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Triple Point Tapered PCF based Refractive Index Sensor

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Abstract—*In this paper we fabricate and demonstrate a tapered PCF based refractive index sensor. Tapered probe was fabricated by using chemical method which was later then splice with SMF from both end. Form the obtained result it was observed that tapering causes the enhancement in the sensitivity. Highest obtained sensitivity was 28.67 dBm/RIU at 1550 nm by linear fitting of the graph in origin. Highest sensitivity in comparison to the conventional fiber makes it useful in various field of sensing.*

1. INTRODUCTION

Photonic crystal fiber uses the property of photonic crystal, generally these fiber are made of single material with an array of air holes running parallel to its length. Huge researches are attracted towards the PCF based fiber sensor from several decades [1-7]. In beginning researcher used the simple fusion splicing to splice photonic crystal fiber (PCF) between two single mode fibers (SMF) but due to the less interaction of evanescent wave with the outer medium it shows low sensitivity [8]. The drawback of low sensitivity was later removed by using tapered PCF between SMF [9-10]. Tapering of PCF causes the enhancement of evanescent wave which are too much sensitive towards the changing in its environment.

In this paper we have fabricated a tapered PCF at three points in the middle portions. Here we use simple fusion splicing method to splice SMF with PCF. The experiment was performed on the refractive indices ranges from 1.344 to 1.411 and gets linear responses. Power gets decreases with increase in refractive indices. With various advantages like robust, compact in size and immune to electromagnetic interference it can be used in every field of sensing area like chemical and biochemical sensing.

2. SENSING STRUCTURE AND SETUP

Schematic diagram of sensing structure is shown in Fig. 1. The sensing structure of our fabricated probe contain the stubbing of tapered PCF between two SMF of both fiber have same cladding diameter. Splicing of PCF with SMF takes place due to the air hole collapsing of PCF. The air hole collapsing in PCF causes the excitation of several cladding modes at same time.

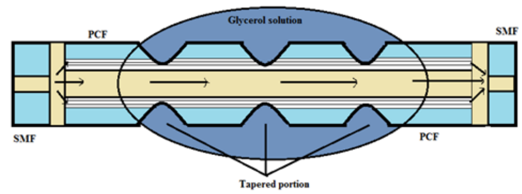

Fig. 1. Schematic diagram of sensing structure

The setup used in the experiment is show in Fig. 2. Our experimental setup consists of a laser source of 1550 nm and an optical spectrum analyzer (OSA). Measurement takes place by beam through method in which one end of fiber connected with the laser source and another end with the OSA, probe was dipped in the solution for which the sensitivity is to be measured. The launched from laser source propagated through SMF get diffracted in PCF and several cladding modes get excited at the same instance.

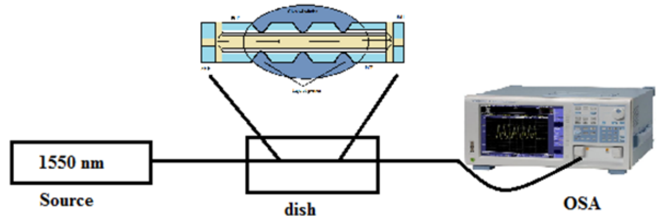

Fig. 2: Diagram of experimental setup

When the light reached to the tapering portion the splitting and recombination of light with core and cladding mode takes place. This recombination and splitting of light may be explained on the basic principle of mach-zhender interference (MZI). So the total transmission can be expressed as-

$$I = I_{core} + I_{cladding} + 2\sqrt{(I_{core} . I_{cladding})}\cos(\delta)$$

Where I is the intensity of the interference signal, and I_{core} and $I_{cladding}$ are the intensities of the core and cladding modes, respectively, and δ is the phase difference of the core mode and cladding modes

$$\delta = \frac{2\pi}{\lambda} \int_L (n_{cladding} - n_{core})\, dz$$

The experiment was performed of the varuous concentation of glycerol resulting various refractive indices varied in the range from 1.344 to 1.411. After each measurement the probe was cleaned with ethanol for accurate sensing.

3. RESULT AND DISCUSSION

The obtained plotted data are shown by figure.3. As the launched light from light source propagate through SMF it diffracted in the cladding portion of PCF, after reaching near the tapered portion it recombine with the core mode according to MZI and enhanced the evanescent waves. These evanescent waves are directly interact with the outer media and hence with increase in refractive indices there is the decrease in power.

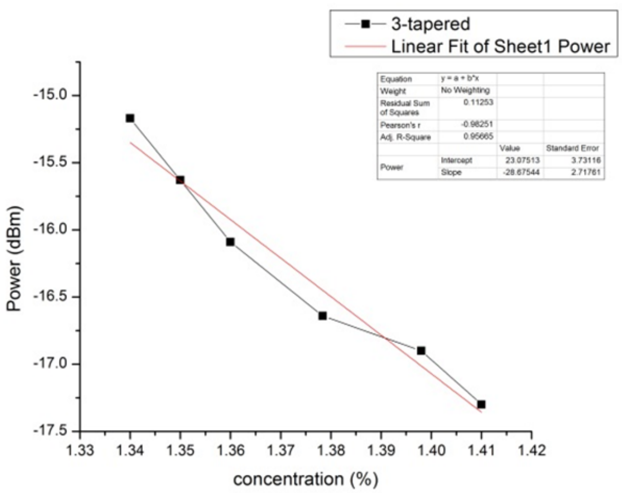

Fig. 3: Plot of the recorded data on origin

The experiment was performed for the long refractive indices ranges varied from 1.344 to 1.411; experiment was performed on room temperature (28 ^{0}C). Here we use triple point tapering in PCF which causes the low sensitivity but better than other standard fiber based sensor. Loss of light takes place from three points due to the triple point tapering and obtained maximum sensitivity of 28.67 dBm/RIU. This type of sensor can be modified further by coating some material on these tapered portions which may enhance more sensitivity.

4. CONCLUSION

In conclusion here, we have studied a triple point tapered PCF based refractive index sensor. The sensor was fabricated by simple fusion splicing method and the SMF used to launch the light in the cladding portion of PCF. These cladding portions light enhance the evanescent wave, and hence we use it for a long range refractive index sensor. The obtained sensitivity was 28.67 dBm/RIU. This may further improve by various modifications.

5. ACKNOWLEDGMENTS

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