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Analysis of Blocked to Spherical Hexagonal Silica Photonic Crystal Fiber to Minimize the Dispersion Profile and Confinement Loss

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***Abstract*— Photonic crystal fibers (PCF) have been investigate two decade back to improve the transmission properties. Initially Optical fibers were in used to transmit data through long channels. There were a great loss of information and the received data was not able to serve properly in all manners. So later on in the field of investigation in 1956 the term was first coined by Mr. N.S. Kapany while he was working in images transmitting device named fiberscope. Number of research papers available in the field of Photonic crystal fibers with different design parameters. Everyone tried to receive better output characteristics using their designs. Here in this paper we also tried to design an angularly displaced blocked to spherical hexagonal structure of PCF using Silica as a PCF material. The aim of this design is to achieve improved optical characteristics by considering various optical parameters. Here Prime consideration for the proposed design are Selecting the diameter of air holes, maintaining the distance between two air holes which is known as pitch, selecting the number of rings or layers for the proposed design. Thereafter with these input parameters the design is simulated to obtain better optical characteristics. Here we try to improve Dispersion, Transmission factor, Confinement loss and Refractive index using sellemier equation.**

***Index Terms*— PCF, Sellemier formula, Dispersion, Refractive Index (R I), Confinement Loss.**

I. INTRODUCTION

The first generation of optical fibers, called multi-modal was large, with core diameter 50-200 µm and cladding 20 µm thick. The large core made the fiber durable. They are easily coupled and easily infused with a light wave. Typically multi-mode fibers are used to transmit infrared light (λ=850 -1,300 nm) from light emitting diodes (LEDs). Over long distances these modes or signal paths have different transit lengths and therefore different signal transit times. The aforementioned terms are often used to describe an index-guiding PCF in which light is confined to a high-index core, surrounded by an air-silica cladding with a lower effective refractive index. Another type of PCF is called photonic band gap fiber (PBF). These fibers guide light in a low-index core through the photonic band gap effect [1].

Photonic crystal fibers are novel optical waveguides that possess a periodic micro structured cladding around a solid or hollow core in the plane perpendicular to the fiber axis. Due to their unique geometrical structure, these fibers can exhibit a large number of optical properties not obtainable in conventional optical fibers [2]. The PCF technology provides great flexibility in terms of geometry and refractive index profile. The main types of PCFs are the following: Index-guiding PCF, Hollow-core PCF, and all-solid Photonic Band-gap Fibers (PBGFs). [3]

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II. METHODOLOGY FOLLOWED:

The proposed structure shown here is designed using Opti FDTD (Finite Difference Time Domain) software. The methodology took place with the selection of appropriate parameters. Number of parameters is varied to achieve better output characteristics like dispersion, refractive index, confinement loss and transmission factor. To achieve nearly zero dispersion it is considered that the diameter of the air hole is kept at 0.5 µm. The distance between two air hole is maintained at 1 µm. For this five layers are considered. The simulation is done using opti FDTD by 19 iterations range of wavelength from 0.2 to 2.0 µm. Finally the designed structure is simulated and the result is obtained which provides the objective of the paper.

III. PROPOSED DESIGN:

By considering parameters mentioned above final structure of proposed work is achieved. It is shown below in figure 1.

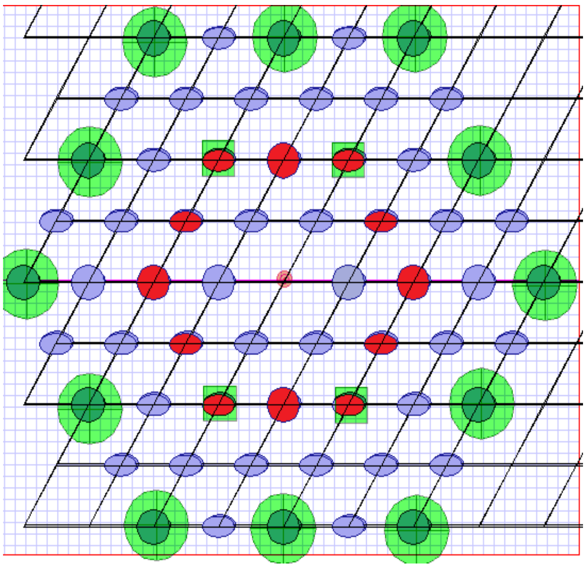

Figure:1 Proposed Hexagonal PCF Structure

This design shows the basic angularly spaced blocked to spherical hexagonal view of the proposed design. The design itself contains small-small honeycomb structure which serves for improvement in optical characteristics.

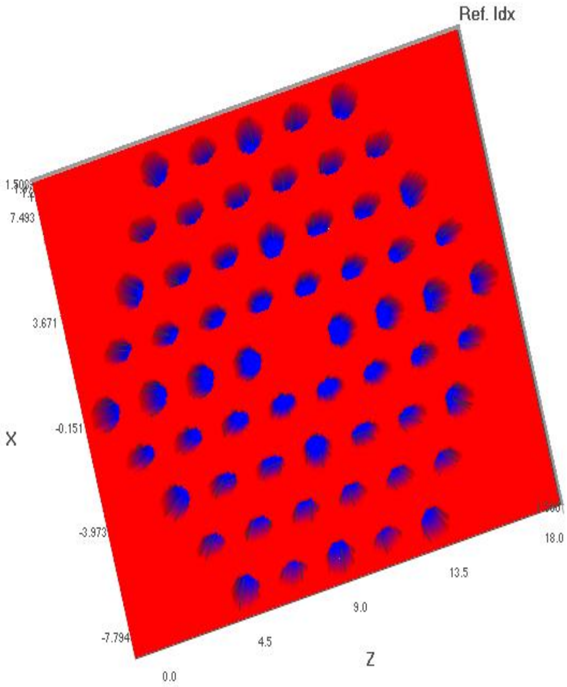

Figure: 2 2D view of proposed structure

Figure 2 above shows the 2D view of the proposed design. It shows the air holes spacing and mode filled pattern of the proposed design. Similarly 3D view of the proposed design is also shown below in figure 3.

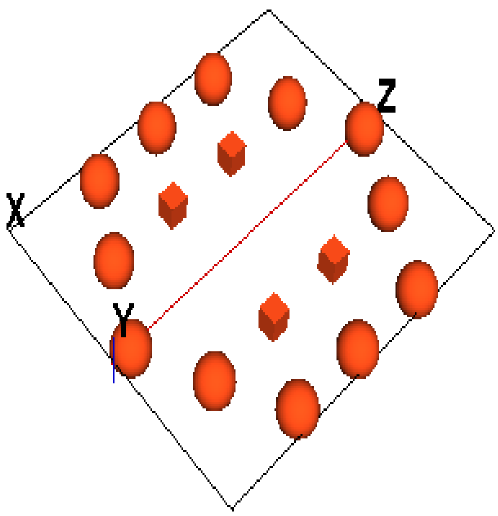

Figure: 3 3D view of proposed design

The Total-field/Scattered-field (TF/SF) technique results from attempts to realize any tilting plan-wave source that avoids the difficulties caused by using either the hard source or the boundary conditions. 2D TF/SF is a special type of formula that generates a wave in the enclosed rectangular surface. Inside the rectangular region, it generates the total field (including incident wave and scattering wave together). Outside of this region, it generates the pure scattering field or reflected field. Figure 4 shows a 2D sketch for 2D TF/SF.

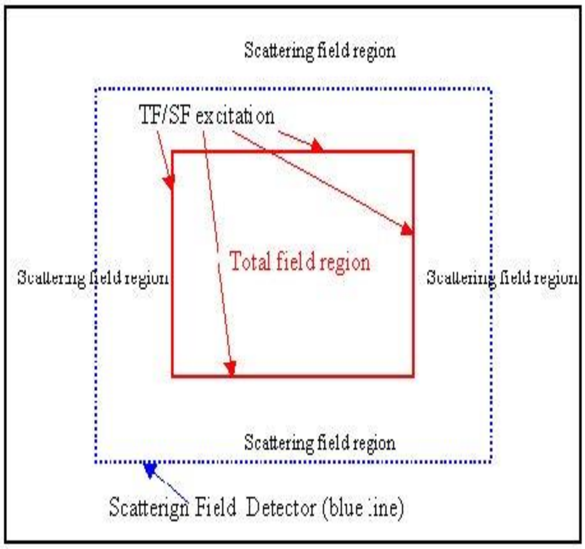

Figure: 4 TF/SF Sketch

TF/SF uses special numerical formula to separate the total field and scattering field. A 2D free space TF/SF response is shown in Figure 5.

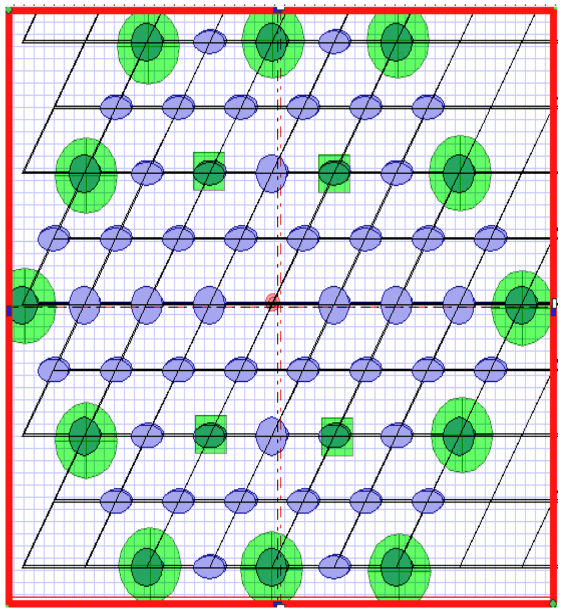

Figure: 5 Field responses for a TF/SF sketch

In OptiFDTD, it is the user's choice to set up the total field working area position, size and the scattering field detector position. After the simulation, the steady state scattering field response can be obtained in the scattering field detector. If all four scattering- field detector lines are active, Radar Cross Section (RCS) can also be performed based on the near scattering field response,

- **Observation Point**

Observes the time domain and frequency domain response. The transmission function can be obtained from the Observation Point analysis.

- **Observation Area**

It is used to compute power transmission ratio, normalized power (power transmission /reflection) versus wavelength and Heating Absorption.

OptiFDTD, transverse Gaussian Beam is expressed as

$$E(x) = A \cdot \exp\left[-\frac{(x-x_0)^2}{2T^2}\right]$$

--------------------- (1)

Where x_0 is the center position and T is being called as half width.

In general, Gaussian Beam radius is the radius at which the field amplitude and intensity drop to *1/e* and *1 / e*^{2}, respectively. Gaussian Beam Size or Gaussian Beam Spot size is the beam diameter which is two times of Beam Radius. Suppose the beam size is denoted as a, which means

$$E\left(x = \frac{a}{2}\right)\Bigg|_{x_0 = 0} = \exp(-1) = \exp\left(-\frac{a^2}{8T}\right)$$

-- (2)

This means

$$T = \frac{a}{2\sqrt{2}}$$

----------------------------- (3)

IV. RESULTS & DISCUSSION:

From the above selected parameters the proposed design shows some variations in the dispersion profile, refractive index, confinement factor and transmission curve. Here we have some database collected from simulation results which are shown below in figures.

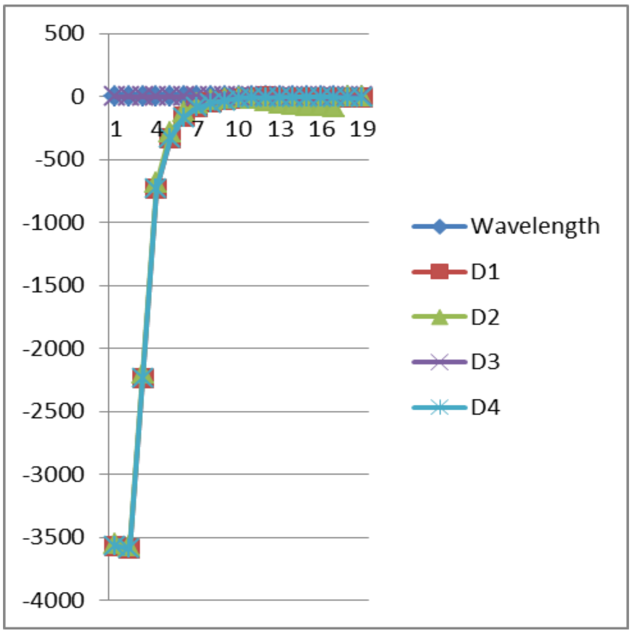

Figure: 6 Analysis of Dispersion of proposed structure

From the above figure 6, it is clear that the proposed design shows nearly zero dispersion at 0.7 to 1.2 micrometer wavelength region. The average dispersion so obtained for this design is 1.125 ps $km^{-1}nm^{-1}$.

Below Figure 7, shows the refractive index of the proposed design. It shows that refractive index of the proposed design is approximately 1.456 in the wavelength region from 0.2 to 0.9 micrometer.

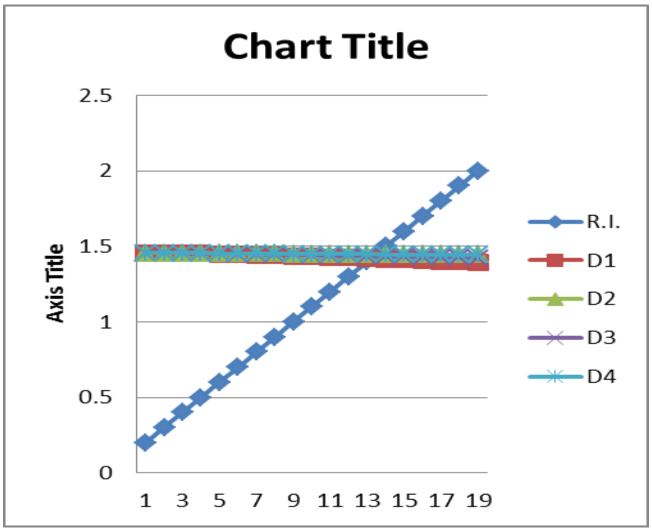

Figure: 7 Analysis of Refractive index of proposed structure

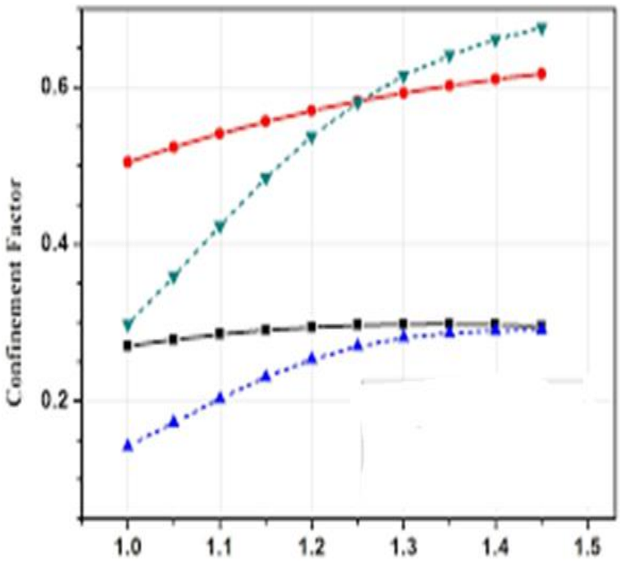

Figure: 8 Confinement Factor for proposed design

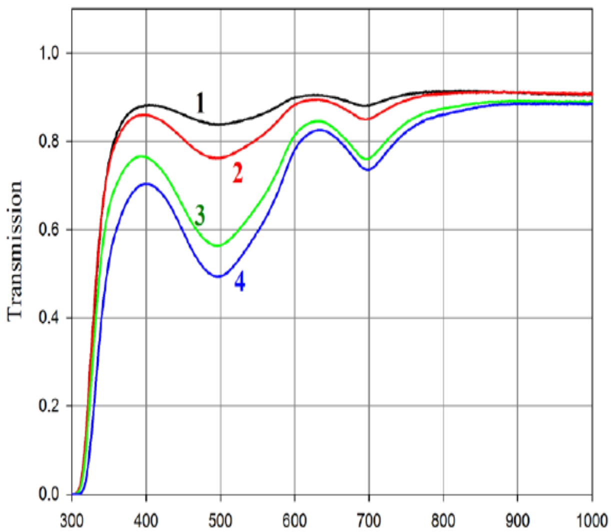

Figure: 9 Transmission Curve of proposed design

Figure 8 and 9 above indicated the confinement factor and transmission curve of proposed structure respectively. It shows that average confinement factor is about 0.006 dB km^{-1} while the average transmission lies in the 0.4 to 0.6 micrometer range.

V. CONCLUSION:

From the discussion and graphs plotted above it is concluded that the proposed structure shows better optical characteristics in the selected wavelength region. The proposed design shows nearly zero dispersion at 0.7 to 1.2 micrometer wavelength region. The refractive index of the proposed design is approximately 1.456 in the wavelength region from 0.2 to 0.9 micrometer which is approximately equal to silica refractive index i.e. 1.457. The confinement factor and transmission curve are better and shown properly here.

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