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Dispersion Management using Multicore Hybrid Cladding in Photonic Crystal Fiber

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ABSTRACT: This paper presents and explores a new design of hybrid Photonic Crystal Fiber (HPCF) with different cladding for obtaining low dispersion in a wide range of wavelength band. The fundamental mode of dispersion for such a Photonic Crystal Fiber (PCF) is analyzed mathematically using Finite difference time domain (FDTD) method. In a given proposed design circular and elliptical air holes are placed to in a circle of boundary. Proposed structure offers low dispersion (-4 to 8) ps/(km·nm) for a wavelength range of 1.15 to 1.65 µm. Proposed structure can be used for different applications such like optical communication and sensors.

Keywords— Optical Fiber, Photonic Crystal Fiber (PCF), Dispersion and Finite Difference Time Domain (FDTD) Method.

I. INTRODUCTION

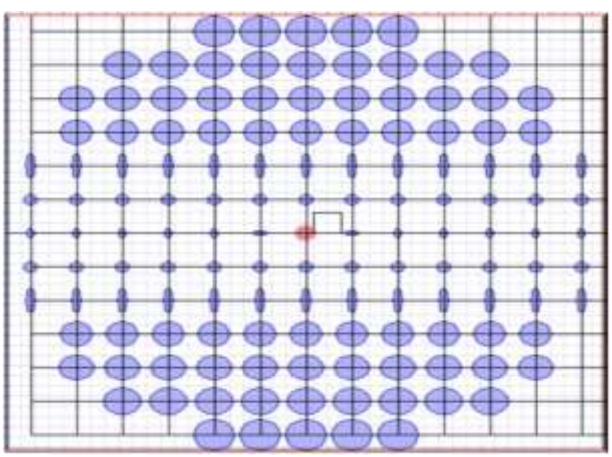
Optical fiber communication systems are used to provide information transmission in light wave system. Such systems have been deployed worldwide since 1980 and have revolutionized the new technology behind communications [1]. Optical fibers are mostly used instead of metal wires because of signals travel along them with lesser amounts of loss. These fibers are used to immune electromagnetic interference, a big challenge from which a metal wires is suffer excessively. This fibers are also used for illumination and are well wrapped in bundles so that they may be used to carry information, thus it allow to viewing in confined spaces. In the case of a fiberscope is used in data communications and telecommunications systems due to its ability to transmit high bandwidths over longer distances than copper conductors [2].

Photonic crystal fibers (PCFs) are fibers with an internal periodic structure made of capillaries and filled with air laid to form a hexagonal structure. Photonic crystal fibers (PCFs) are composed of central core which is surrounded by a cladding made from different periodic capillaries that can be hollow (air) or low index material. A defect can be diameter is designed and simulated. imposed on the structure by removing central capillary which acts as a core. Light can propagate through the defects (core) of the crystal structure [3-4]. Due to the flexibility in design freedom of PCFs, various laudable optical properties, such as ultra flat dispersion, high nonlinearity, large, ultra high birefringence and large effective mode area, etc have been demonstrated with PCFs where as not possible in conventional optical fibers [5]. Photonic crystals are used for a wide variety of electromagnetic applications extending from radio waves to optical wavelengths. Photonic crystal silica fibers appeared as the first application of photonic crystals to the real world of optical communications [6]. In presented paper, we propose a newly designed hybrid PCF contains a finite number of air holes in form of circular and elliptical in shape. It can be linearly placed in a circle of boundary that gives low dispersion (-4 to 8) ps/(km·nm) for a wider wavelength range of 1.15 µm to 1.65 µm that can be used for telecommunication purpose, sensor applications.

II. DESIGN METHODOLOGY

Fig. 1 shows the layouts of hybrid PCF with different diameter. HPCF square lattice parameter with pitch ʌ =1.65 µm and different diameter is designed and simulated. There are six cowered structures with center are available in Circular and elliptical air holes shape. Given structure is available a given parametric value in our design. Design contains ellipses in first line are as e1 [elliptical ratio q=q1/q2=(0.075×p) / (0.15×p)=0.5], circles in line two have radius r1=0.2384×p/2, ellipses in line three are e2 [elliptical ratio q=q1/q2 =(0.1875×p/2)/(0.75×p/2)=0.25], circles in line four have radius r2=0.7×p/2, circles in line five have radius r3=0.75×p/2, circles in line six have radius r4=0.8×p/2 and circles in line seven have radius r5=0.9×p/2. Line 1 and line 3 contain ellipses. The central elliptical air holes in the line one is rotated by an angle of 900 for obtaining better lower dispersion properties.

Fig.1.Hybrid PCF with Circular air holes and elliptical air holes having pitch ʌ =1.65 µm



obtained by the following equation [5]. $D(\lambda)=d/d\lambda(1/v_g(\lambda))=-(\lambda/c)d^2n_r/d\lambda^2$ ps/(km·nm) eq(1)

III. SIMULATION METHODOLOGY

The simulation tool used for this work is OPTIWAVE Software and the Finite difference time domain (FDTD) method has been used to characterize the performance of the PCF. The Finite difference time domain (FDTD) method is widely used for calculating the evaluation of an electromagnetic field in depressive environment [7]. Dispersion D (λ) in optics is a phenomenon which causes separation of a wave into its spectral components and is defined as the change in pulse width per unit distance of propagation (i.e., ps/km/nm), where c is the velocity of light in vaccum, λ is the wavelength. Dispersion D can be Dispersion of our proposed design is shown in the fig.4.

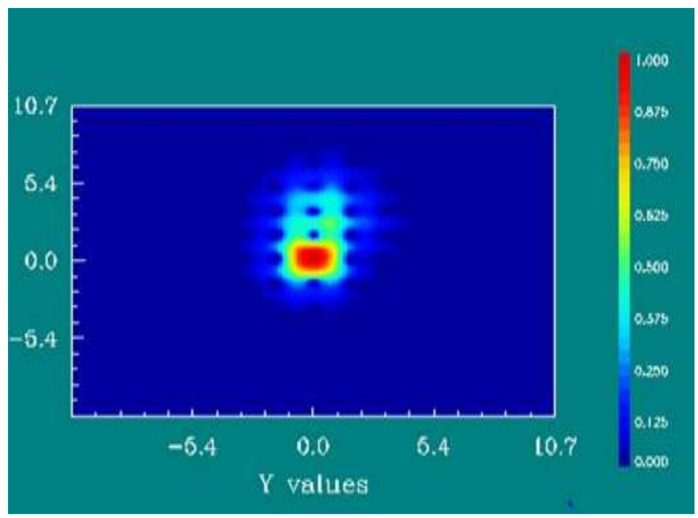


Fig.2.Modal Analysis in square Lattice with circular and elliptical air holes

IV. FLOW CHART OF THE SIMULATION WORK

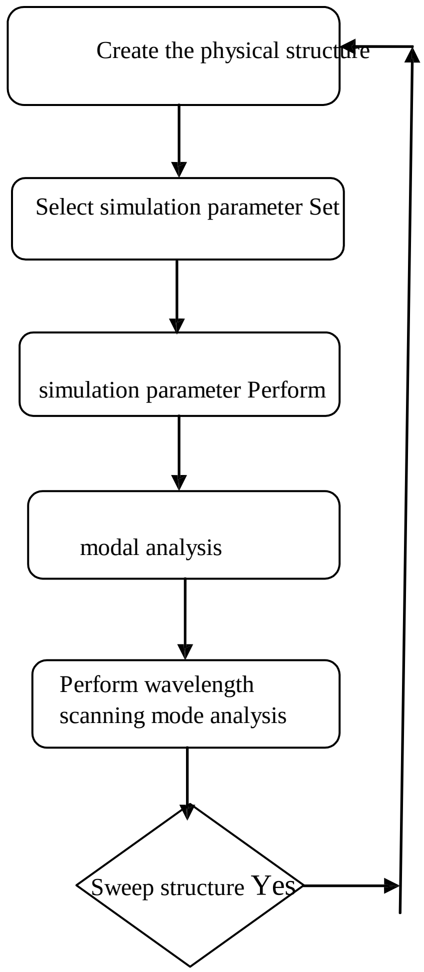


Fig.2. Flow chart of the simulation

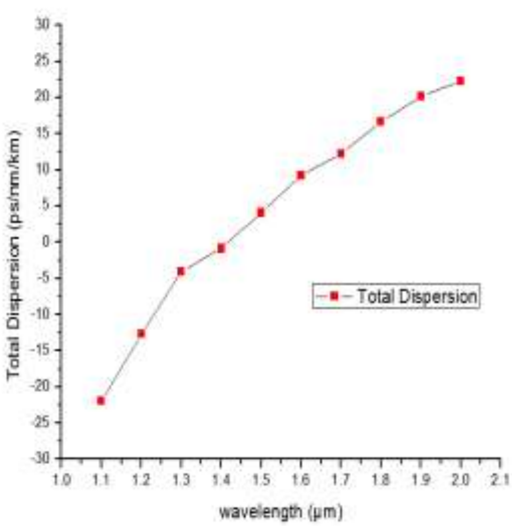


Fig.4 Graph between total Dispersion and Wavelength

V. SIMULATION RESULT

According to the simulation, it is observed that x and y axis polarized modes are strongly bounded in the high-index core region, giving the birefringence at the exciting wavelength λ=1.55µm and our design is better considering low dispersion of (-4 to 8) ps / (km·nm) for a broader wavelength range of 1.15 to 1.65 µm. Modal analysis in square lattice with circular and elliptical air holes having pitch λ=1.65µm is as shown in fig.3, seen that our design is better chromatic dispersion properties.

According to simulation, it is considering low dispersion of (-4to-8) (ps/km-nm) for a wide wavelength range of 1.15 to1.65. It is observed that dispersion is very low for a broader wavelength range for the excitation wavelength of λ=1.5µm.With ultra-flattened dispersion, the proposed PCF is useful for future applications either in telecommunications or sensing domain.

VI. CONCLUSION

In a given paper, a relatively simple polarization maintaining low dispersion has been reported. The low dispersion 6.05 ps/(km.nm) is achieved at the excitation wavelength 1.55µm. This design can be improved further research for getting better ultra dispersion flat 0±0.5 ps/ (km.nm). This design process requires high attention to flattened chromatic dispersion curve obtain in elliptical air hole rings compare than Circular air hole ring . Photonic crystal fibers having properties such as high birefringence for optical fiber based sensors, nonlinearity for nonlinear optics applications and ultra dispersion flat are crucial for telecommunication. It can be concluded that by changing the width of PCF the dispersion can be modified to achieve desirable properties within the required wavelength domain.

REFERENCES

[1]. Govind P. Agrawal,"Fiber-Optic Communications Systems", Third Edition. Copyright ㅿ 2002 John Wiley & Sons, Inc. ISBNs: 0-471-21571-6 (Hardback); 0-471-22114-7 (Electronic).

[2]. Mark Curran,Brian Shirk ," Basics of Fiber Optics".

[3]. P.Russell,"Photonic-Crystal ibers",Science, Vol.299,pp.358-362,17 January, 2003.

[4]. Bjarklev, J. Broeng and A.S. Bjarklev, "Photonic Crystal Fibers",Kluwer Academic Publisher, ISBN-1-4020-7610-X,2003.

[5]. R. R. Mahmud," Low Dispersion Nonlinear Polarization Maintaining Photonic Crystal Fiber Using Hybrid Cladding", International Conferenceon Electrical Engineering andInformation & Communication Technology (ICEEICT) 2014.

[6]. Marcos A. R. Franco, Valdir A. Serrão, and Francisco Sircilli, "MicrostructuredOptical Fiber for Residual Dispersion Compensation Over S+C+L+U Wavelength Bands," IEEE Photonics Technology Letters, Vol. 20, Issue 9,pp. 751-753, May 1, 2008.

[7]. R.Buczynski, "PhotonicCrystal Fibers", ActaPhysicaPolonica A, Vol.106,Issue -2, 2004.

[8]. M. Samiul Habib, M. Selim Habib, S. M. A. Razzak, M. A. Hossain and Y. Namihira, "Polarization Maintaining Large Nonlinear Coefficient Photonic Crystal Fibers Using Rotational Hybrid Cladding," Optik - International Journal for Light and Electron Optics, vol. 125, no. 3, pp. 1011-

[9]. S.M. Abdur Razzak and Yoshiniri Namihira "Proposal for Highly Nonlinear Dispersion- Flattened Octagonal Photonic Crystal Fibers", IEEE Photonic Technology Letters, Vol . 20 ,Issue 4, pp. 249-251, February 15, 2008.

[10]. www.optiwave.com/product/fdtd-refrences.html

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