Chalcogenide Glass Thin Films: Preparations, Properties and Applications

ISBN: 978-81-951728-4-9

Recent Trends in the Design of Optical Splitters Based on 2-D Photonic Crystals

Tushar Kant Srivastava
Department of Physics,
Udai Pratap (Autonomous) College,
Varanasi, Uttar Pradesh, India

Jyotsna Srivastava
Department of Physics,
R.S.K.D. P.G. College,
Jaunpur, Uttar Pradesh, India

Abstract

The demand for optical power splitters is growing globally, due to the rapid deployment of fiber-to-the-premises, optical metropolitan area network (MAN), and active optical cables for TV/Video signal transport. Photonic crystals have been under the area of rigorous subjective and experimental investigation that owes to provide with promising applications and packages in micro- and optoelectronics. As photonic crystals (Phc) imbibe the properties of artificial periodic

ISBN: 978-81-951728-4-9

structure which can be used to generate band gaps that inhibit propagation of light at desired or certain frequency leeway. As an advantageous out-turn of the photonic band gap effect, ample number of ultra mini optical devices including switches, modulators, filters, gates so on and so forth are implemented which exhibit such captivating attributes and are marked as superior seeker for integrated optics circuits and dense wavelength division multiplexing (DWDM) optical communication systems so on and so forth. The chapter deals with the recent developments in the design of photonic crystal based optical splitters employed for high speed optical communication systems.

Keywords:Photonic Crystals, Optical Communication Systems, Optical Splitter, Dense Wavelength Division Multiplexing (DWDM), Metropolitan Area Network (MAN).

Introduction

"Photonic Crystals" (PC) are dielectric structures with periodic spatial alternations of the refractive index on the dimensions of the wavelength of the light[1,2]. The propagation of electromagnetic waves is forbidden for all wave inside this band gap. There are several applications such as the control of light emission and propagation and the trapping of photons have been realized the photonic band gap and artificially introduced defects.

During the last several years, more than a few foremost scientific and engineering applications such that the

ISBN: 978-81-951728-4-9

management of light emission and propagation and the trapping of photons, had been realized the photonic band gap and artificially offered defects. PCs are defined as structures with periodically varying dielectric constant in special symmetric course with periodicity of the order of the wavelength of the sunshine within the material that the PCs are fabricated from. In line with the dimensions of the periodicity, PCs are categorized into one-dimensional (1D), i.e. The place the dielectric variation is along one path. In a similar way two-dimensional (2nd) and third-dimensional (3D) PC are defined when the dielectric consistent varies alongside two and three path respectively. Schematic samples of one of kind varieties of PCs are shown in Fig.1.

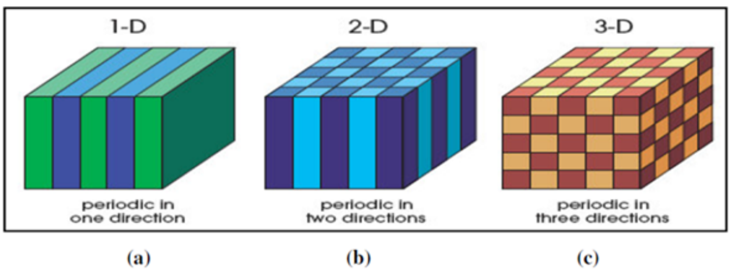


Fig 1: Schematic Depiction of Three Types of Photonic Crystals

Over the last two decades, photonic crystals have been under the area of rigorous subjective and experimental investigation that owes to provide with promising applications and packages in micro- and optoelectronics. As photonic crystals (Phc) imbibe the properties of artificial periodic

ISBN: 978-81-951728-4-9

structure which can be used to generate band gaps that inhibit propagation of light at desired or certain frequency leeway. As an advantageous out-turn of the photonic band gap effect, ample number of ultra mini optical devices including switches, modulators, filters, gates so on and so forth are implemented which exhibit such captivating attributes and are marked as superior seeker for integrated optics circuits and dense wavelength division multiplexing (DWDM) optical communication systems so on and so forth.[3-7].

The demand for optical power splitters is growing globally, due to the rapid deployment of fiber-to-the-premises, optical metropolitan area network (MAN), and active optical cables for TV/Video signal transport.

Splitters are bidirectional optical distribution devices with one input and multiple outputs:

- The signal which enters from input port (downlink), it proceeds from the OLT and it is divided among multiple output ports.
- The signals which enter from the exits (uplink), they come from ONT and they are combined at the entrance.

The fact of being completely passive elements, it allows them to operate without extern power, lowering their cost of deployment, operation and maintenance. Since optical splitter is a key component in optical access network, it is necessary to ensure its reliability sufficient to operate for a lifetime of more than 20 years. Fig 2 shows the basic principle

ISBN: 978-81-951728-4-9

of optical power divider. [8-10]

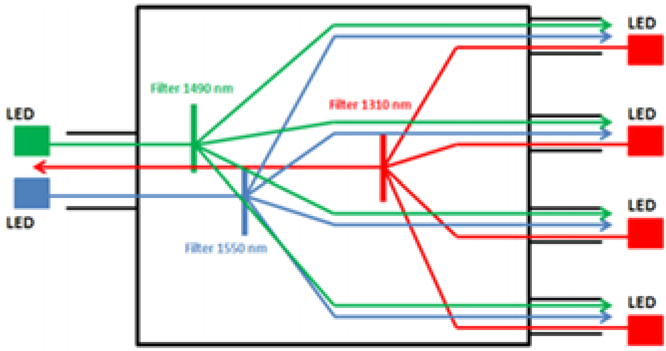


Fig 2: Optical Power Divider

Review Of Developments In Optical Splitters Based On 2-D Photonic Crystals

(a) Modeling of Photonic Crystal Structure based Power Splitter: (M. Kaushik, G. Saxena Sneh Lata Yadav, Ashutosh Mishra)

In this paper the authors have designed a 1x 2 Y-Junction Splitter.The software used is optiFDTD, a power divider based on photonic crystal structure can be designed and important properties of optical power divider such as refractive index, DFT Ey, DFT Hx, DFT Hz, observation points, power at the input and output ports and pointing vector are investigated. In the paper the radius of the atoms were varied and the output power were calculated at each port. The paper also the mentioned about the Structure and Designing of the optical power splitter.

After when all the designing and the simulations were done and the results of the output power at both the output

ISBN: 978-81-951728-4-9

ports were calculated and further compared on the basis of the different atomic radius it was concluded that the best splitting of power took place when the radius was chosen to be 0.28μm and the Fig. 3 represents the comparison of the above analysis:

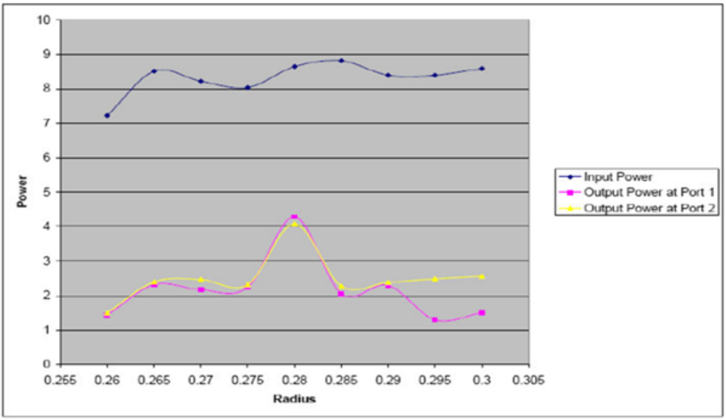


Fig 3. : Graph For Input and Output Powers at Different Radius

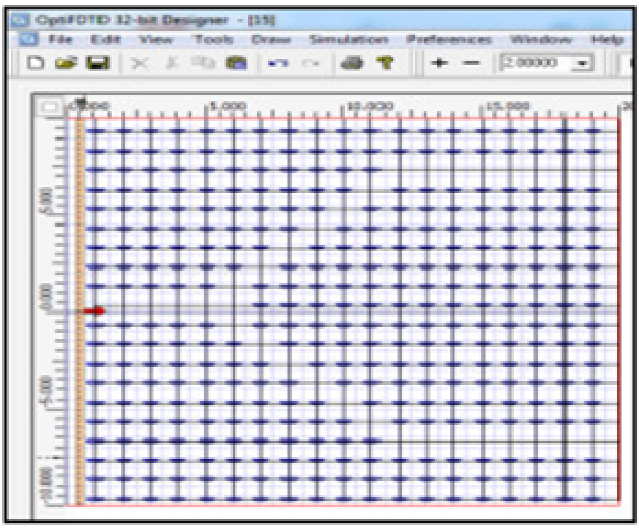
(b) Bandgap And Field Propagation Analysis Using Photonic Crystal: (P.K.Ramya Devi Sri, V.Ramanathan)

In this paper, the authors presented the design of Y splitter 2D photonic crystals and elliptical Y splitter 2D photonic crystals. The Overall size of the 2D Y splitter structure is designed with the dimension of square lattice are 20μm*20μm and the hexagonal lattice are 21μm*17μm.They considered the photonic crystals with dielectric rods (refractive index=3.40) and these rods are surrounded by air (refractive index= 1) with the lattice constant 300 nm and the Y splitter

ISBN: 978-81-951728-4-9

has been designed for TE-polarized light.

The input wave is selected to be a Gaussian Modulated Continuous Wave which is applied with a vertical input plane with an input wavelength of 1.00385μm and the waveguide is formed by the line defect of the Photonic crystal..The simulations, electric field distribution and the band are calculated using the FDTD method and the PWE method. Hence the conclusion derived is that the band gap which is calculated by the PWE method has improved characteristics for the 2D photonic crystal than the 2D elliptical Y splitter photonic crystal. Since, the analysis for the band gap is completed for the two splitters and it has been found out that two band gaps and three band gaps have been created for the square and hexagonal lattice respectively. The simulation graphs have been represented in figures 4 to 7.



ISBN: 978-81-951728-4-9

Fig 4: Layout of 2D elliptical Y splitter Photonic

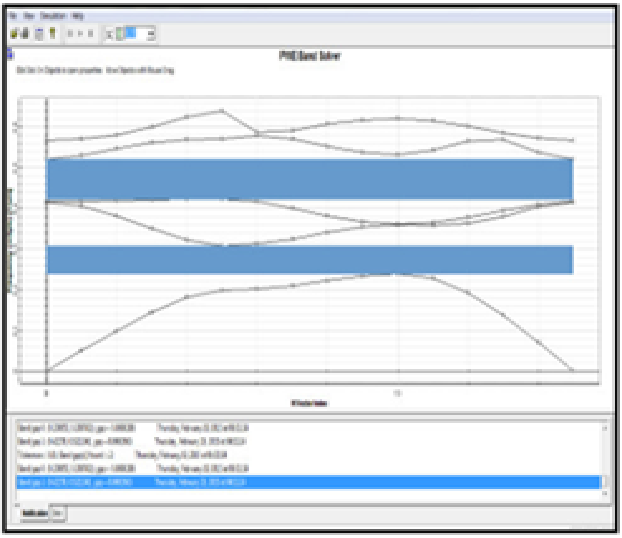
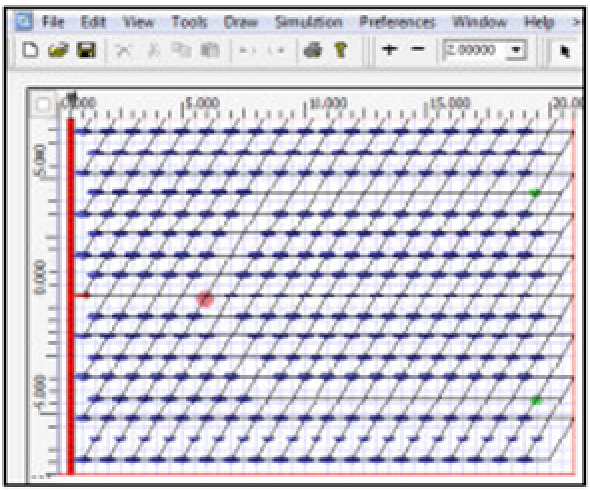


Fig 5: Band gap of Y-splitter – Square lattice

Crystal- Square lattice



ISBN: 978-81-951728-4-9

Fig 6: Layout of 2D elliptical Y splitter Photonic

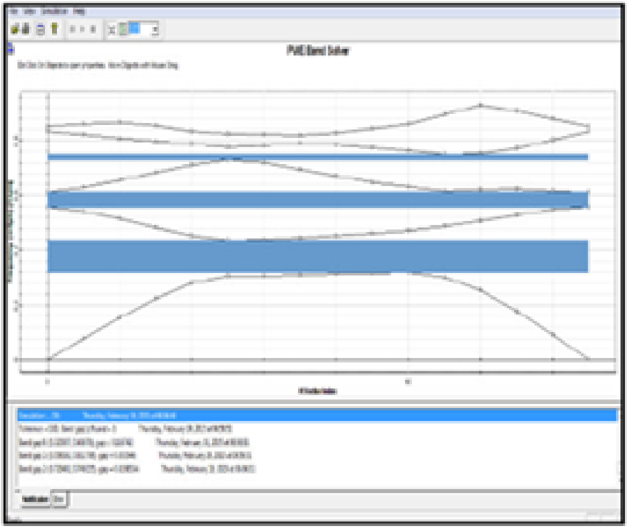


Fig 7: Band gap of Y-splitter –Hexagonal lattice

Crystal- Hexagonal lattice

(c) A Novel 1 x 8 Optical Power Splitter Using Tapered Waveguide Coupling : (Yuanmin Cai, Tetsuya Mizumoto, and Yoshiyuki Naito)

The authors demonstrated the performance of a novel 1 x 8 power splitter. Consisting of seven three-guide power couplers connected in a cascade manner, the fabricated power splitter has a relatively short length of 11 mm. By virtue of adopting the taper-formed waveguide in the constituent couplers, this power splitter is expected to provide a wide bandwidth and a little polarization dependence. Also, it has the advantage of strong tolerance to the waveguide parameter deviation which is most likely to take place in

ISBN: 978-81-951728-4-9

device fabrication process.

(d) Photonic band structures of 2d photonic crystals with half-elliptical holes (A. Marin, L. A.Preda, M. Ciobanu, D. Savastru, E. M. Carstea2, L. Ghervase, and S. Dontu)

In this paper, the photonic band gaps in a two-dimensional photonic crystal with a square lattice composed of half-elliptical rods in air using the plane-wave expansion method. The results showed that the horizontal elliptical structure leads to much narrower band gaps than the half-elliptical one, which is 20.99% for the elliptical structure and 35.56% for the half-elliptical structure. Both vertical and horizontal half-elliptical structures are shown to increase with increasing ellipticity. As for the average frequency of the band gap, values are almost the same in both cases. It was reported that a half-elliptical structure, because of a reduced symmetry in contrast to the circular and elliptical structures, yields higher band gaps and allows a better control of electromagnetic radiation propagation. In the future, the data can contribute to the development of industrial applications, including efficient amplification of the light-emitting diodes and solar cells and biomedical analysis of integrated photonic circuits.

(e) Study of 1x4 Optical Power Splitters with Optical Network (Miss. Gayatri Y. Gurav, Prof. Maruti B. Limkar, Prof. Sanjay M. Hundiwale)

This paper is aimed to provide reviews on different

ISBN: 978-81-951728-4-9

design techniques and fabrication process required while designing 1X4 optical power splitter. The 4- level splitter can be used for cascading in the distributed network. The splitter cascade distributes the optical signal from one fiber to 16 subscribers via 4 splitting points in different locations but with equal signal levels for all 16 subscribers.

(f) Review and Analysis of Photonic Crystal Beam Splitters for Optical Communication Applications : (Juhi Sharma , Ritu Sharma, Lalit Kumar Dusad)

Here, review and analysis of photonic crystal beam splitter is done. Based on the major research findings, the design and simulation of I x8 beam splitter in 2-D photonic crystals is presented. The transmission spectra of this lx8 beam splitter are analyzed by using FDTD method. The PBG has been calculated by PWE method. It has been observed that there is nearly equal distribution of power at each output port of this lx8 beam splitter. The transmission power at the upper and the lower output ports of the input waveguide is almost same due to equal flow of energy on both upper and lower sides of the input waveguide. The structure provides high transmission efficiency. The size of this lx8 beam splitters is around 363 11m2. Further, better performance may be obtained by optimizing the various design parameters. The device may be useful in optical communication applications and photonic integrated circuits.

ISBN: 978-81-951728-4-9

(g) Design of a Low-Loss Y-Splitter for Optical Telecommunication using a 2D Photonics Crystal : (Md. Mahfuzur Rahman, Mamun Hasan, Saeed Mahmud Ullah)

The design in this paper is a Y-junction based 1×2 power splitter formed in 2-D slab PC is analyzed primarily by using 2-D FDTD computational method. 1200 junction and 600 bend are optimized for obtaining maximum power transmission in 1×2 Y-junction based power splitter. As a consequence, 94% of input power is transmitted with 240nm (1.34μm-1.58μm) broad spectrum.

(h) Improving Splitting Efficiency in Photonic Crystal Waveguide : (Monika Gupta, Ramesh Bharti, Vikas Sharma)

In this paper, optical power splitting using Y-junction has been proposed. Y-junction based 1×2 power splitter formed in 2-D PC is analyzed primarily by using 2-D FDTD computational method. 1200 junction and 600 bend are optimized for obtaining maximum power transmission in 1×2 Y-junction based power splitter. The computation is done in the same 2D FDTD computational method.

Conclusion

The optical power splitter or divider is an essential element in photonic integrated circuits which is used in fiber optic networks. General constitution of the splitter is divided into two materials, an input and an output port. Ideally, the

ISBN: 978-81-951728-4-9

input power is equally divided into the output ports without any major reflection and radiation loss. The chapter presents the review of recent developments in the design of optical splitters.

References

1. *Harkiranjeet Kaur, R.S. Kaler, "Design and Analysis of 2D Photonic Crystal Wavelength Routers using Micro-Ridge and Arc Waveguides", Communicated to Fiber and Integrated Optics*
2. *V.P. Bykov, "Spontaneous Emission in a Periodic Structure", Soviet Journal of Experimental an Theoretical Physics, vol. 35, no. 6, pp. 269-273, 1972.*
3. *K. S. Yee, "Numerical Solution of Initial Boundary Value Problems Involving Maxwell's Equation in Isotropic Media,", IEEE Transactions on Antenna Propagation, vol. 14, no. 3, pp. 302-307, 1996.*
4. *Opti-FDTD Tutorials Finite Difference Time Domain Photonics, Simulation Software © 2013 Optiwave.*
5. *J. D. Joannopoulos, P.R. Villeneuve, S. Fan, "Photonic Crystals. Putting a new twist on light", Nature, vol. 386, no.4, pp. 143, 1997.*
6. *John, "Strong localization of photons in certain disordered dielectric superlattices,Physical Review Letters, vol. 58, no. 23, pp. 2486-2489, 1987.*
7. *S. G. Johnson and J. D. Joannopoulos, Introduction to Photonic Crystals: Bloch's Theorem, Band Diagrams, and Gaps (But No Defects), 3rd Ed.: MIT, 2003.*

ISBN: 978-81-951728-4-9

8. *M.Kaushik, G.Saxena ,Sneh Lata Yadav, Ashutosh Mishra"Modeling of Photonic Crystal Structure based Power Splitter", International Journal Of Emerging Technology & Research, 2013.*
9. *P.K.Ramya Devi Sri, V.Ramanathan, "Bandgap And Field Propagation AnalysisUsing Photonic Crystal", National Conference on Computing and Communication, 2015.*
10. *Yuanmin Cai, Tetsuya Mizumoto, and Yoshiyuki Naito, A Novel 1 x 8 Optical Power Splitter Using Tapered Waveguide Coupling, IEEE PHOTONICS TECHNOLOGY LETTERS, VOL. 3, NO. 2, FEBRUARY 1991*
11. *A. Marin1, L. A.Preda, M. Ciobanu, D. Savastru, E. M. Carstea, L. Ghervase, and S. Dontu, PHOTONIC BAND STRUCTURES OF 2D PHOTONIC CRYSTALS WITH HALF-ELLIPTICAL HOLES, 4 October 2012)*
12. *Miss. Gayatri Y. Gurav, Prof. Maruti B. Limkar, Prof. Sanjay M. Hundiwale, Study of 1x4 Optical Power Splitters with Optical Network, SSRG International Journal of Electronics and Communication Engineering (SSRG-IJECE) – volume1 issue 4 June 2014.*
13. *Juhi Sharma , Ritu Sharma, Lalit Kumar Dusad, Review and Analysis of Photonic Crystal Beam Splitters for Optical Communication Applications, International Conference on Green Computing and Internet of Things,2015*
14. *Monika Gupta, Ramesh Bharti, Vikas Sharma, Improving Splitting Efficiency in Photonic Crystal Waveguide,*

ISBN: 978-81-951728-4-9

International Journal of Recent Research and Review, Vol. VII, Issue 2, June 2014

15. *Yuangang Zhonga, Xiyao Chenb*, Zexuan Qianga, Guimin Linb, Junzhen Jianga, Yishen Qiua and Hui Lia, A 1 × 4 optical splitter for TE modes based on a silicon photonic crystal self-collimation ring resonator, Journal of Modern Optics,2013.*
16. *Rajat Dey, "Optical Power Splitting Techniques Using Photonic Crystal Line Defect Waveguides," Ph.D Thesis, The University of Western Ontario, London, Canada, 2011.*
17. *Jones, C.J., Director, Miscellaneous Optics Corporation, interview, Sept. 23 2011.*
18. *H. Hojo and N. Uchida, "Control of Electromagnetic waves by 2-D plasma Photonic Crystals", plasma and industrial applications, IEEE, (2005).*
19. *K.M. Leung and Y.F. Liu,"Photon band structures: The plane-wave method", Phys. Rev. B, vol. 41, pp. 10188-10190, 1990.*
20. *Peiyuan Zhang, Hao Guo, Hongjun Chen, Cancan Wang, Xiong Zhang, "Novel composite beam splitter with directional coupler and Y- junction using photonic crystal," Optik 124, pp.3384-3386,2011*