Calculating Modal Index for Different Lattice Pitch Using Hexagonal PCF

Md.Mahbub Hossain and Dr. Md. Maniruzzaman

***Abstract*—The design of Photonic Crystal Fiber (PCF) is very supple. There are several parameters to control: air hole shape and diameter, refractive index of the glass, type of lattice and distance between hole to hole that is lattice pitch. Autonomy of design allows one to obtain endlessly single mode fibers, which are single mode in all optical range and a cut-of wavelength does not exist. By manipulating the structure it is probable to design desired dispersion properties of the fiber. PCFs having zero, low, or anomalous dispersion at visible wavelengths can be designed and fabricated. In this paper, we have tried to get the effective modal index of hexagonal PCF considering different lattice pitch using OPTI FDTD 8 Software.**

***Index Terms*—Dispersion, Lattice, PCF, Refractive Index**

I. INTRODUCTION

The idea of a photonic crystal fiber was available for the first time by Yeh [1] in 1978. They proposed to clad a fiber core with Bragg grating, which is similar to 1D photonic crystal. A photonic crystal fiber made of 2D photonic crystal with an air core was made-up by P. Russell in 1992 and the first PCF was reported at the Optical Fiber Conference (OFC) in 1996 [2].

PCFs have achieved outstanding properties in birefringence [3], dispersion, single polarization single mode [4], nonlinearity [5], and effective mode area [6], and also excellent performances in the applications of fiber sensors, lasers and nonlinear optics over the past several years. Great numbers of research papers have highlighted some optical properties of the PCFs such as ultrahigh birefringence and unique chromatic dispersion, which are almost impossible for the conventional optical fibers.

PCF consisting of homogeneous medium, frequently undoped silica, with a lattice of air holes [7]. The guiding region is realized by breaking the lattice periodicity at the center of the fiber. In this case, the guiding effect is due to the transverse propagation keep back of the air hole photonic crystal band gap. Recently, the guiding consequence has been recognized also in holey fibers (HFs) with an unequal [8] or even with an arbitrary [9] hole distribution.

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In these cases, some authors [10], [11] described the field confinement to total internal reflection because, by removing a hole, a high-index region bounded by a lower average index is obtained.

Anyway, the guiding mechanism can be qualified, in all cases, to multiple interferences due to the periodic or to the random set of the air holes and, as a consequence, it strongly depends on the geometry of the cross section, in particular on shape, dimension, reciprocal distance, and arrangement of the holes. For all these reasons, a numerical model is able to accurately describe the extraordinary properties of both PCFs and HFs, in so far as it is able to accurately describe geometrical characteristics of the cross section. The fiber cross section representation is very accurate being the domain divided into sub domains with triangular or quadrilateral shape and step index profiles can be exactly presented. The finite difference approach allows polarization effects to be taken into account, and mode effective indexes are directly given as output data. This has allowed the investigation of chromatic dispersion in PCFs and hole-assisted fibers as well as the understanding of how geometrical characteristics can affect transmission properties such as group velocity dispersion (GVD) and polarization mode dispersion in PCFs or HFs.

In this paper, we have calculated the effective modal index of three different lattice pitches 2.2μm, 2.3μm and 2.4μm by simulating the hexagonal Holey PCFs with core radius is 0.6μm.

II. SIMULATION METHOD AND RESULT

Vast potential of geometry manipulation and air-holes shapes arrangements have increased the complexity of numerical analysis of PCFs. The main purpose of simulations is to find out the correct mode effective refractive index which will be essential for study of propagation characteristics of Holy PCFs. Such structures demand efficient numerical methods to analyze them accurately. Thus, many modeling methods have been applied in this perception, such as the plane wave expansion method, localized function method, finite element method, finite difference time domain method, finite difference frequency domain method, Fourier composition method or multipole method. The results presented in this paper have been achieved by using the Finite Difference Time Domain method (FDTD). For a given frequency, the numerical propagation constants and mode patterns can be calculated. The main geometrical quantities concerned: hole diameter d, the hole pitch Λ used in the implementation are displayed in Fig. 1.

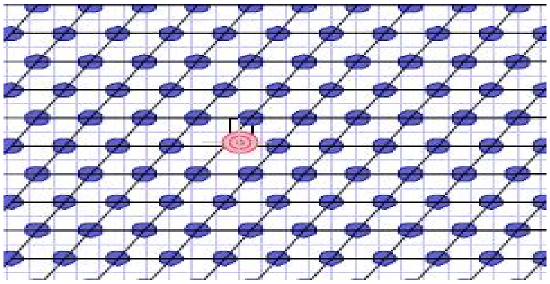

Fig.1 Hexagonal PCFs Cross Section Geometry

For simulation, the wavelength 1.3µm is used with number of modes is 1. Also, core radius is 0.6µm, mesh delta X (µm)-0.0890 and Z (µm)-0.0890, run for 840 time steps(auto), boundary condition TBC and complex modal solver is used. Used three different pitch lattice Λ=2.2µm, Λ=2.3µm, Λ=2.4µm. After simulation, for Λ=2.2µm the effective modal index is 1.44117788, for Λ=2.3µm this is 1.44317666 and last for Λ=2.4µm, this index is found 1.44472389 and for all three the polarization is FVect TE. Fig. 2. shows the refractive index distribution and remaining Fig.(3-5) shows the field intensity and confinement of Electric field Ey.

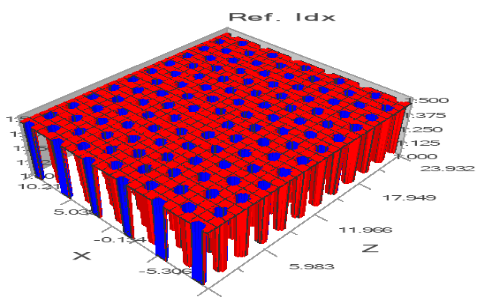

Fig. 2 Refractive Index Distribution of Hexagonal PCFs

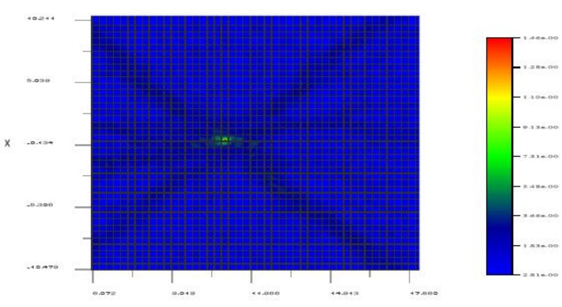

Fig. 3 Electric Field Intensity Ey

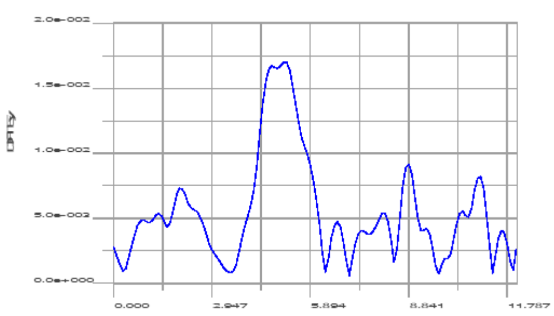

Fig. 4 Electric Field Intensity DFTEy

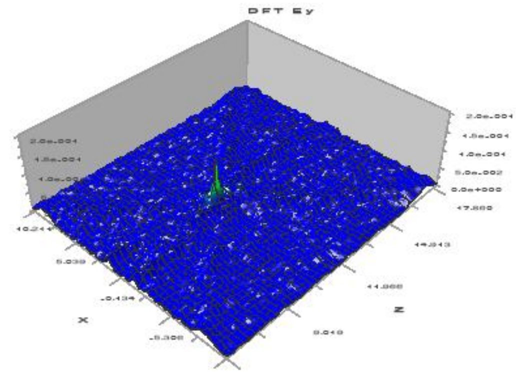

Fig. 5 Electric Field Intensity 3D view

III. CONCLUSION

The main objective of this paper is, to get the effective modal index for three different lattice pitches and observed the refractive index distribution and electric field intensity. For three different lattices pitch the effective modal index is changed significantly which we thing will be great effect in the dispersion study. Further investigation will be carried out consideration different geometry of Holy PCFs to get the accurate modal index that will useful for achieving dispersion, loss etc.

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