Novel In-line Photonic Devices Made by Post-Processing Photonic Crystal Fibers

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Abstract: Novel in-line photonic microcells are made by post-processing stock photonic crystal fibers. The applications of these microcells for in-fiber accelerometers and gain and absorption cells are discussed.
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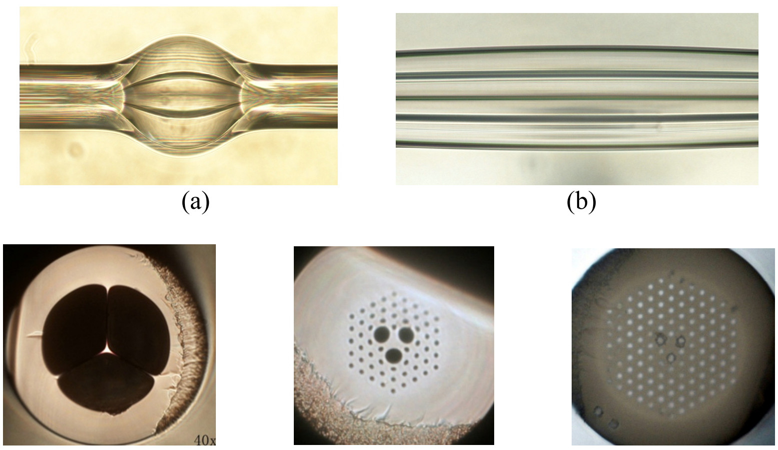
1. Introduction

Commercial photonic crystal fibers (PCFs) are typically made of pure silica and have a periodic array of air-holes running along their length [1]. The inclusion of air-holes provides extra freedom to radically change the properties of these fibers by post processing. There have been reports on modifying the size, shape and distribution of air-holes to locally change the waveguide properties to create novel photonic devices. These include the fabrication of in-line fiber polarizers [2] and long period gratings [3], anamorphic core-shape transitions [4] and nonlinear applications [5]. Gas [6] and acoustic [7] sensors based on modified hollow-core PCFs were also reported.

We here report the fabrication of a novel class of in-line photonic microcells by inflating selected air-holes and tapering a commercial large mode area PCF (LMA-10 from NKT Photonics). The application of such photonic microcells for in-fiber amplifiers, fiber lasers, and in-fiber accelerometers are discussed.

2. The photonic microcell

The fabrication process of the microcells is described in [8]. It involves pressurization of selected air-hole of a PCF when it is been heated/tapered at a particular location along the fiber. Figs. 1(a) and 1(b) are the side views of two microcells made respectively by electric arc discharge of a fusion splicer and by a flame-brushing technique. The arc discharge produces short microcells with a length of hundreds of micrometers, while the flame-brushing produces longer microcells with a length up to 7 centimeters. Figs. 1(c)-1(e) show the cross-sections at different locations along the cell. At the center of the cell, it is a suspended core (SC) fiber, and the transition from the SC to the original PCF is adiabatic. By pressurizing selected air-holes, microcells with a single SC and multiple SCs with different birefringent and modal properties may be made, as shown in Fig. 2. The insertion losses of these cells are low and ranges from ~0.1 to ~0.5 dB.



(a) (b)

(c) (d) (e)

Fig. 1. Side-view of microcells produced by (a) arc discharge and (b) flame brushing. Cross-section of a microcell at different locations along the cell: (c) at the center, (d) at the transition region, and (e) away from the cell.

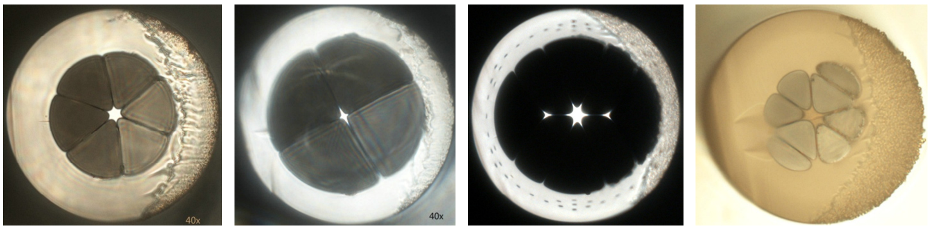
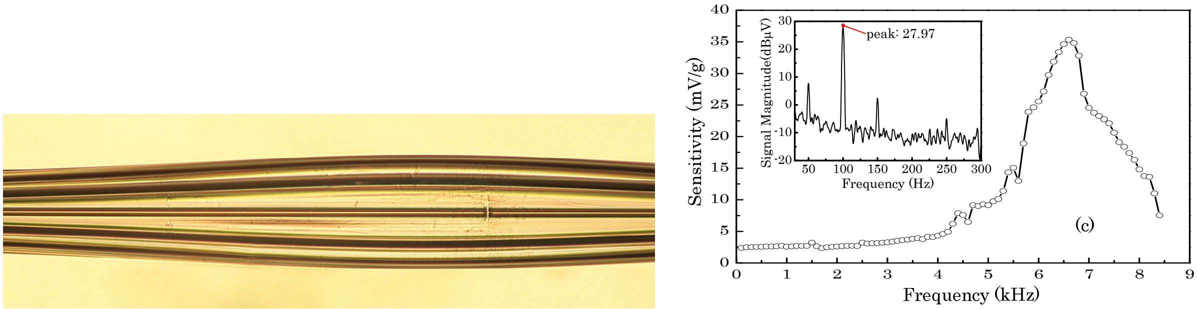


Fig. 2. Cross-sections of various microcells

3. In-fiber amplifier and accelerometer

As demonstrations of potential applications of the microcells, we made an in-fiber cantilever beam accelerometer [8]. An in-line microcell with a SC is firstly made by the flame brushing method, and the SC is then cut by a femtosecond laser so that a small gap is introduced between the two sections of the core. The surrounded struts of one section are removed by scanning the focused femtosecond laser beam across them, resulting in a cantilever beam as shown in Fig. 3(a). The cantilever deflects with applied acceleration, results in misalignment between the two sections of the core, and modulates the transmitted light intensity. An important advantage of this design is that the whole cantilever beam is encapsulated in the microcell, making it easier to mount as well as free from contamination from outside environment. The frequency response of the accelerometer are shown in Fig. 3(b).

We also made optical gain cells by drilling lateral micro-holes into the SC region and filling the microcell with laser dye, Rhodamin 6G. The results will be reported at the conference.



(a) (b)

Fig. 3. A fiber accelerometer and its performance [8]

4. Conclusion

We reported the fabrication of in-fiber photonic microcells with a suspended core by post processing a commercial PCF. The photonic microcells may be useful components for absorption/florescent-based spectroscopic sensors and refractive index sensors, as well as gain cells for future fiber amplifiers and laser systems. The authors acknowledge the support of the Hong Kong SAR government through GRF grant PolyU 5177/10E.

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