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An Effective Single Core Photonic Crystal Fiber For Minimum Dispersion

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Abstract

We are proposing a new modified design of hexagonal single core crystal fiber (PCFs) in this paper. Silicon material is used for Photonic Crystal Fiber design. The proposed design consist of one circle on wafer sized 50umx50um. Simulation is done using OpticFDTD software for evaluation of electric field distribution with polarization and dispersion. The propose design shows minimum dispersion as compared to other Photonic crystal fiber available.

Keywords: OptiFDTD software, electric field distribution with polarization, dispersion, total internal refection.

INTRODUCTION

In today's digital era Photonic Crystal Fibers (PCF) due to its variable dispersion behavior has attracted many researcher [1]. Due to unique nature and variable structural parameters. PCF is a involved in various applications such as gas sensors, Non liner device, high power transmission and many more [2-13]. Unique parameters of PCF helps to have various propagation characteristics. Such as confining the light forward at core [3-4]. PCF commonly referred as holy fiber (HF) evolving silicon has vast unique characterization in over proposed design [10-13]. We have investigated the electric field distribution with polarization and dispesion.

This paper is divided into five section. Section I presents brief introduction. Technical details of proposed structure is discussed in section II. Section III discuss the proposed structure. Simulation and outcome is discussed in section IV. Section V describes the comparison and conclusion.

PCF GEOMETRY

The geometry of PCF is presented in Fig 1. It consist of hexagonal high core photonic crystal fiber with dimension 50.00 um (length) X 50.00 um (width).The dimension for uniqueness are refractive index (n)=1.46,diameter(d)=2.4um and pitch value =2.3.

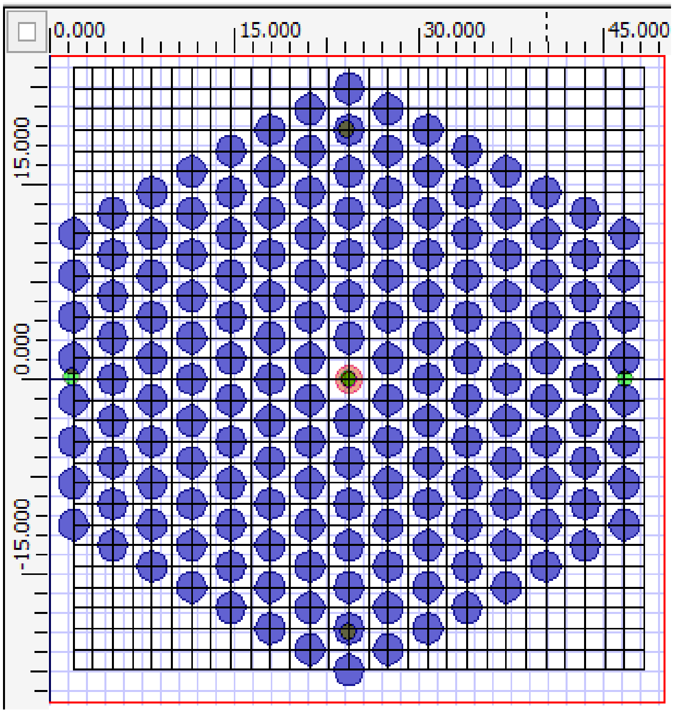

Figure 1. Single core hexagonal structure of PCF

Proposed geometry of PCF is simulated via Opti Wave FDTD Software.

TECHNICAL DETAILS OF PROPOSED STRUCTURE

In this section, we propose a new design of index guided photonic crystal fiber. The proposed geometry of index guided PCF design is shown in Fig. 1. The proposed hexagonal shaped PCF structure consists of one circular Elliptic Waveguide of equal radius. The second innermost ring consists of circular air pipe of fixed radius 2.4µm and pitch value 2.3 um.

For Simulation propose radius of PCF is kept constant at diameter 2.4 um and wavelength varied 1.35 um & 1.4 um for calculates refractive index and electric field distribution with polarization. Simulation is carried out for getting effective electric field distribution and polarization with variable axis for minimizing the dispersion.

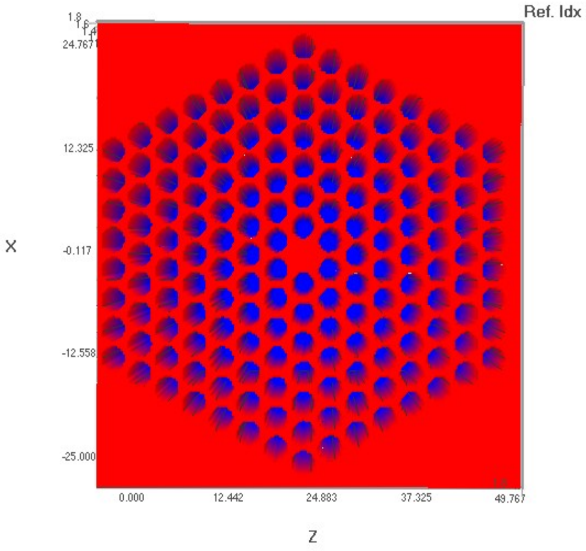

Figure 2. Single core refractive index hexagonal structure of PCF.

The waveguide dispersion is calculated at different wavelength using equation 1 [1-7].

$$D = -\frac{\lambda}{C}\frac{d^2 n_{eff}}{d\lambda^2} \qquad \text{.....eq.1}$$

Table 1. Eq.1parameter details

Parameters	Nomenclature	Units
D	Dispersion	ps/(nm-km)
n_{eff}	effective modal index	µm
C	velocity of light	µm
Λ	Wavelength	µm
L_c	Confined loss	µm
B	Birefringence	NA
$n_{x,}$, n_y	Effective refractive	NA
Note. 2nd order derivative is computed for evaluation.		

Two more formulas utilized for formation of geometric as per eq. 2 and eq.3 for birefringence and refractive index.

$$B = (n_x - n_y) \qquad \text{...... eq.2}$$

where B is the birefringence, n_x and n_y are the effective refractive index .

$$L_c = 8.686\text{Im}[k_0 n_{eff}] \qquad \text{.....eq.3}$$

Where $k_0$is the gap number and is capable $\frac{2\pi}{\lambda}$, λ is the corresponding wavelength, Im[n_{eff}] is the imaginary part of effective modal index number [8].

The proposed structure is simulated and analyzed as per table 1 and geometry Fig.1, for electric field distribution with polarization and dispresion at the output of optical fiber.

Table 2. Various parameters assumed in structure of PCF

S. No.	Content	Holes
1	Wafer Dimension	Length = 50 um Width = 50 um
2	Wafer Material	Silica
3	Material 2D	Air
4	Material 3D	Silica
5	Inputs	PointSource1
6	Pitch	2.3
7	Radius	1.2um
8	Diameter of air holes	2.4um
9	Refractive index	1.46

SIMULATION RESULTS AND ANALYSIS

Using the signal final proposed geometry of PCF as per Fig.1is simulation consisting of wavelengths 1.35um and 1.4um. Pitch factor is kept 2.3 from center to center at equal spacing between two air holes to get characteristics of lattice.

Assumed dimension of proposed geometry of PCF are as per table 2.

The proposed structure is uploaded via refractive index for 3d mode and corresponding results obtained are projected in fig 3 to fig 5. The result justifies that dispersion is very less and proper coupling of signal can be achieved to the best extend. It further justifies uniform distribution of electric field distribution.

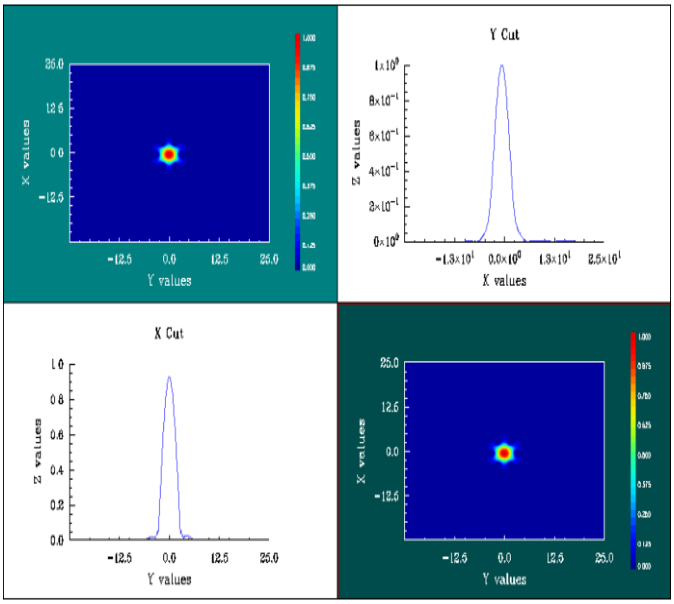

Figure 3. Electric field distribution with polarization core region and waveguide pattern.

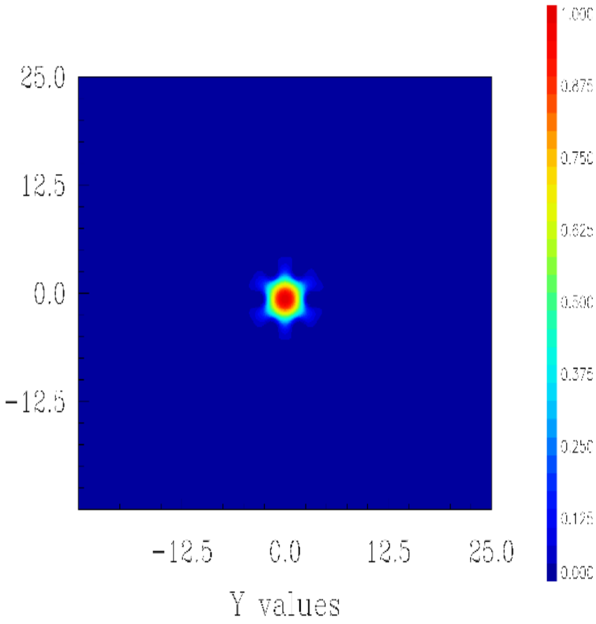

Figure 4. Electric field distribution with polarization core region

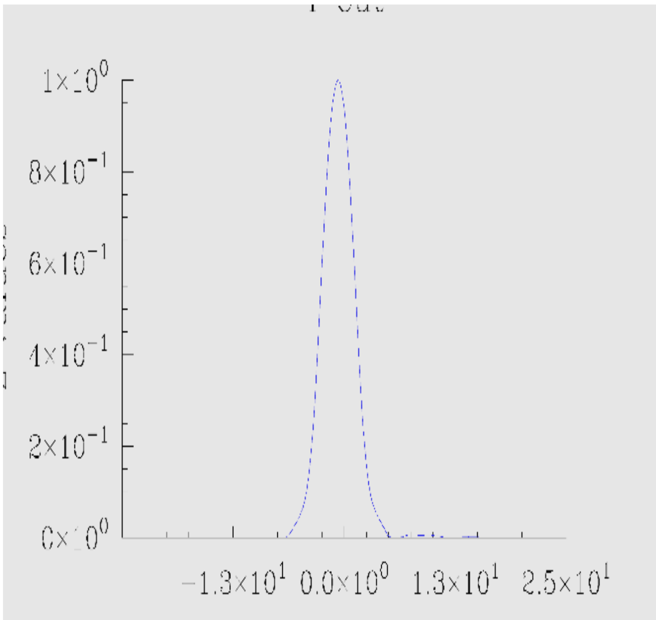

Figure 5. Electric field distribution with polarization

The proposed simulation maybe used in applications were mininezion dispersion is at most inportant.

Table 3. Comparison of parameters

S. No.	**Content**	**Holes**	**Other works[8]**
1	Wafer Dimension	Length = 50 um Width = 50 um	Length = 32 um Width = 32 um
2	Wafer Material	Silica	Silica
3	Material 2D	Air	Silica
4	Material 3D	Silica	Air
5	Inputs	PointSource1	PointSource1
6	Pitch	2.3	1
7	Radius	1.2	0.6
8	Diameter of air holes	2.4	1.2
9	Electric field distribution	**Uniform**	**Non-Uniform**
10	Polarization	**Effective**	**Present not effective**
11	Dispersion	**Minimization**	**About threshold**

We have also compared the evaluated result of other work with our work, which finally justifies that if uniform electric field distribution with effective polarization and minimum dispersion is required than our geometry is the better option. The only limitation is slight increase in pitch, radius & diameter of holes.

CONCLUSION

As per result obtained we can conclude that proposed structures is more robust for low dispersion with uniform electric field distribution supported by uniform polarization. As the dispersion is minimum the PCF proposed can be utilized for tele-communication, bio-medical and industries etc.

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