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Analysis of Refractive Index in Decagonal Structure of Photonic Crystal Fiber having Hole within Core

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Abstract— **This paper comparatively analyzes decagonal 4 clading ring structure having circular & square hole within core and structure without hole in core. All simulations have been performed in COMSOL Multiphysics simulation tool. Effective refractive index is calculated for each design by varying pitch keeping cladding air hole diameter constant and by varying air hole diameter keeping pitch constant. Dispersion is calculated using finite element method. By comparing all the designs Optimized design is obtained.**

Index Terms— **Dispersion, Finite element analysis, Photonic Crystal Fiber, Wavelength.**

I. INTRODUCTION

Photonic crystal fiber is a structure which consist of few air hole arrays assembled along the waveguide length of the fiber. It is also known as 'Holey Fiber. PCF's have a number of exceptionalpropertiesthatarenotrealizedinconventional optical fiber. Proposed index guided photonic crystal fiber, guides light by total internal reflection (TIR) between a solid core and a cladding area with various air- holes. PCFs can be categorized in two classes, first is index guiding PCF and another is photonic band gap PCF. The various better properties can be proposed over conventional optical fibers, such as high birefringence and endlessly single-mode operation, high/low nonlinearity, Negative dispersion, even guidance in a hollowcore,andverylowconfinementlosspropertiescan be obtained in the optical communication range with thesePCF's.

Photonics is a branch of modern science and technology that link electronics and optics and often deals with generation, propagation and detection of light. Thus photonics can manage the photons. Photonic crystal fibers (PCFs) are new class of optical fiber based on the photonic crystals properties. They are fabricated with hollow air holes running parallel with the fiber which acts as cladding and directs the light. The optical analog possesses the photonic crystal, which provides support in replacing the atoms or molecules with the help of macroscopic media with different dielectric constants, and the dielectric material function here helps in replacing periodic potential. The Photonic crystals in combination with photonic-band gaps are generated to avoid light propagation in definite directions at certain ranges of wavelengths. Photonic crystal fibers are an unorthodox form of normal fiber optics, often utilize the total internal reflection or light detention in hollow-core methods to transmitthe light.

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In reality, such a fiber was first urbanized in 1996 in the form of a photonic-crystal cladding with a interrupted range of hollow air holes. It was laternoticed that the periodic character of air holes is not vital for silica-core fibers only if the cladding has several air holes that efficiently reduce its index of refraction below of the silica core. In such case, light is directed by the total internal reflection, and the air holes are used to decrease the index of the cladding region. The air holes which are periodic in nature become important in the so-called photonic bandgap fibers, in which the optical form is restricted to the core by periodic variations of the refractive index inside the cladding. The core of such kind of fibers frequently holds air to which light is cramped by the photonic band gap. Such accurate PCFs can operate as an extremely nonlinear medium if air is replaced with an appropriate gas or liquid.

To produce unique modal characteristics as single mode operation in the wide range of wavelength, highly tunable dispersion PCF's can be designed.

The design of non uniform air cladding effectively is achieved by taking different air hole layers is also considered in this paper.

Photonic crystals offer stimulating potentials for key performing techniques in optical communication systems, such as delay elements, chromatic dispersion compensators, polarization mode dispersion mitigates and wavelength adjoin fall filters.

Photonic crystal fiber is less costly than copperwires.

Sinceopticalfibersarenarrowerthancopperwires, additional fibers can be bundled into any -width cable than copper wires. This allows more receiver lines to go in excess of the same cable. The loss of signal in photonic crystal fiber is less. It is preferably suitable for carrying digital information, which isespecially helpful in computer networks.

II. PCF DESIGNS

Photonic crystal fiber have been designed by us in 3 types: (i) Decagonal structure (ii) Decagonal structure with circular hole in core and (iii) Decagonal structure with square hole in core. We have designed four rings in cladding area with perfectly matched layer surrounding the cladding. Core is made of silica and air is filled in cladding. Designs are shown in Fig 1, 2 &3.

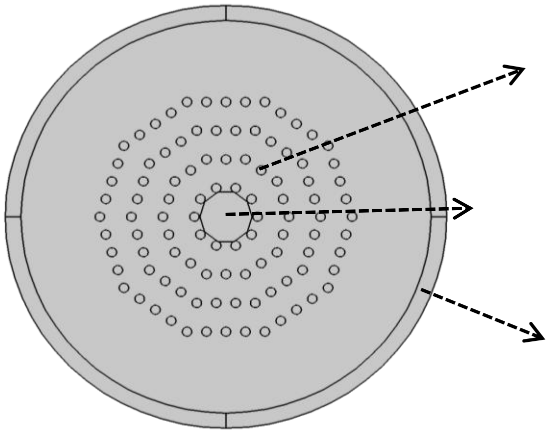

Fig 1 Decagonal 4 Ring Structure

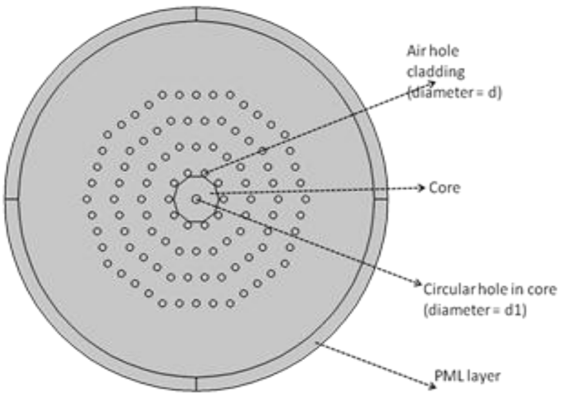

Fig 2 Decagonal 4 Ring Structure with circular hole in core

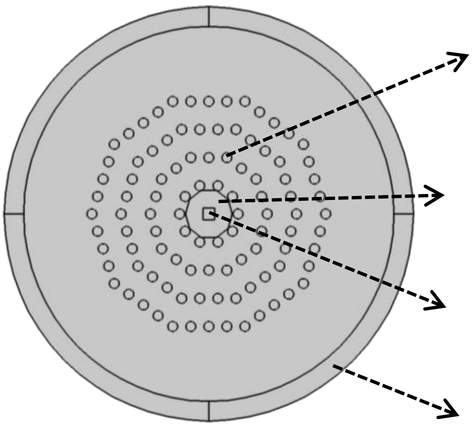

Fig 3 Decagonal 4 Ring Structure with square hole in core

In above designs diameter of cladding air hole is d and spacing between two air holes is pitch. Diameter of circular hole is d1 which is constant and side length of square hole is a, which is also kept constant.

III. ANALYSIS OF PCF BASED ON EFFECTIVE REFRACTIVE INDEX

PCF designs are based on effective refractive index by varying pitch keeping air hole diameter (0.5µm) constant by varying air hole diameter keeping pitch (2µm) constant at different values of wavelength. Diameter of circular hole is 0.6µm and side length of square hole is 0.6µm.

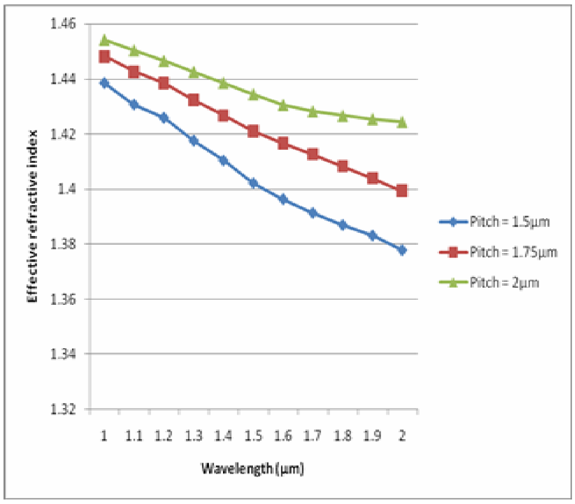

Fig-4: Effective refractive index for different pitch

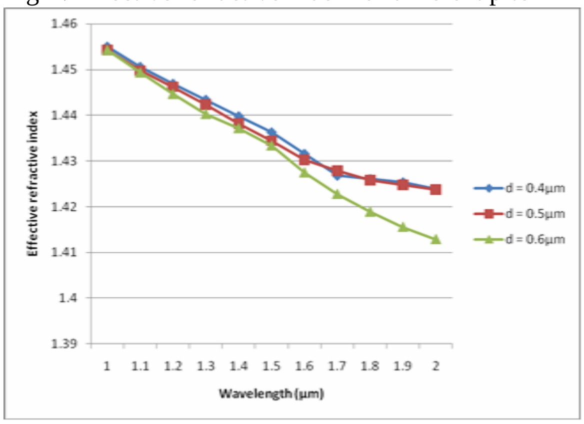

Fig-5: Effective refractive index for different diameter

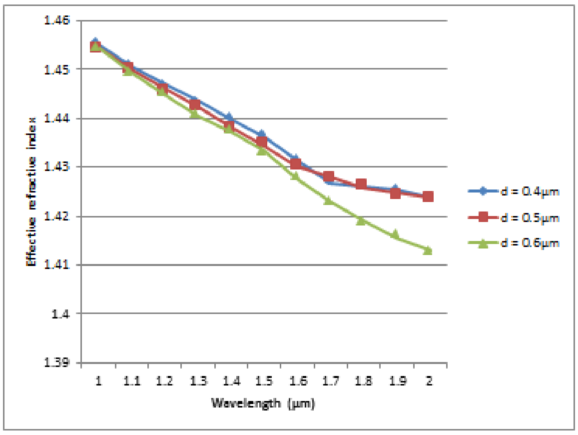

Fig.6: Effective refractive index for different diameter in PCF (circular hole)

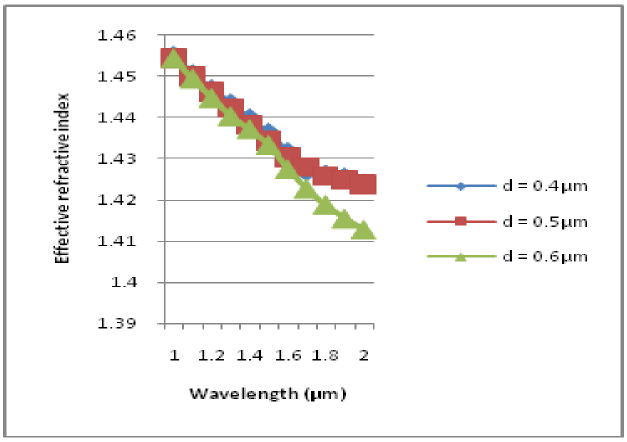

Fig. 7: Effective refractive index for different Diameter in PCF (square hole)

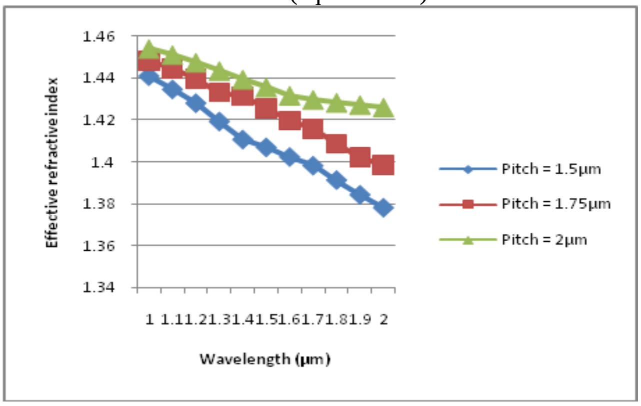

Fig. 8:Effective refractive index for different pitch in PCF (square hole)

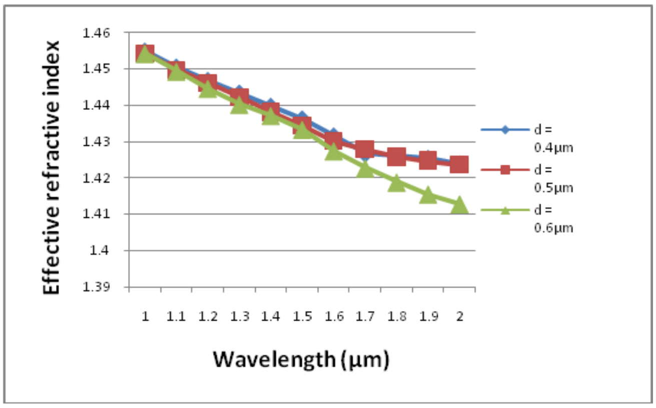

Fig. 9: Effective refractive index for different diameter in PCF (circular hole)

IV. Conclusion

In conclusion, according to our observations, values of pitch and air hole diameter are 1.75µm and 0.5µm respectively. At these values PCF with square hole in core produces better results of effective refractive index but in case of dispersion this structure produces high dispersion at lower wavelengths and low dispersion at higher wavelengths as compared to other designs. In future various other designs of decagonal structure can be compared using COMSOL or other simulation tools. Besides effective refractive index and dispersion, other factors like confinement loss, propagation constant etc can be computed according to different affecting factors.

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