VIS-NIR Bend loss Sensitive Photonic Crystal Fibers

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Abstract

In this work we present bend loss characteristics of silica Photonic Crystal Fibers (PCFs) in the VIS-NIR-IR region. The PCFs made using the Stack-and-Draw technique consist of triangular and rectangular hollow lattices. The bend loss dependency of these PCFs was characterized by using an optical spectrum analyzer (OSA) and a white light source. The optical transmittance spectra were measured for different bend radius. These PCFs are sensitive to bending losses in the VIS-NIR region, but insensitive in the IR region. These PCFs may be used to bend sensors or optical filters.

Keywords: Photonic crystal fibers, triangular and rectangular hollow lattices, bend loss sensitive.

1. Introduction

Many important applications of optical fibers depend on the bending characteristics. Fiber-to-the Home (FTTH) applications demand that the optical fibers have bending insensitive behaviors or very low loss to bending [1]. The conventional core/clad optical fibers (Single Mode Fiber-SMF or Multimode Fiber-MMF) are usually bending sensitive within the range IR. On the other hand, the PCFs are usually bending insensitive within the range VIS-IR. We believe that PCFs may have useful FTTH applications in the very near future. In this work we introduce a new PCF composed of triangular and rectangular hollow lattices that have bending sensitive characteristics. This PCF may be used to bend sensors, optical filters and others devices.

2. Experimental

Figure 1 shows the cross section images of a PCF pre-form (24 mm external diameter) and a cane pre-form (3.5mm external diameter). The pre-forms were fabricated using the stack-and-draw technique [2]. From images of figure 1 it is possible to observe the triangular and the rectangular hollow lattices. Figure 1-A shows the stacking of capillaries with three different kinds of Inner diameter (ID) and Outer Diameter (OD) ratios. The Transparent capillaries have an ID/OD = 24.9/28, the Red capillaries have an ID/OD=13.91/19.96, and the Blue capillaries have an ID/OD=18.53/31.73. The Transparent and Red color capillaries form the triangular hollow lattices, and the Blue color capillaries form
a rectangular hollow lattice. Figure 1-B shows the triangular and rectangular hollow lattices of a cane with their external diameter of 3.5mm.

Figure 1. Cross section images of the PCF pre-forms. (A) Image showing the stacking of capillaries and rods. (B) Image of a 3.5mm cane showing the triangular and rectangular hollow lattices.

Figure 2 shows the experimental set-up used to measure the bending characteristics of the optical fibers. Figure 2-A shows a device (rod) to measure the bending properties of fibers. This device is not appropriate for bend diameters lesser than 2 mm because the fiber break easily. On the other hand, figure 2-B shows a device that consists of four rods located in the corner of a rectangular block. The diameter of these rods can be variable from 1mm. The stress caused to the fiber by this device is low in comparison to that of figure 1-A. In this work, we have used the set of figure 1-A (rods with diameters from 2 mm), because it is a device easy to fabricate and also because only one turn around perimeter was necessary to analyze the bending properties.

Figure 2. Set-up to measure bending properties. (A) Rod device to bend the fiber. (B) Device that consists of four rods located in the corner of a rectangular block. We have used the bend diameters (Φ) higher than 2mm.

3. Results and Discussions

Figure 3 shows the PCFs cross section images obtained using an optical microscope. Figure 3-A shows clearly that the small and large hollows form a
triangular lattice. On the other hand, Figure 3-B shows clearly that the small and large hollows form a triangular lattice, but the small hollows form a rectangular lattice. Both PCFs were obtained from similar canes (Fig. 1-B), but the principal difference was the drawing temperature. The PCF of figure 3-A was drawn at high temperature in comparison to that of figure 3-B.

Figure 3. Cross section images of PCFs with triangular (A), and Triangular & Rectangular (B) hollow lattices.

Figure 4 shows the power transmitted spectra as function of the bending diameters of a conventional Single Mode Fiber (SMF), a Bend-Insensitive-Loss Fiber (Commercial BLI-fiber of Draka Company), and a PCF (8 hollow rings around the solid core, with hollows form only a triangular lattice). The spectra of Figure 4-A were obtained without bending (1), bending diameters of 10mm (2), 7mm (3), 5mm (4), and 2mm (5).

Figure 4. Power transmitted spectra as function of bending diameters. (A) SMF, (B) PCF, and (C) BLI Draka Fiber.
The spectra of Figure 4-B were obtained for the same bending conditions that of figure 4-A. The spectra of Figure 4-C were obtained without bending and with bending diameter of 2mm. From this figures it is possible to observe that only the PCF is insensitive to bending. The SMF and the BLI are sensitive to bending in the IR region. Figure 5 shows the power transmitted spectra of PCFs of figure 3. The spectra of Figure 5-A correspond to the fiber of figure 3-A, and the spectra of figure 5-B to that of fiber of figure 3-B. The power transmitted spectra show the bending losses at VIS-NIR region.

![Graph](image1.png)

*Figure 5. Power transmitted spectra as function of the bending diameters. (A) PCF of figure 3-A, (B) PCF of figure 3-B.*

### 4. Conclusions

We have fabricated PCFs and characterized the PCFs as function of the bending diameters. The PCF structures are based on triangular and rectangular hollow lattices. The PCFs are sensitive to bending losses in the VIS-NIR region, but insensitive in the IR region for PCFs with rectangular lattices. These PCFs may be used to bend sensors or optical filters.

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### References