Investigation of Zero order Chromatic Dispersion for Fused Silica Glass PCF with Hexagonal structure

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***Abstract*—** A new kind extremist flattened dispersion Hexagonal structure photonic crystal fiber with two different air-hole diameters in cladding region is projected and the dispersion is investigated employing a compact 3-D finite distinction frequency domain method with the anisotropic perfectly matched layers (PML) absorbing boundary conditions. The proposed result is through numerical simulation and optimizing the geometrical parameters like by changing the hole diameter (d), pitch (^) photonic crystal fibers for the Hexagonal structure. After analyzing all the result It has been demonstrated that it is possible to obtain zero dispersion in a wavelength range of 1.5 to 2.0 μm with low confinement losses from a six ring into which ring are designed as elliptic and circular.

***Keywords*—** Effective Refractive Index (n*eff*), Photonic Crystal Fiber (PCF), Scalar Effective Index Method (SEIM), Transparent Boundary Condition (TBC).

I. INTRODUCTION

The Photonic crystal fibers (PCFs) have greater advantages like as endlessly single-mode at all different wavelengths and highly birefringent effect [1, 2]. On the other hand tailorable effective modal areas and irregular dispersion at visible and near infrared band [1] are also some other advantages. A magnetic attraction field is often propagated with low loss once Photonic crystals typically contain insulator materials that function electrical insulators. The Holes are approved in a lattice-like structure in the dielectric and repetitive identically at regular interval which is known as a photonic band gap.

The lattice configuration holes could be of different diameter or different shape. In PCFs is incredibly vital for, over a broadband wavelength aim specific, immoderate planar dispersion PCFs are essential for

optical information transmission systems [3]. On the other hand, earlier designs are all based on triangular PCFs and ultra flattened dispersion properties of square-lattice PCFs is very few on the report. Subsequently it is very essential to investigate ultra flattened dispersion in square-lattice PCFs [4]. In recent time the elliptic waveguide property is used to fabricate the crystal structure. We can also use linear waveguide to design the squared shape holes [5]. In this paper we used elliptic air holes. The Silica as a core material is extensively used for most of the PCF structure and the cladding is surrounded by the air holes and the shape of the air holes can be designed by the elliptic waveguide, linear waveguide and Arc waveguide [6, 11]. In this work we use fused silica crown glass as material. Here we are using fused silica instead of pure silica with 1% fluorine. A compact two-dimensional (2-D) finite difference frequency domain approach described in with anisotropic perfectly matched layers (PML) absorbing boundary conditions is used [1]. The calculated results show that our proposed PCF can simultaneously realize ultra-flattened dispersion and low confinement losses in a wide wavelength range. It is relative. In this paper, we propose a new kind of Hexagonal structure PCF with six rings air-holes.

II. ADVANTAGES OF PCF

The PCF is having so many unique properties in search of the thought of Research paper from the last decade as high birefringence, very high and low nonlinearity, wideband dispersion [1,7] flattened characteristics, endlessly single mode guiding [8], fiber sensors and fiber lasers which are not realizable by conventional optical fiber. Such as super prisms and three-dimensional (3-D) mirrors are perfect crystals and valuable for fabricating dispersive elements. The frequencies and directions of propagating magnetic force waves make them especially useful in optical telecommunications and as laser applications.

III. TYPES OF LOSSES AND CALCULATION

Material dispersion: Due to the different group velocities of various spectral components launched into the fiber from the optical source so that pulse broadening will occurs and produce material dispersion. It happens once the part rate of the plane wave propagating within the insulator medium varies nonlinearly with wavelength and a fabric is about to exhibit material dispersion [9, 11].

Waveguide dispersion: Determination of the distortion in signals at the output of end is done by dispersion, which is an essential categorization factor of optical fiber. The actual information carrying capacity or bit rate of the optical fiber is accountable of affection. When we examine the Dispersion gives an suggestion that the distortion to optical signals occurs when signal propagate down in the optical fibers while communication process is going on. An additional factor which affect is delay distortion. For example, creates the broadening in transmitted light pulses so that so that it will cause restriction of the information carrying capacity of the fiber [8].

In the case of digital communication due to attenuation and dispersion the sending light pulses get distorted and the light pulses become broadened in optical fiber transmission. This phenomenon is known as Inter symbol interference (ISI) so that symbol will be overlapped to each other. When at the receiver section decision making mechanics is applied so that this section can not distant between to receive symbol and will produce error (0 instant of or 1 instant of 0) [9]. The dispersion (D) is proportional to the subsequent derivative of the η_{eff}, with esteem to the wavelength (λ) obtained as:

$$D = -(\frac{\lambda}{c})\frac{d^2}{d\lambda^2}[Re(\eta_{eff})] \qquad \text{(Eq. 1)}$$

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 depends upon the calculation of the sum of the geometrical dispersion (or waveguide dispersion) and the material dispersion obtained as:

$$D(\lambda) = D_g(\lambda) + \Gamma D_m(\lambda) \qquad \text{(Eq. 2)}$$

Where Γ is the confinement factor in material (if we use Borosilicate crown glass), which is close to unity for the most practical PCFs as the modal power is almost confined in the material with high refractive index.

Confinement Loss: An additional imperative loss is confinement or leakage loss originates from the finite width of the cladding structure. By selecting the parameters *d* and Λ properly in PCFs we can formulate confinement loss minor. On the other hand, for miniature core fibers wherever the core size is analogous or slighter in dimension than the conceded light-weight wavelength, a foremost involvement in full loss of the fibers is accessible by the confinement loss [9]. Confinement loss is predominantly dominating within the wavelength region attention grabbing for telecommunication applications, as typically imperative negative conductor dispersion is absolute because of dispersion. The bulky negative conductor dispersion around 1550 nm may be achieved by lease the sphere go through into the shield region, which consecutively provides rise to augmented confinement loss. Low confinement loss may be achieved for small core PCFs by coming up with the fibers with a minimum of 6 rings of air holes for a closely packed structure. Raising the amount of air hole rings ends up in a supplementary reduced confinement loss (Eq.3) [10, 12]

$$\text{Confinement Loss (dB/m)} = 8.686\ \text{Im}[k_0 * \eta_{eff}] \qquad \text{(Eq. 3)}$$

Where $k_0 = \frac{2\pi}{\lambda}$, λ is wavelength of light and η_{eff} is the effective refractive index of the proposed.

IV. PROPOSED DESIGN

Table 1 Structure parameter of PCF for achieving flattened dispersion for different structure.

Parameter(unit)	Value
Pitch	2 μm
Holes diameter (d) (μm)	Variable
Air fraction refractive index	1.0
Silica glass refractive index	1.458
Propagating wavelength (μm)	1.55 μm
Number of rings in the cladding	6 Rings

Here I proposed three design structures which have common design parameter except the diameter of holes in all the rings as shown in Table 1.

Design-1

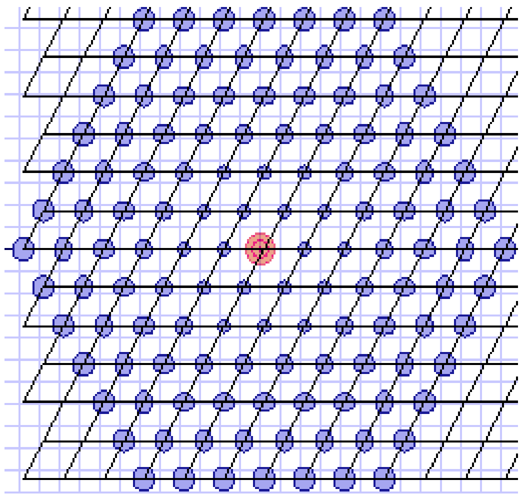

Figure 1 Proposed design PCF

Design-II

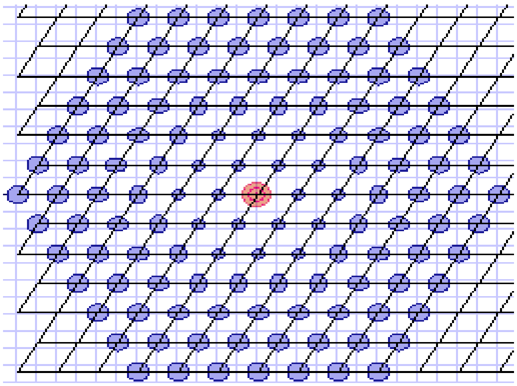

Figure 2 Proposed design PCF

Design-III

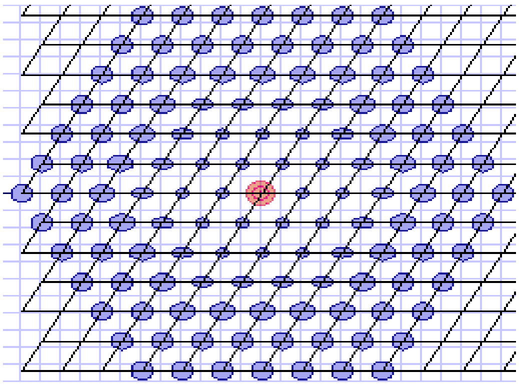

Figure 3 Proposed design PCF

In my proposed work there is a comparison between all the three designs is based on Total dispersion (chromatic dispersion) and Confinement loss as shown in Figure 4. The total dispersion or chromatic dispersion is the sum of waveguide dispersion and material dispersion.

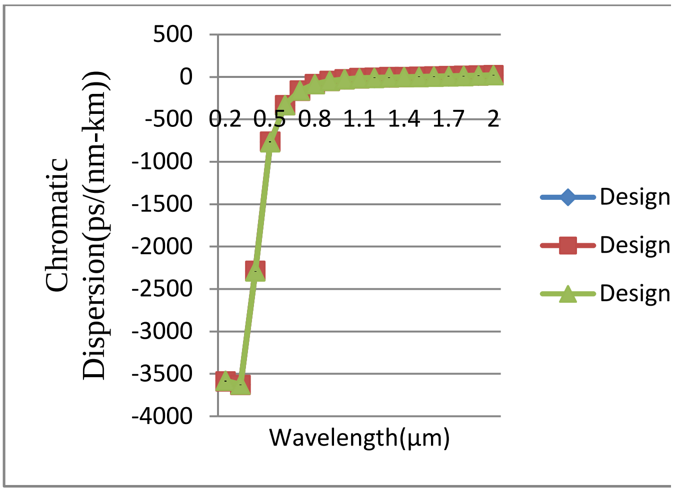

Figure 4 Flattened Dispersion comparison between different proposed structures.

Also Figure 5 showing the confinement loss comparison loss between all three structures.

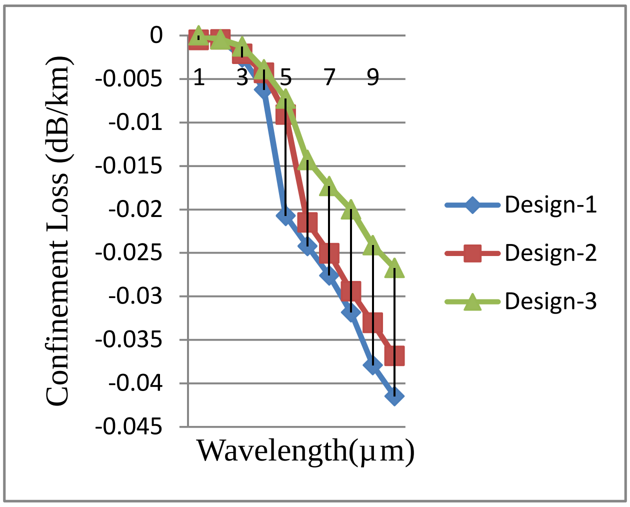

Figure 6 Confinement Loss comparisons for all three proposed structure

V. RESULT

All the three Proposed PCF structure provides us flattened dispersion values. We have already shown that the proposed PCF can exhibit almost zero dispersion. Among three structures, Design-III has nearly zero dispersion at 1.55µm wavelength. For the confinement loss again comparison between three structures, Design-III gives minimum confinement loss below -0.03dB/km. In this paper of the proposed PCF with six rings of array of air holes is designed for investigation of almost zero dispersion and minimum confinement loss with the elliptic air holes but holes have different diameter.

VI. CONCLUSION

According to above conclude result, so we obtained that the dispersion calculated for proposed photonic crystal fiber using the Scalar index method gives best result in comparison of other structures. So that here we have calculated the dispersion for various structure but it shows that when we increase the diameter of holes both Chromatic dispersion and Confinement loss are decrease with comparison to other structure with less diameter but Pitch 2.00 µm is same for all and select total 6 layers, gives best result. The fiber parameters are optimized to yield best agreement with available data.

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