reflectometry performances 2, but taking into account of the polarization.

Sensor manufacturing

TFBGs were manufactured into hydrogen-loaded SMF by means of a 1095 nm uniform phase mask and a laser emitting at 244 nm. Phase mask was tilted by 6°. Before coating, gratings were annealed (100 °C – 12 hours) to stabilize the gratings. Zinc oxide was deposited by Radio Frequency (RF) sputtering. RF power was about 200 W during the deposition, which was conducted at a pression of 2 Pa. The composition of the gas was 90 % Ar and 10 % O2. The deposition was made in two steps (180° rotation). Investigated thickness of the film were 100, 200, 400 nm. Before use, coated gratings were annealed at 300 °C during 3 hours in order to stabilize the films. It led to a loss of 10 dB in the peak-to-peak amplitude.

Experimental set-up

Experiments were led with an optical source covering the C+L bands, a linear polarizer and an optical spectrum analyzer, as shown in Fig. 2. Spectrum is firstly measured in air and the two orthogonal modes are found by modifying the angle of the linear polarizer. Then, for each solution, from 1.328 to 1.600 by step of 0.1 RIU, the spectra for s and p polarized light are recorded. In Fig. 4, spectra obtained in air for the two orthogonal polarization states (p and s) are shown. The two families of modes are clearly separated.

Demodulation

The separation between s and p states exists also in higher SRI, which was not the case for a bare TFBG. Tracking cladding mode is suitable as efficient demodulation technique 5. Peak wavelengths increase with the SRI.

With ZnO coating, p-polarized (Fig. 6 (b)) light shows a higher sensitivity (3 times factor) than the orthogonal state of polarization (Fig. 6 (a)). It has a linear behavior until the SRI corresponds to the effective RI of the considered mode.

A straightforward technique is based on the computation of the area delimited by upper and lower envelopes. It shows that p-polarization state is the most sensitive (Fig. 7 (b)). Linear range is broader than without coating (1.35 – 1.42 against 1.39 – 1.42 without coating 1-3). The slope is 50% higher for p than s-polarized light for a 400 nm coating.

We have demonstrated that Zinc Oxide coating of a few hundreds of nm increases the polarization dependency of TFBGs. It maintains the two orthogonal polarization states s and p non degenerated (with a few hundreds of pm between s and p resonance peaks) beyond SRI higher than the one of silica. The p-polarization state is more sensitive to the SRI variation, leading to more sensitive refractometers (3 times factor) on a larger range of refractive index, using tracking mode or area demodulation techniques.

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