Demonstration of Chromatic Dispersion in Borosilicate Crown Glass Microstructure Optical Fiber

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ABSTRACT: *We developed the theoretical and experimental method for chromatic dispersion of Borosilicate Crown microstructure optical fiber from scalar effective index method (SEIM) and TBC has been reported. To maintain the flat and zero dispersion in photonic crystal fiber (PCF) different air hole diameter has been introduced. Here we use Borosilicate Crown glass as a core material. A photonic crystal fiber with large effective mode area and flat dispersion property may be very usefull for next generation optical data.*

Keywords: *Effective Refractive Index (n_{eff}), Photonic Crystal Fiber (PCF), Scalar Effective Index Method (SEIM), Transparent Boundary Condition (TBC).*

I. INTRODUCTION

In these years PCF [1,2] is very attracted in the research group because of many of their attractive properties [3] as high birefringence, very high and low nonlinearity, wideband dispersion [4-10] flattened characteristics, endlessly single mode guiding [11,12], fiber sensors [13, 14] and fiber lasers [15,16]. Many research papers have published some optical properties of PCFs such as unique chromatic dispersion, which are almost impossible for the conventional optical fibers. Most PCFs are used silica as core material and core is surrounded by air holes called photonic crystal structure [17-20]. The PCF is made by a single material. Here we use Borosilicate crown glass as core material. Borosilicate glass was first developed by German glassmaker otto Schott in the late 19th century. Most borosilicate glass is coloreless 70 % silica, 10% boron oxide, 8% sodium oxide, 8% potassium oxide and 1% calcium oxide are used in the manufactore of borosilicate glass. Borosilicate crown glass (BK7) is an optical material used in a large fraction OPTICS products. It is relatively hard glass, doesn't scratch easily. Another important feature of BK7 is very good transmission down to 350 nm. Due to these properties, BK7 are widely used in the optics industry.

In this paper , we proposed two layer cladding PCF characterized by a common air hole space (pitch) and two different air hole diameters. The structure can ensure flat dispersion in a wide wavelength range and simple than the existing designs.

II. PROPOSED STRUCTURE

Figure 1. shows the proposed PCF. The inner three layer of cladding is composed of a common air hole pitch ∧ and diameter d_1 and outer three layer of cladding is composed diameter d_2, where d_1 is less than d_2. To achieve larger mode area we design the air holes of inner rings are chosen smaller. We have investigated the dispersion for different air hole diameter of inner and outer ring.

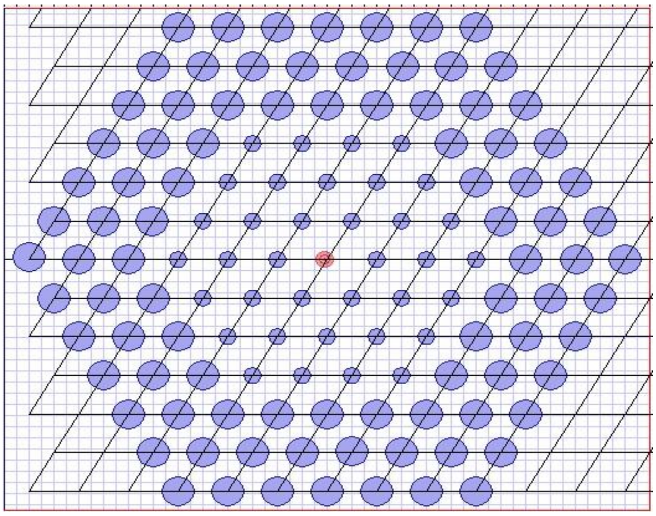

Figure 1. Proposed PCF.

Structure Parameter-

1. $d_1 = 0.5$ µm, $\wedge = 2.0$ µm and $d_2 = 1.5$ µm
2. $d_1 = 0.6$ µm, $\wedge = 2.0$ µm and $d_2 = 1.4$ µm
3. $d_1 = 0.7$ µm, $\wedge = 2.0$ µm and $d_2 = 1.3$ µm
4. $d_1 = 0.8$ µm, $\wedge = 2.0$ µm and $d_2 = 1.2$ µm

The wafer chosen is of Borosilicate crown glass with 1.5168 refractive index and the air hole refractive index is 1.0. In figure 1 we have change the inner and outer ring air hole diameter.

The value of refractive index of Borosilicate crown glass can be calculated by Sellemier formula [21,22].

III. EQUATIONS

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$$n^2 - 1 = \sum_i \left(\frac{A_i \lambda^2}{\lambda^2 - \lambda_1^2} \right) \quad (1)$$

Total dispersion is always calculated by adding waveguide dispersion and material dispersion.

$D_T = D_W + D_M$

Waveguide dispersion D_W is defined as –

$$D_w = -\left(\frac{\lambda}{c}\right)\frac{d^2}{d\lambda^2}n_{eff} \tag{2}$$

Where λ is the operating wavelength and c is the velocity of light in a vacuum [25].

IV. SIMULATION RESULTS

The effective refractive index difference is increased between proposed PCF and conventional PCF.

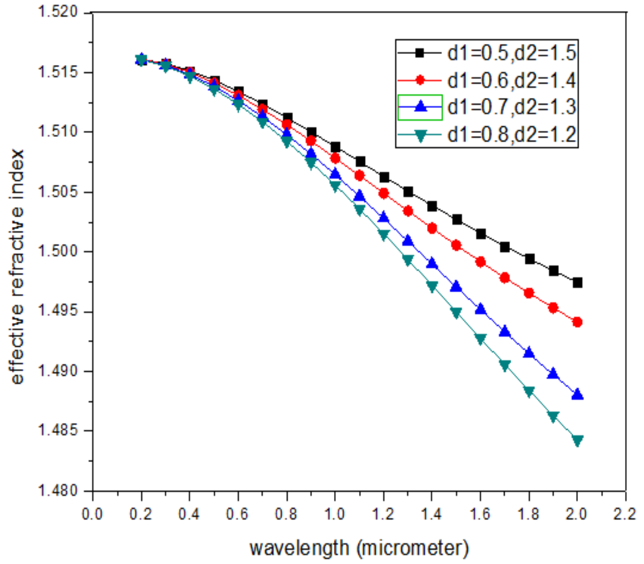

Figure 2. Shows the difference between effective refractive index of conventional PCF and Proposed PCF.

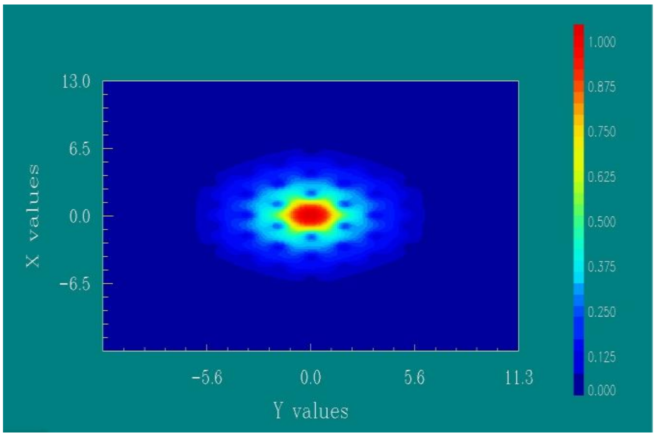

Figure 3. Shows mode field pattern of proposed PCF.

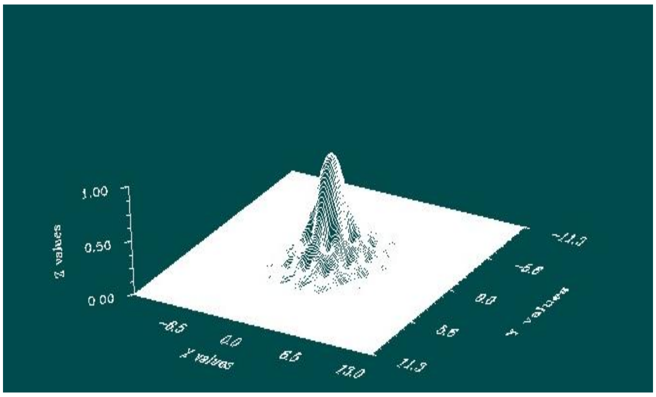

Figure 4. 3-D mode field pattern of proposed PCF.

The wafer is designed for width 26 µm and thickness 22.5166 micrometer. Material dispersion is always unchanged for any structure (hexagonal or square). It is also independent of structure parameter as air hole diameter 'd' and pitch '^'.

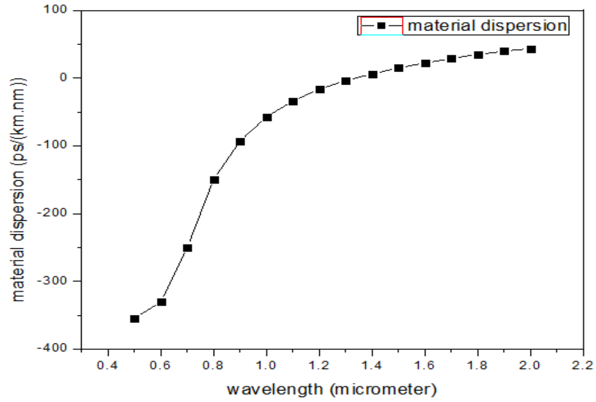

Figure 5. Material dispersion of Borosilicate crown glass PCF.

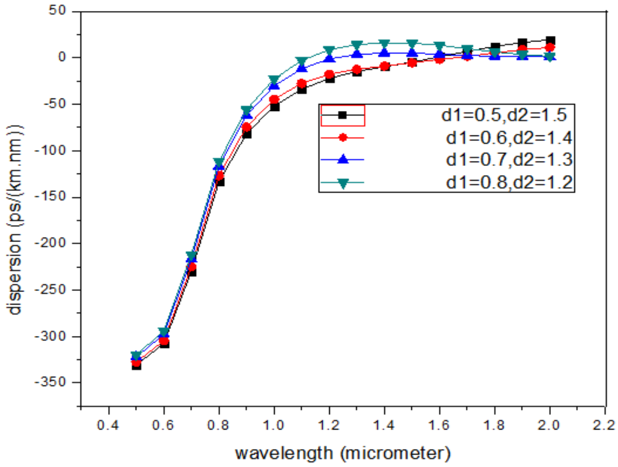

Figure 6. Chromatic dispersion of the proposed PCF for different values of the air hole diameters d_1 and d_2 when air hole spacing '^' = 2.0 µm.

The proposed Borosilicate crown glass PCF makes almost flat dispersion.

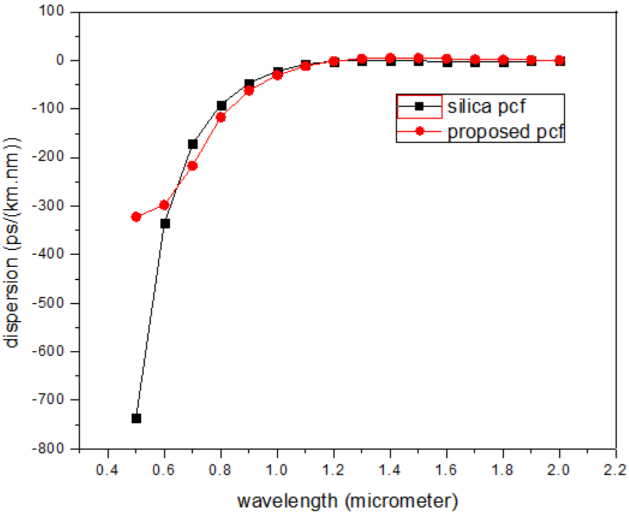

Figure 7. Shows the chromatic dispersion of proposed Borosilicate crown glass PCF and silica glass PCF when pitch '∧' = 2.0 µm, d_1 = 0.7 µm and d_2 = 1.3 µm.

V. CONCLUSION

The above results indicate that the proposed Borosilicate crown glass PCF has almost zero and flat dispersion in low wavelength range as silica glass PCF. But Borosilicate crown glass has good properties (like cheaper, good transmission, easy availability) compare to silica glass. So we can use Borosilicate crown glass as a core material on the place of silica glass. Borosilicate crown glass can substitute of silica glass.

ACKNOWLEDGEMENTS

The authors thanks Mr. Bheem Singh, Chairman, RIET, Prof. Anoop Singh Poonia, Director, Chandrawati Education Society and Ms. Kirti Vyas, HOD, Arya College of Engineering & I.T, Jaipur for valuable efforts in preparation of the manuscript.

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