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Research paper

Designing of Rectangular Photonic Crystal Fiber to Minimize the Total Dispersion

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Abstract

Since optical fibers are extra thin strands of ultra-pure glasses which are designed to transmit lights from transmitter section to a receiver section. Such light signals can be represented as electrical signals which include audio information, videos information or various data information in any combination. Since everyone knows that an optical fiber consists of three main regions. The center region of the fiber is known as **core**. This core region actually used to carries light. Its diameter lies in the range from 9 micrometer (μm) to 100 micrometer. In this paper I just try to design a rectangle structure of silica fiber with an alternate diameter range in every layers of the design which varies from 0.5 micrometer to 1 micrometer and kept pitch of the design is 2 micrometer. With all these parameters I found the refractive index of the designed Structure obtained is 1.433 and calculated dispersion in the 2 micrometer to 20 micrometer range is nearly zero.

Keywords*: PCF, Opti FDTD, Sell Meier, R.I., Dispersion*

1. Introduction

Optical fibers plays an important role as a transmission medium Because it provides a private pipeline way which can carries a huge amounts of information containing data. This is different from over-the-air broadcast or hard-wired copper wire lines carrying electrons. It can transmit data in various schemes. Among them three schemes are discussed here.

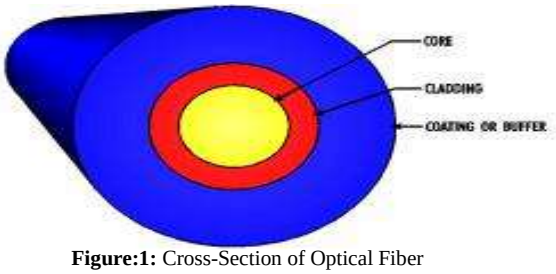

Figure:1: Cross-Section of Optical Fiber

The first scheme uses a metallic transmission with a copper wire or coaxial cable to convey a modulated electrical signal containing information data. This scheme allows for a limitless number of channels in which each channel has limited information of data and distance capability of copper cable. This scheme is shown in figure 2.

2. Refractive Index

The Index of Refraction or in general refractive index is defined as value calculated from the ratio of the speed of light in a vacuum medium to that in a other medium of different density. If light impacts the interface between two medias then it is partially reflected and partially refracted. The refractive index can be calculated by snell's law. It shows that the incident angle **θ(1)** is related to the refraction angle **θ(2)** which can be represented by Snell's law as follows:

$$n_1 \times \sin(\theta_1) = n_2 \times \sin(\theta_2)$$

Here **n** is represented as refractive index of material 1 and material 2 in different mediums and **θ** is the angle of light traveling through these materials with respect to the normal. When the two refractive indices are equal (**n(1)** = **n(2)**), then the light is passed through without refraction.

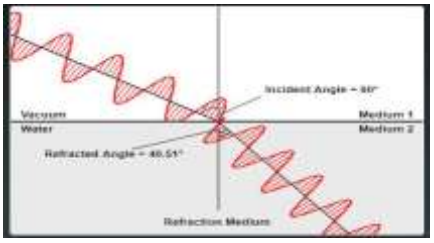

Figure: 2: Refraction of Light

The **refractive index** is also defined as the ratio between the velocity of light (**c**) in free space and its velocity **η** in a particular medium. This is given as

$$n = c/\eta$$

The refractive index of a medium depends on the frequency of light passing through it. That is the highest frequencies having the highest values of **n.** The Gregory's refractometer can be used to

calculate index of refraction. Some time we can also use The **Sellmeier equation** which is an empirical relationship between refractive index and wavelength for a particular medium. This was first proposed in 1871 by Wilhelm **Sellmeier**.
The Sellmeier equation is given as:

$$n(\lambda) = \sqrt{1 + \sum_{i=1}^{M} A_i \cdot \frac{\lambda^2}{\lambda^2 - {\lambda_i}^2}}$$

Where λ is wavelength and A is constant. Today Sellmeier formula is widely used in optical science and optical industry to describe and characterize the dispersion**.**

3. Dispersion:

Simplest meaning of dispersion is a lack of uniformity in the sizes or quantities of the items of a group or series. The word dispersion can also be used to indicate the spread of the information data. According to Reiglemen, "**Dispersion** is the extent to which the magnitudes or quantities of the items differ from the original data or the degree of diversity obtained. Dispersion is a value which indicates the extent to which all other values are dispersed about the central or threshold value in a particular distribution. The average measures the center of the data, and it is one aspect of observation.
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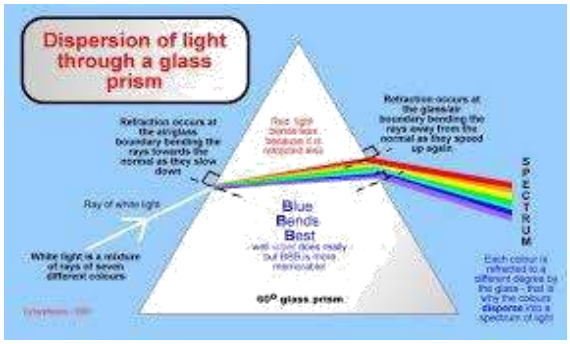

Figure: 3 Dispersion

Material Dispersion occurs due to the interaction of various wavelengths with the physical matter in the crystalline structure of the glass. As the wavelength increases or

frequency decreases, the material dispersion decreases.

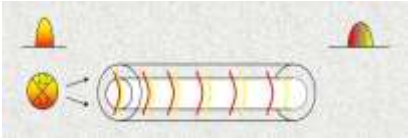

Figure: 4 Material Dispersion

Waveguide dispersion or chromatic dispersion arises due to waveguide effects. The dispersive phase shifts for a wave in a waveguide differ from those which the wave would experience in a homogeneous medium.

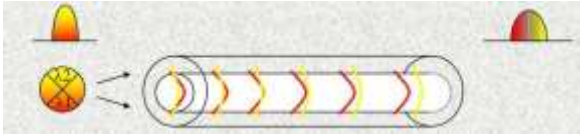

Figure: 5: Waveguide Dispersion

The total dispersion is the combination of both Material & Waveguide dispersions.

4. Proposed Design

To calculate the refractive index and dispersion of silica material with the novel rectangular design I prepare a four layer rectangular structure having diameter of air holes is 2 micrometer, pitch is 1 micrometer keeping alternate air hole missing in each row. In this way when I used Opti FDTD then I found its refractive index is 1.435 and dispersion for these parameters is zero. The proposed design is shown below:

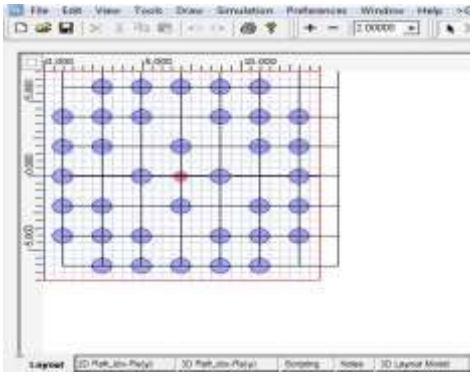

Figure: 6: Proposed layout design

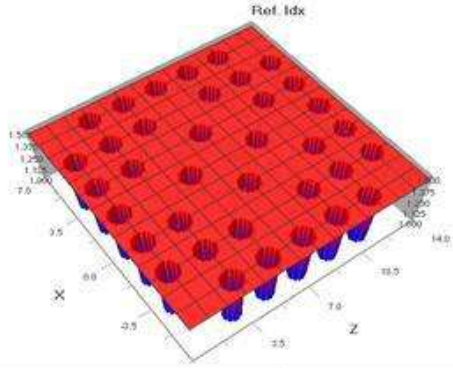

Figure: 7: 2D structure of proposed design

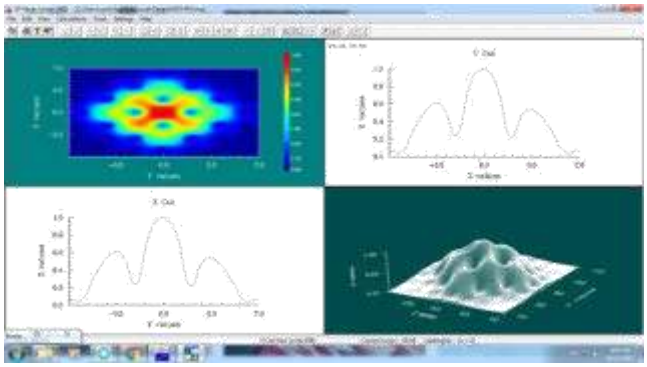

Figure: 8: Mode solver diagram of proposed design

With all these parameters when I calculate the refractive index and dispersion I found the result which is shown below with graphical representation.

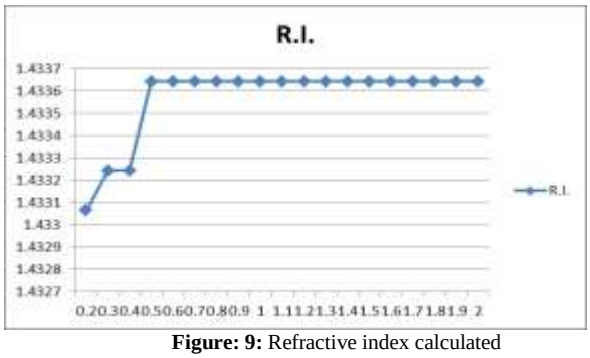

Figure: 9: Refractive index calculated

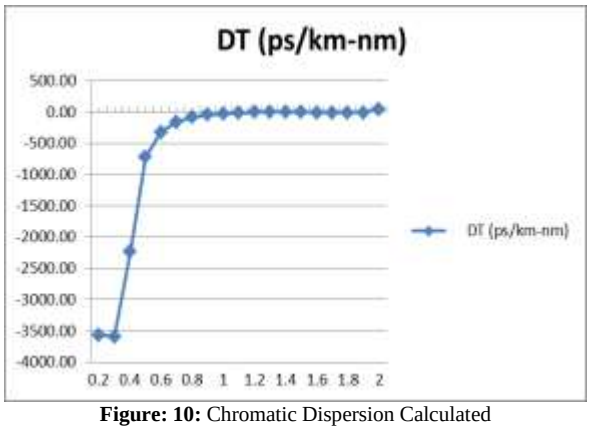

Figure: 10: Chromatic Dispersion Calculated

5. Conclusion

In the end I would like to conclude that with the use of proposed rectangular design of silica PCF I found refractive index as 1.435 and dispersion is zero. When we try to manipulate the parameters used then such result vary accordingly and it differs the result so obtained.

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