Flattened Dispersion of Hexagonal Chalcogenide As_2Se_3 Glass Photonic Crystal Fiber with a Large Core

Ravindra Kumar Sharma, Kirti Vyas, Ajay Kumar Bairwa

Abstract— In this paper, we have proposed a novel structure of the fabrication of a chalcogenide As_2Se_3 glass photonic crystal fiber (PCF) with increased core diameter. As comparision with the normal PCFs in which silica glass is used as core material, the proposed PCF has following feature; firstly we have used the chalcogenide As_2Se_3 glass as core material in which the first ring area contains no air holes. Then the proposed PCF has a large core area chalcogenide As_2Se_3 glass photonic crystal fiber. There are low chromatic dispersion in the proposed PCF comparied to normal As_2Se_3 glass PCF. The chromatic dispersion is almost flat in the range of 2.4 micrometer to 4.0 micrometer range when the air hole diameter 'd' is 1.0 micrometer and air hole space '˄' is 2.0 micrometer.

Index Terms— chalcogenide As_2Se_3 glass, chromatic dispersion, photonic crystal fiber.

I. INTRODUCTION

Optical fibers have are used as good transmission medium for short, medium and large distances. Now a days, research is carried on photonic crystal fibers (PCFs) which are also called holey fibers [1,2]. The PCF technology is used to create a fiber with high nonlinear coefficient and zero chromatic dispersion. The PCFs have a central region called core surrounded by periodic air holes which work as a cladding. We can control the chromatic dispersion of the PCFs by changing the core material, air hole diameter 'd' and air hole spacing '˄'. When we increase the ratio of the air hole diameter to the air hole spacing (d/˄), the zero dispersion is achieved [3,8]. In the recent years, research works are focused on different type of core and cladding material in different type of PCFs. Now a days non silica glasses like soft glasses, chalcogenide are used in PCFs [4,9]. Chalcogenide glasses have large refractive index (2.4 – 3.0) compare to other glasses. This means non- linearity of chalcogenide glasses As2Se3 fiber is almost 10,000 times higher than silica glass at 1.55 micrometer [5].

In this paper, we worked on a novel structure of PCF in very long wavelength region. In the proposed PCF, chalcogenide As2Se3 glass is used as core material and second, the center core is made larger than that of conventional As2Se3 PCFs. We have use semi- vectorial effective index method (SVEIM) for comparing dispersion properties.

II. PROPOSED STRUCTURE

Figure 1 shows the proposed PCF structure. In conventional As2Se3 glass PCF we normally find that there is one missing air hole in the center of the PCF , which makes core of the PCF , and six air holes are arranged in the first ring of hexagonal PCF. On proposed structure to make larger core total seven holes are removed from As2Se3 glass PCF, one from center of hexagonal and six holes from first ring. then total seven missing air holes in core region is called large core. The second ring area and all outer rings are same arranged, like conventional PCFs. Semi- vectorial effective index method is used for TE mode and Neumann boundary condition is used for the simulation.

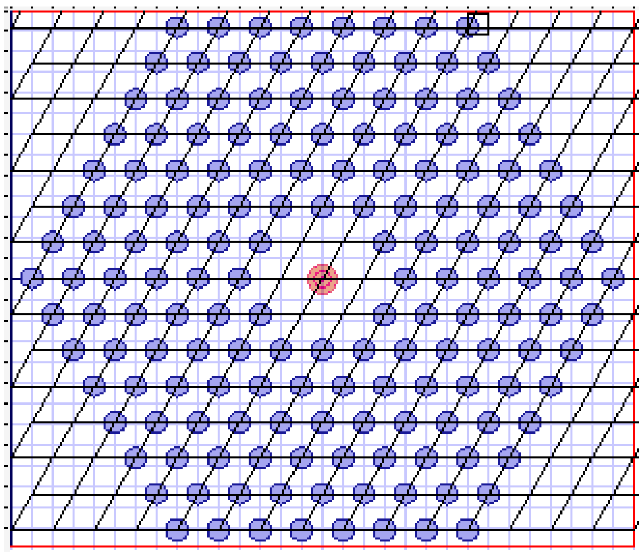


Figure 1. The structure of the proposed PCF.

The value of refractive index of As_2Se_3 glass can be calculated by sellemier formula [6].

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

However in the transparency region, we can reduced the sellemier's formula into Cauchy relation [7,10].

Manuscript received on April 14, 2012.

Ravindra Kumar Sharma, M.Tech (Scholar) Electronics & communication, Rajasthan technical university, Arya college of engineering andI.T.,Jaipur,india.09414437778,(E-mail:ravindra.8810@gamil.com).

Kirti Vyas,, Electronics & communication, Arya college of engineering and I.T, Jaipur, Rajasthan. india, (E-mail:kirtivyas19@gamil.com).

Ajay Kumar Bairwa, Electronics & communication, Rajasthan technical university, Rajdhani institute of technology and management, jaipur, rajasthan 09782729025. (E-mail: ajay1383@gmail.com).

$$n^2 = A + \frac{B}{\lambda^2} + \frac{C}{\lambda^4} \qquad (2)$$

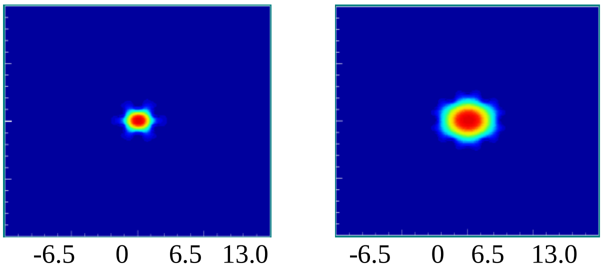
Here, A = 7.56, B = 1.03 μm^2 and C = 0.12 μm^2 are Cauchy coefficients. Using these relations we can also calculate the material chromatic dispersion, which is defined in equation (3).

$$D_M = -\left(\frac{\lambda}{c}\right)\frac{d^2}{d\lambda^2} n \qquad (3)$$

Where c is the velocity of light in vacuum and λ is the wavelength of light.

III. SIMULATION RESULTS

Figure 2 (a) and (b) shows the simulated modes field at ∧ =2.0 μm and air hole diameter d = 1.0 μm at 2.4 μm wavelengths of conventional PCFs and proposed PCFs respectively.



(a) (b)

Figure 2 simulated mode field of the (a) normal PCF (b) proposed PCF with ∧ = 2.0 μm and d = 1.0 μm at 2.4 μm.

In figure 3 plot of the refractive index of conventional PCF and proposed PCF are shown. The refractive index of proposed PCF is much higher than the conventional PCF. The refractive index difference is increased between the conventional PCF and proposed PCF with the increasing wavelength, and the refractive index difference is 0.0334 at 2.4 μm wavelength.

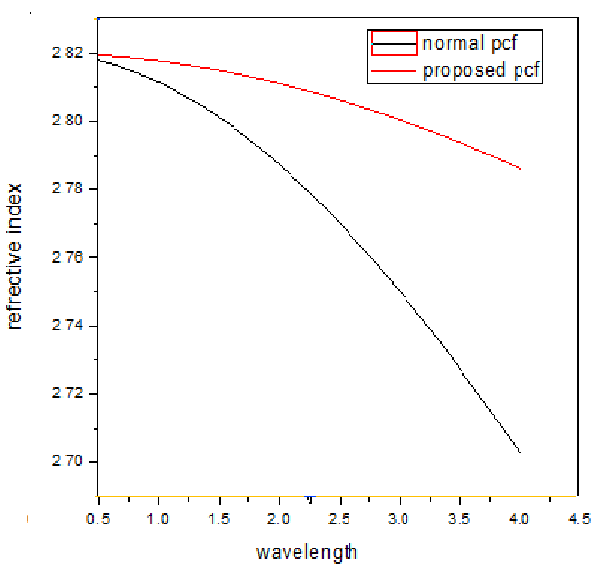


Figure 3. Notable difference of refractive index between conventional PCF and proposed PCF.

IV. CHROMATIC DISPERSION

For good explanation first we have plotted material dispersion of chalcogenide As_2Se_3

PCF as shown in figure 4. The total dispersion D = D_M + D_W. Waveguide dispersion D_W is defined as-

$$D_W = -\left(\frac{\lambda}{c}\right)\frac{d^2}{d\lambda^2} n_{eff} \qquad (4)$$

Here refractive index n for core material is calculated by sellemier formula. Material dispersion is always independent on pitch '∧' and diameter of air holes 'd'.

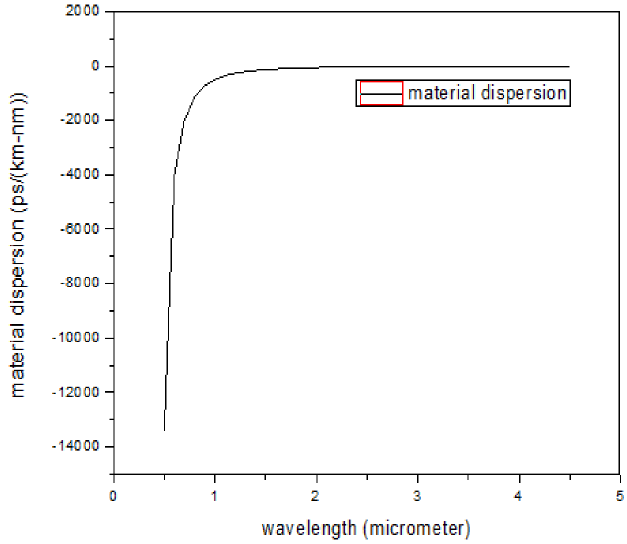


Figure 4. Material dispersion curve of As2Se3 glass PCF.

Figure 5 shows the simulated chromatic dispersion of the proposed PCF for different values of air hole diameter d. the chromatic dispersion is almost flattened in range of 2.4 μm to 4.5 μm, when pitch '∧' is 2.0 μm. decreasing the air hole diameter the chromatic dispersion is also decreased.

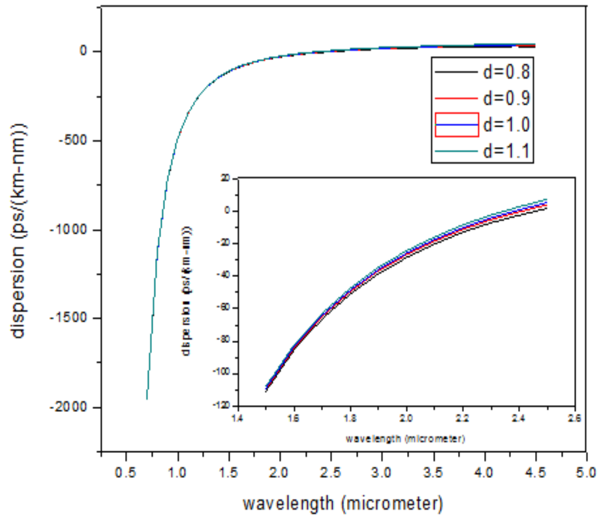


Figure 5 chromatic dispersion of the proposed PCF for different values of the air hole diameter d when air hole spacing ∧ = 2.0 μm.

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

The structure of the proposed PCF (large center core) makes the chromatic dispersion flat in long wavelength region.

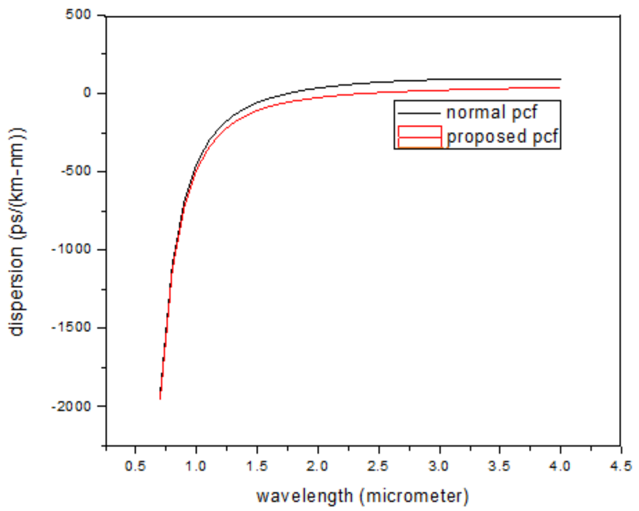


Figure 6 shows the simulated chromatic dispersion of the proposed PCF when ∧ = 2.0 µm and d = 1.0 µm.

V. CONCLUSION

In this paper we have proposed a novel structure of flattened and low dispersion compare to normal PCF structure. The features of the proposed PCF is that the center core is larger than that of conventional As_2Se_3 glass PCFs means seven air holes are missing in core. The core material is used As_2Se_3 glass in both PCF. The large core structure makes the flat and near by zero chromatic dispersion compare to conventional PCF. Negative, positive and almost zero flat dispersions are also achieved by changing air hole diameter d while keeping pitch ∧ constant.

REFERENCES

1. Knight, T.A. Birks, P. St. J. Russel, and D.M. Atkin, " All silica single-mode optical fiber with photonic crystal cladding", Opt. Lett, 21, pp. 1547 – 1549 (1996).
2. J. Broeng, D. Mogilevstev , S.E. Barkou, and A. Bjarklev, "Photonic crystal fibers: a new class of optical waveguides", Optical fiber Technology, 5, pp. 305-330(1999).
3. M.J. Gander, et.al. "Experimental measurement of group velocity dispersion in photonic crystal fiber", Electron, let. 35, pp. 63-64 (1999).
4. A.V. Husakou, J. Hermann, Appl. Phys. B77 (2003)227.
5. D.I. Yeom, E.C. Magi, M.R.E. Lamont, M.A.F. Roelens, L. Fu, B.J. Eggleton, Opt. Lett. 33(2008) 660.
6. G.P. Agarwal, Nonlinear Fiber Optics, third ed., Academic Press, New York, 1995.
7. G. Boudebs, S. Cherukulappurath, M. Guignard, J. Troles, F. Smektala, and F. Sanchez," Linear optical characterization of chalcogenide glasses",Opt. common. 230, 331- 336 (2004).
8. L.P. Shen, W.P. Huang and S.S. Jain, "Design of photonic crystal fibers for dispersion – related applications", J. Lightwave Technol, 21pp. 1644- 1651 (2003).
9. K. Thyagarajan, R.K. Varshney, P. Palai, A.K. Ghatak, and I.C. Goyal, " A noval design of a dispersion compensating fiber", IEEE Photon Technol, Lett. 8, pp. 1510- 1512 (1996).
10. Bhawana Dabas , R.K. Sinha, " Dispersion characteristic of hexagonal and square lattic chalcogenide As_2Se_3 glass photonic crystal fiber", opt. Comm. 283, 1331- 1337 (2010).

AUTHORS PROFILE

Ravindra Kumar Sharma received the B.E. degree in Electronics and communication (2008) and pursuing M.Tech in digital communication system. He is currently Asst. prof. in the department of E&C, Rajdhani institute of technology & management, jaipur. He is also associate of The Institution of Engineers (India). His current research includes photonic crystal fiber.

Kirti Vyas received the B.E. degree in Electronics & communication (2004) from MCET, Laxamangarh and M.Tech. in communication system (2008) from MNIT, jaipur. She is also pursuing in Ph.D. She is currently Asst. Prof. in the department of E&C, Arya college of engineering and I.T, jaipur. Her current research includes antenna & communication system.

Ajay Kumar Bairwa received the B.E. degree in Electronics and communication (2005) and M.Tech in communication system (2010) from MNIT, Jaipur, India. From 2011 he is currently working as Head and Asst. Prof. in the department of E&C, Rajdhani institute of technology and management. Rajasthan technical university,Kota. His current research includes optical fiber communication.

.