International Journal of Advance Research in Science and Engineering
Volume No.07, Special Issue No.01, April 2018
www.ijarse.com
IJARSE
ISSN: 2319-8354

Highly Negative Dispersion Compensating Dual Core Photonic Crystal Fiber

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ABSTRACT

Proposed dual core photonic crystal fiber (DC-PCF) consists with inner and outer core, where outer core is formed by putting the high refractive index material in the third ring around the inner core. We have numerically calculated the effective refractive index and dispersion characteristics of proposed DC-PCF, and achieved highly negative dispersion in the order of 10^4.

Keywords- photonic crystal fiber (PCF), highly negative dispersion, dispersion compensation.

I.INTRODUCTION

Photonic crystal fiber is the new type of optical fiber. It consist periodic array of air holes running along the entire fiber length around the core of the fiber. Light propagation in PCFs is much superior to standard fiber. PCFs can be divided into two main categories. The first one is index guiding fibers like standard fibers in which light travels by the modified total internal reflection. And the second one is photonic band gap fibers in which light is guided by the photonic band gap effect. PCFs have unique optical properties such as endlessly single mode operation over a wide range of wavelength [1-2], good dispersion characteristics [3-5], dispersion compensation fibers [6-7], low confinement loss, etc. Dispersion compensation can be realized in PCF by demolish the symmetry of the structure.

In this paper, we have designed DC-PCF using COMSOL Multiphysics software based on Finite Element Method (FEM). High value of negative dispersion can be obtained by the interactions between the inner and outer core of photonic crystal fiber. This can be used as dispersion compassion in optical communication systems.

II.NUMERICAL RESULTS AND DISCUSSIONS

DC-PCF is modeled by the inner core and outer core. The inner core is made of silica whose refractive index is 1.45 but the outer core is formed by putting the high refractive index material with refractive index 1.3942 in the third ring air holes around the inner core and the refractive index of air is 1. The diameter of circular air holes is d=1.2μm, hole-to-hole distance ($\wedge$) is 2.2μm.

The dispersion D(λ) can be calculated as the sum of waveguide dispersion and material dispersion which is expressed numerically by [6].

$$D(\lambda) = D_w(\lambda) + D_m(\lambda) \qquad (1)$$

$$D_w(\lambda) = -\frac{\lambda}{c}\frac{\partial^2}{\partial\lambda^2}\mathrm{Re}(n_{eff}) \qquad (1.1a)$$

$$D_m(\lambda) = -\frac{\lambda}{c}\frac{\partial^2 n_m}{\partial\lambda^2} \qquad (1.1b)$$

Where, D(λ) is the total dispersion, $D_w(\lambda)$ is the waveguide dispersion, $D_m(\lambda)$ is the material dispersion, n_{eff} is the effective index, n_m is refractive index estimated by using Sellmeier equations [7] and speed of light in vacuum is c. In this paper material dispersion is neglected due to very high value of negative dispersion.

Effective refractive index of the fundamental polarization modes and which is the combined effect of inner and outer core and calculated by using COMSOL Multiphysics software.

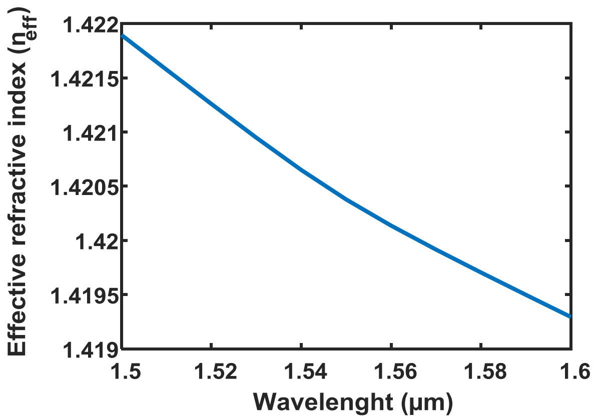

Fig.1 Effective refractive index with wavelength of proposed PCF

From the fig(1) we can see that effective refractive index of the DC-PCF decreases with the wavelength.

Fig.2 shows the Electric field intensity of the proposed PCF at different wavelength such as less than (1500 nm), higher than (1600 nm) and equal to the phase matching wavelength λ_P (1560nm). We know that the fundamental mode dependes on the phase matching wavelength. If the operating wavelength is less than phase matching wavelength the fundamental mode is in the inner core but if the operating wavelength is greater than phase matching wavelength the fundamental mode is switched to the outer core.

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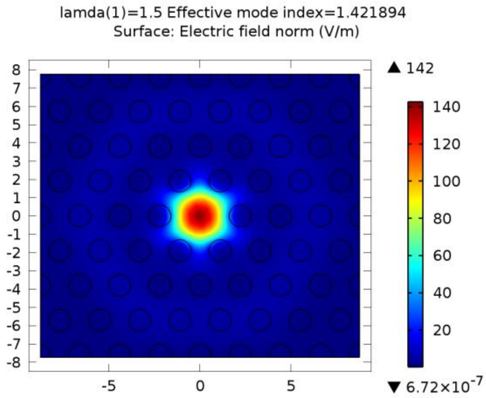
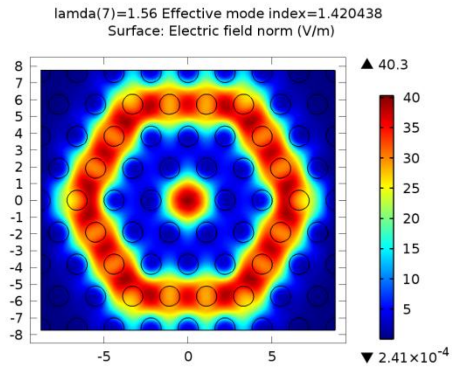
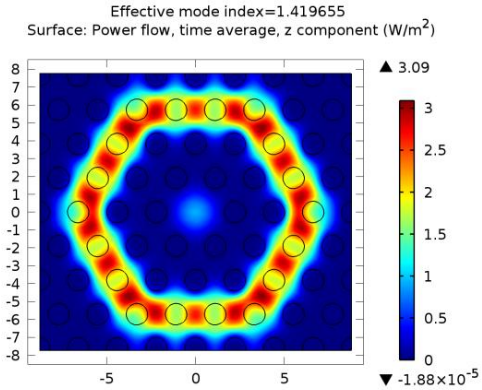


(a)



(b)



(c)

Fig.2 Electric field intensity (a) if λ =1500nm($\lambda < \lambda_P$) (b) if λ =1560nm($\lambda = \lambda_P$) (c) if λ =1600nm($\lambda > \lambda_P$)

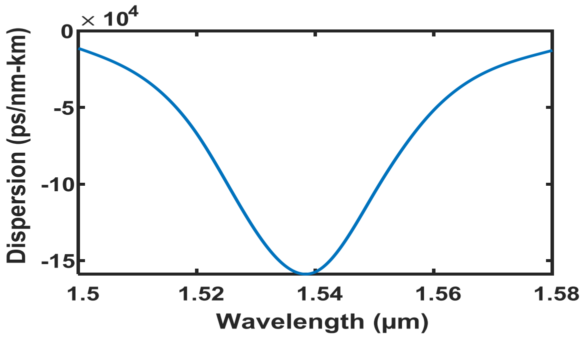


Fig. 3 Dispersion curve with wavelength of PCF.

Fig.3 shows the dispersion characteristics with wavelength of the proposed PCF. It has a very high negetive dispersion as compaired to previous proposed PCF that can be achieved in dual core photonic crystal fiber [8]. The calculted value of negative dispersion is -150000 ps/nm-km at wavelength 1540 nm in proposed PCF.

III. CONCLUSION

In this paper, we have numerically calculated high negative dispersion -150000 ps/nm-km. The peak value of dispersion and the corresponding wavelength can be tuned by varying the diameter of the air holes, the refractive index of the material in the outer core and also by demolish the symmetry of the PCF structure.

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