Analysis of hybrid elliptical air hole ring As_2Se_3 glass PCF for Zero Dispersion

Ashish Mittal, Ajay Kumar Bairwa, Ramesh Bharti

Abstract— **Photonic crystal fibers (PCFs) are other type of optical fibers. Photonic crystal fibers (PCFs) are formed with an internal periodic holes structured, laid to form of square, rectangular and hexagonal lattice. In this paper, hybrid rings hexagonal lattic PCF with circular and elliptical (with various angles) air holes has designed and shifted of Nil dispersion wavelengths to higher wavelength range with changing in elliptical air holes angles. Here chalcogenide glass is used as like a core material because chalcogenide glass erects a large IR wavelength. In this design we will achieve zero dispersion wavelengths. When we make the hybrid elliptical air holes and change the air holes angles (horizontal to vertical side), dispersion is decreased.**

Index Terms— **refractive index (n_{eff}), Finite difference time domain (FDTD), Photonic crystal fiber (PCF), transparent boundary condition (TBC),Dispersion.**

I. INTRODUCTION

Photonic crystal fibers (PCFs) [1,2] are attracting in few last years because of their unique properties that are not present in conventional and regular optical fibers. Photonic crystal fibers are made of with a periodical air holes structured along its length and core material as silica glass, As_2Se_3 glass. [3-7]. Here we use the chalcogenide As_2Se_3 glass as a core material because chalcogenide glasses are based on chalcogen elements as like S, Se and Te and other additional elements, as Ge, As and Sb. In the PCF middle region is called solid core when we removed the middle air hole. At First we designed a hexagonal six layer chalcogenide glass PCF and calculate the dispersion. When we change the first, third and fifth ring periodic circular air holes to elliptical air holes then this PCF is called hybrid elliptical air hole PCF. The dispersion of hybrid elliptical air hole ring PCF is calculated using FDTD method and transparent boundary condition (TBC). Proposed hybrid vertical elliptical air hole ring is also compared with the conventional (regular) circular air hole chalcogenide As_2Se_3 glass PCF. It is possible to control the PCF dispersion properties by changing the air hole diameter "d" and pitch "^" [10-13]. Elliptical air hole ring PCF is calculated using FDTD method and transparent boundary condition (TBC). Proposed hybrid vertical elliptical air hole ring is also compared with the conventional(regular) circular air hole chalcogenide As_2Se_3 glass PCF. It is possible to control the PCF dispersion properties by changing the air hole diameter„d and pitch "^" [10-13].

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II. DESIGN PRINCIPLE

Figure 1 shows the conventional As_2Se_3 glass PCF. In conventional hexagonal As_2Se_3 glass PCF we find that there is only one missing air hole, which make solid core of the PCF.

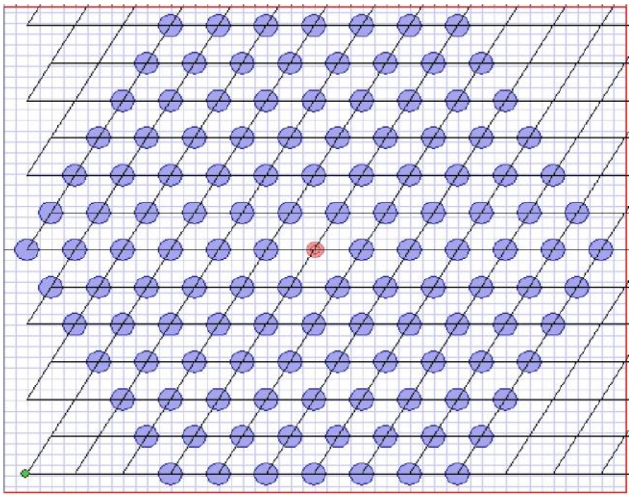

Figure 1. layout of circular air hole rings PCF having six rings and air hole diameter „d" = .75 μm.

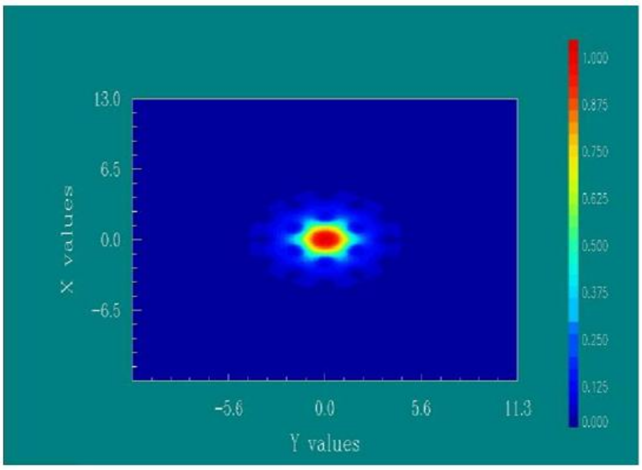

Figure 2. 2-D mode field pattern of conventional PCF.

Now, we change the first, third and fifth rings of conventional As_2Se_3 glass PCF, circular air hole change to horizontal elliptical air holes. The elliptical air hole is defined as the ratio of „a" and „b". here „a" is the major diameter and „b" is the minor diameter of air hole. However, elliptical air holes are very d ifficult to control when the fabrication of PCF [14].

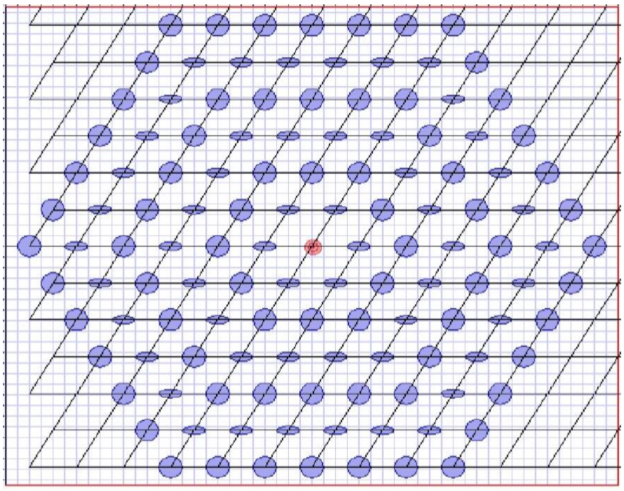

Figure 3. layout design for a hexagonal chalcogenide As_2Se_3 glass PCF with first, third and fifth ring horizontally elliptical air holes, here "a" = .75 µm and „b" = 0.5 µm for elliptical air holes and „d" = .75 µm for circular air holes.

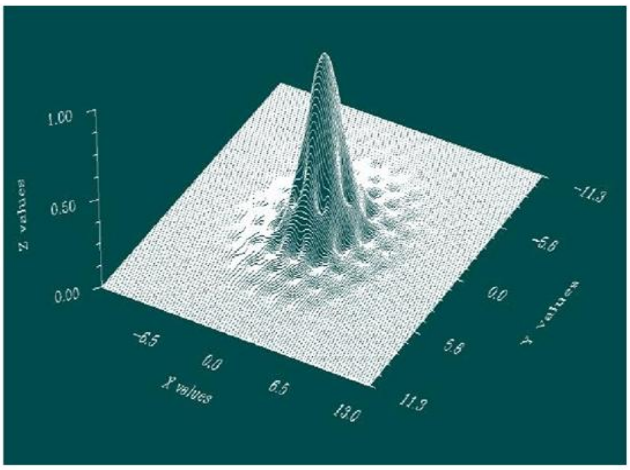

Figure 4. 3-D Mode field pattern of hybrid horizontally elliptical As_2Se_3 glass PCF having six rings.

Chalcogenide As_2Se_3 glass using as a core material with 2.821 refractive index and air holes refractive index is 1.0. The wafer is designed for width 25 micro meter amd thickness 22.5167 micro meter.

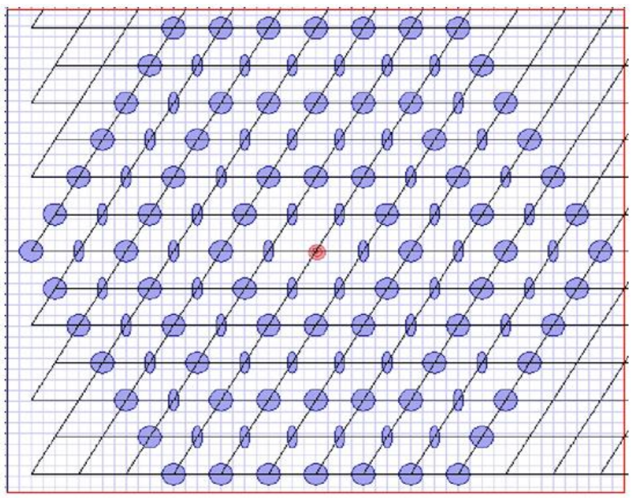

Figure 5. A hexagonal chalcogenide As_2Se_3 glass PCF with first, third and fifth ring vertically elliptical air holes, here „a" = 0.5 µm and „b" = .75 µm for elliptical air holes.

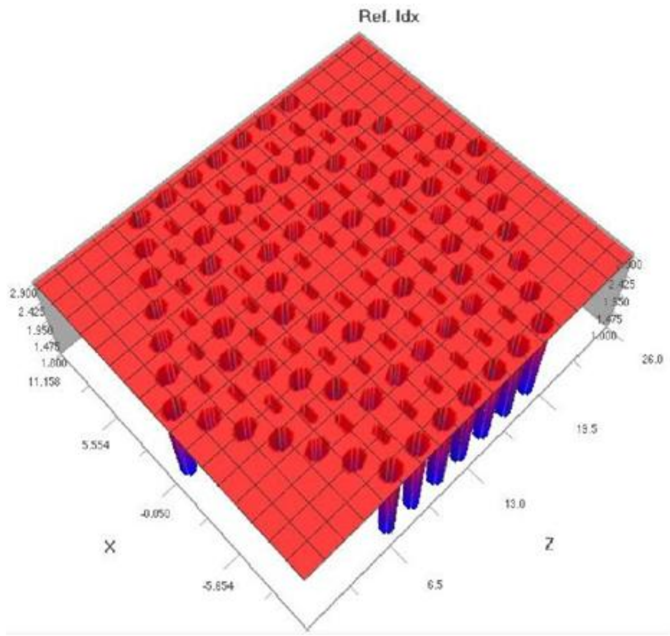

Figure 6. Three diamensional view of refractive index of proposed structure.

The effective refractive index is $n_{eff} = \beta/k_0$, β is propagation constant. The waveguide dispersion parameter D_w is obtained as –

$$D_W = -\left(\frac{\lambda}{c}\right)\frac{d^2}{d\lambda^2}n_{eff} \tag{1}$$

and total dispersion $D = D_W + D_M$. where λ is the signal wavelength and c is velocity of light in a vacuum [15,16]. We can calculated the refractive index of chalcogenide As_2Se_3 glass PCF by sellemier formula[17,18].

$$n^2 - 1 = \sum_i \left(\frac{A_i \lambda^2}{\lambda^2 - \lambda_1^2}\right) \tag{2}$$

III. Simulation Results

Material dispersion is always unchanged for any lattice structure as hexagonal and square. It is also independent of structural parameter as air hole diameter "d" and pitch "^". So for good explanation first we have plotted material dispersion of chalcogenide As_2Se_3 glass.

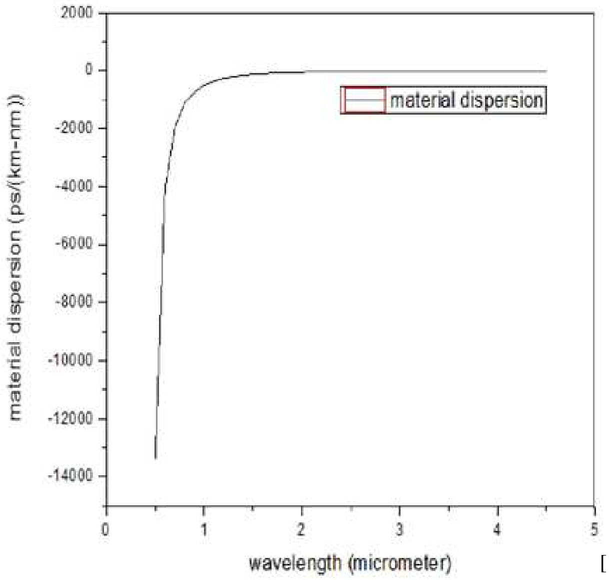

Figure 7. Material d ispersion curve of As_2Se_3 glass PCF.

The proposed As_2Se_3 glass PCF (hybrid vertically elliptical air hole ring) makes almost zero and flattened dispersion compare to conventional six layer hexagonal PCF.

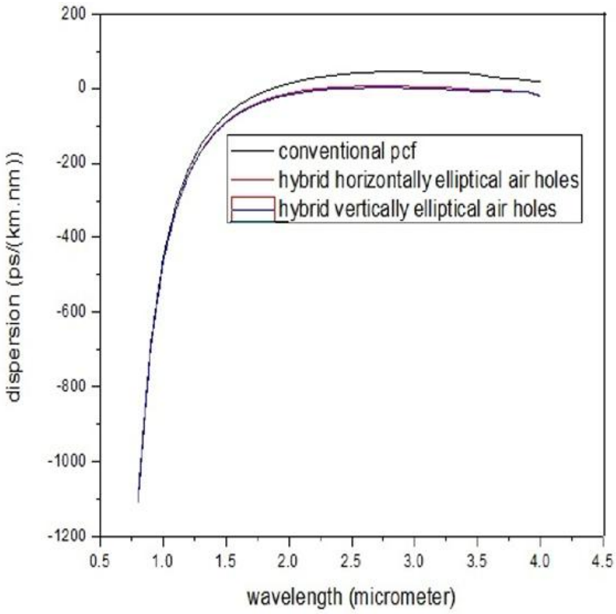

Figure 8. Shows the comparision of chro matic dispersion of the proposed As_2Se_3 glass PCF and conventional As_2Se_3 glass PCF when pitch "^"= 1.75 µm.

IV. Conclusion

The above results indicates that the proposed hybrid elliptical air hole rings PCF has almost Nil and flat dispersion compared to normal(regular) conventional As_2Se_3 glass PCF. It has been shown the results of flattened dispersion of 0.38913 ps/(km.nm) can be obtained in the range 2.4 µm to 2.9 µm. As shown in figure 3 and figure 5 the axis of elliptical air holes has rotated by 90 degree.

V. Future work

This design can be done by changing the air hole diameter and also changing the layers of air hole rings. The further analysis can be done by removing some inner holes layer and changing circular air holes to elliptical.

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