Direct Bragg grating writing in a hybrid PDMS/Silica photonic crystal fiber

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Infiltration of materials into the air holes of the PCFs can potentially manipulate their optical properties creating a new category of fibers termed as hybrid PCFs [1] and many devices based on hybrid PCFs have been developed [2-5]. Recently, a hybrid PCF with poly-dimethylsiloxane (PDMS) elastomer inclusions has been demonstrated [6]. PDMS is widely used in the area of photonics and optofluidics. It is highly transparent with a refractive index ~1.41, conserving the total internal reflection guiding mechanism of the hybrid PCF. When PDMS is irradiated with UV light its refractive index increases [7]. In this paper we present the first example of a Bragg grating directly written using UV light on the PDMS inclusions of a conventional silica PCF.

In our experiments, we used an Endlessly Single Mode PCF (ESM-12-02, Crystal Fibre) with a core diameter of about 12 μm in which the air holes with diameter 3.5 μm are arranged in a hexagonal pattern with a pitch of 7.7 μm. All the holes of the PCF were filled with PDMS elastomer as described in [6] up to a length of ~6 cm. The inset in Fig. 1a) shows a SEM picture of the PDMS filled PCF. A 2.5 cm-long uniform FBG was written in the PDMS filled section of the PCF by using a doubled CW argon laser (λ=257 nm, P=100 mW) and a uniform period phase mask. Fig 1a) shows the transmission spectrum of the grating where a clear notch is evident. The reflectivity of the grating is approximately 3.5%, it is centered at 1552 nm with a FWHM of 0.05 nm.

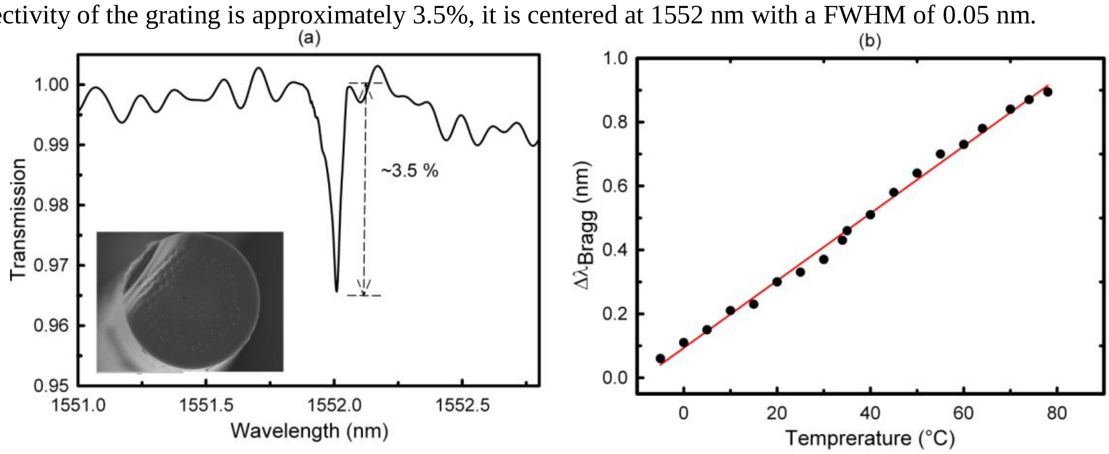

Fig. 1 a) Transmission spectrum of the fiber Bragg grating. Inset: SEM picture of the PDMS filled PCF. b) Temperature dependence of the of the Bragg grating resonance shift.

Fig.1b) shows the dependence of the Bragg wavelength shift with temperature from -5 to 80 °C. The wavelength shift is quite linear (R=0.995) with a temperature coefficient of 10 pm/°C. We used a commercial PCF with large core (12 μm) hence the overlap of the fundamental mode field with the PDMS elastomer is very weak; nevertheless we managed to write and characterize a Bragg grating by periodically changing the refractive index of the elastomer inclusions. PDMS has a high thermo-optic coefficient (-4.5×10^{-4}/°C). We expect that both the reflectivity and thermal response of the Bragg grating will be enhanced in a PCF with smaller core where there is stronger overlap of the modal field with the PDMS inclusions.

References

[1] A. Cerqueira S. Jr., F. Luan, C.M.B. Cordeiro, A. K. George, and J. C. Knight, “Hybrid photonic crystal fiber,” Opt. Express, **14**, 926 (2006).
[2] L. Xiao, W. Jin, and M. S. Demokan, "Photonic crystal fibers confining light by both index-guiding and bandgap-guiding: hybrid PCFs," Opt. Express **15**, 15637 (2007).
[3] T. Larsen, J. Broeng, D. Hermann, and A. Bjarklev "Thermo-optic switching in liquid crystal infiltrated photonic bandgap fibres," Electron.Lett. **39**, 1719 (2003).
[4] S. Torres-Peiró, A. Díez, J. L. Cruz, and M. V. Andrés, "Fundamental-mode cutoff in liquid-filled Y-shaped microstructured fibers with Ge-doped core," Opt. Lett. **33**, 2578 (2008).
[5] B. J. Eggleton, P. S. Westbrook, C. A. White, C. Kerbage, R. S. Windeler, and G. L. Burdge, "Cladding-Mode-Resonances in Air-Silica Microstructure Optical Fibers," J. Lightwave Technol. **18**, 1084 (2000).
[6] C.Markos, K. Vlachos, and G. Kakarantzas, "Bending loss and thermo-optic effect of a hybrid PDMS/silica photonic crystal fiber," Opt. Express **18**, 24344 (2010).
[7] B. Schnyder, T. Lippert, R Kotz a, A. Wokaun,V. Graubner, O. Nuyken “UV-irradiation induced modification of PDMS films investigated by XPS and spectroscopic ellipsometry” Appl. Surface Sci. **532-535**, 1067 (2003).