ISSN: 2349-6495

New Design of Hexagonal Silica Glass PCF with Near Zero Dispersion

Juhi Jain[1], Arun Gandhi[2]

[1]M.Tech Scholar, ECE Department, Jaipur National University (JNU), Jaipur
[2]Department of Electronics & Communication, Baba Farid College of Engineering & Technology, Bathinda

Abstract—*The dispersion in PCFs likewise other conventional optical fibers determines performance of optical systems. A highly birefringent index-guiding photonic crystal fiber with flattened dispersion is proposed by introducing elliptical air holes in the cladding and small holes both in the core area and in the cladding. In this paper we investigate the method for chromatic dispersion of Silica glass from the scalar effective index method using transparent boundary condition with elliptic waveguide. It has been studied that it is possible to obtain zero dispersion in a wavelength range of 1.5 to 2.0 µm from a 6 ring into which inner three ring are designed as circular and the outer three ring are designed by using elliptic air holes for the calculation of Flat and near zero dispersion in PCF within range of 0.2 to 2.0 µm wavelength.*

Keywords—Photonic crystal fibers (PCFs),Chromatic dispersion, Elliptic waveguide,SVEI Method.

I. INTRODUCTION

Because of the excellent propagation properties, photonic crystal fibers (PCFs) have attracted considerable attention since their first fabrication in 1996 [1]. Many research groups all over the world are making constant effort to establish the superiority of PCFs over conventional fibers because of its novel optical characteristics. It has been reported that PCF can realize endlessly single-mode guiding [2], controllable nonlinearity [3], flexible chromatic dispersion over a wide wavelength range [4], large effective area [5,6] and highly birefringence [7,8]. PCF, known as holey fiber, is a microstructure fiber consisting of air hole array that run along the waveguide length of the fiber. Photonic crystals [2] usually consist of dielectric materials that serve as electrical insulators or in which an electromagnetic field can be propagated with low loss. Holes are arranged in a lattice-like structure in the dielectric and repeated identically and at regular intervals, the resulting crystal will have what is known as a photonic band gap, a range of frequencies within which a specific wavelength of light is blocked. The holes used in the lattice structure could be of different diameter or different shape. Recently the elliptic waveguide [5] properties are used to fabricate the crystal structure. The most important factor for any optical fiber technology is losses of signal. In this paper, we have designed PCF by using six sets of rings which is characterized by a different air holes, pitch with different diameters in which the six are of elliptic waveguide which is intimated in the proposed structure. The structure can ensure flat dispersion in a wide wavelength range and simple than the existing designs.

II. PROPOSED STRUCTURE

Fig. 1 shows the proposed PCF. The six layers of cladding is composed with elliptical waveguide of a common air hole pitch Λ and radius r_1, r_2. For achieving the designated larger mode area, we proposed the inner rings air holes of smaller area. We have investigated the dispersion for different air hole parameter of inner and outer ring.

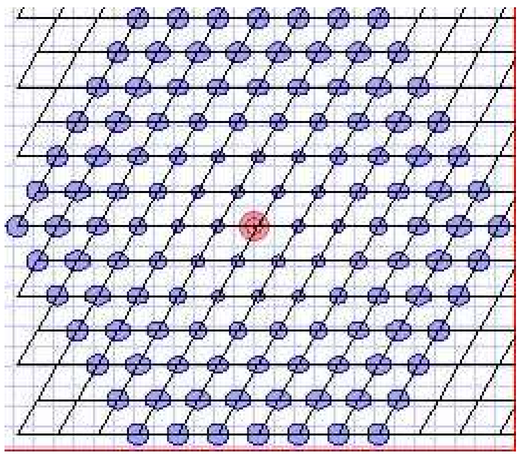

Fig1. Proposed PCF

III. STRUCTURE PARAMETER

Cladding Layers

1. r_1 = 0.3 µm, r_2 = 0.3 µm (for inner two rings)
2. r_1 = 0.4 µm, r_2=0.4 µm (for third ring)
3. r_1= 0.6 µm, r_2=0.5 µm (for forth ring)
4. r_1= 0.5 µm, r_2=0.5 µm (for sixth ring)

Where r_1 denotes the radius of major axis and r_2 denotes the radius of minor axis. Pitch ∧ = 2.0 µm
The wafer chosen is of Silica glass with 1.456 refractive index and the air hole refractive index is 1.0.

IV. DISPERSION

The dispersion (D) is proportional to the second derivative of the η_{eff} with respect to the wavelength (λ) obtained as:

$$D_W = -(\frac{\lambda}{c})\frac{d^2}{d\lambda^2}[Re\left(\eta_{eff}\right)]$$

Where Re[η_{eff}] is the real part of η_{eff}, λ is wavelength, and c is the velocity of light in vacuum. The total dispersion is calculated as the sum of the geometrical dispersion (or waveguide dispersion)

EQUATIONS

BY USING THE SELLEMIER FORMULA WE CAN CALCULATE THE VALUE OF REFRACTIVE INDEX OF SILICA GLASS-

$$n^2 - 1 = \sum_i (\frac{A_I\lambda^2}{\lambda^2 - \lambda_i^2})$$

With the help of refractive index we are calculating the value of material dispersion of Silica glass.
It is a phenomenon in which the phase velocity of a wave depends on its frequency. For the calculation of dispersion from various combinations of holes we have find that the proposed PCF structure is design as shown in Fig 2. The total dispersion consists of both waveguide and material dispersion.
And the total dispersion, D = D_M + D_W.Where λ is the operating wavelength and c is the velocity of light. D_M is the material dispersion, D_W is the waveguide dispersion.

V. RESULTS

The results, so obtained gives that the dispersion calculated for proposed photonic crystal fiber using the scalar index method gives best results in comparison of other structures.
In this paper we obtained the best result near zero dispersion at the wavelength of 1.55 µm, where the pitch value is 2.0.
Fig. 2 and Fig. 3 show the mode field pattern of the proposed PCF structure with different values.

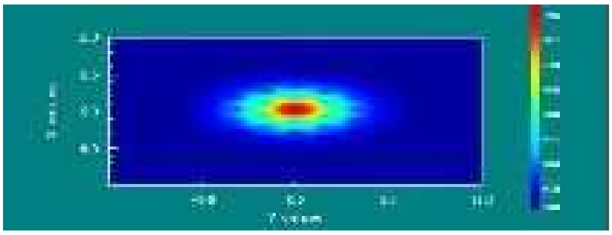

Fig. 3: mode field pattern of proposed pcf

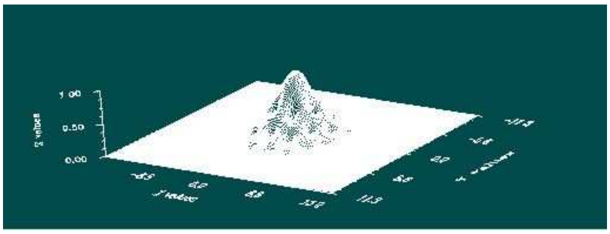

Fig. 3: 3D mode field pattern of proposed pcf

Table 1: Comparison of total dispersion at different wavelength

Wavelength(µm)	Dispersion (ps/(nm-km))
0.5	-798.23
0.6	-370.92
0.7	-177.46
0.8	-89.19
0.9	-50.16
1	-19.05
1.1	-6.17
1.2	-9.19
1.3	-8.85
1.4	-1.69
1.5	2.84
1.6	2.18
1.7	-0.63
1.8	-1.67
1.9	-0.08
2	2.96

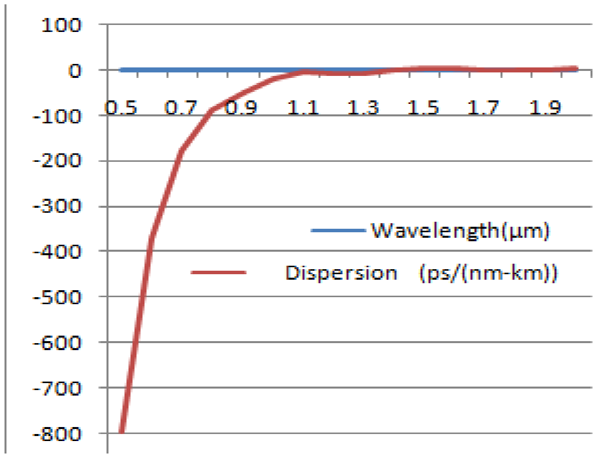

Fig. 4: Chromatic Dispersion of proposed PCF

VI. CONCLUSION

Silica material is used in the different application of the optical fiber. 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 ‘^’.

Here we have calculated the dispersion for various data but it shows that when we consider different air holes diameter of inner three layers and outer three layers then it gives best result. The fiber parameters are optimized to yield best agreement with available data.

REFERENCES

[1] Agrawal A, N. Kejalakshmy, J. Chen, B.M.A. Rahman and K.T.V. Grattan, “*Golden spiral photonic crystal fiber*: Polarization and dispersion properties”, Opt. Lett, Vol. 33, 2008, pp 2716- 2718.

[2] Shen L.P, W.P. Huang and S.S. Jain, “Design of photonic crystal fiber for dispersion related applications”, J. LightwaveTechnol, vol. 21, 2003, pp 1644- 1651.

[3] Poletti F, V. Finazzi , T.M. Monro , N.G.R. Broderick, V. Tsc and D.J. Richardson, “ Inverse design and fabrication tolerences of ultra-flattened dispersion holey fibers”, Opt. Express, vol. 13, 2005, pp 3728- 3736.

[4] Huttunen A and P. Torma, “Optimization of dual core and microstructure fiber geometries for dispersion compensation and large mode area”, Opt. Express, Vol. 13, 2005, pp 627- 635.

[5] Dong X and H.Y. Tam, “Temperature insensitive strain sensor with polarization maintaining photonic crystal fiber based on sagnac interferometer”, Appl. Phys. Lett, Vol. 90, 2007.

[6] Liu X, X. Zhou, X. Tang, J. Ng, J. Hao, T. Chai, E. Leong and C. Lu, “ Swithable and tunable multiwavelength erbium doped fiber laser with fiber bragg grating and photonic crystal fiber”, IEEE Photon. Technol. Lett, Vol. 17, 2005, pp 1626- 1628.

[7] Sapulak M, G. Statkiewicz, J. Olszewski, T. Martynkine, W. Urbanczyk, J. Wojcik, M. Makara, J. Klimek, T. Nasilowski, F. Berghmans and H. Thienpont,“ Experimental and theoretical investigations of birefringent holey fibers with a triple defect”, Appl. Opt., Vol. 44, 2005, pp 2652- 2658.

[8] Anthkowia K.M, R. Kotynski, T. Nasilowski, P. Lesiak, J. Wojcik, W. Urbanczyk, F. Berghmans, and H. Thienpont, “Phase and group modal bifringence of triple defect photonic crystal fibers”, J. Opt. A. Pure Appl. Opt, vol. 7, 2005, pp 763- 766.

[9] Chen D and L. Shen, “Highly birefringent elliptical hole photonic crystal fibers with double defect”, J. Light. Technol, vol. 25, 2007, pp 2700- 2705.