Journal of Management Engineering and Information Technology (JMEIT)
Volume 5 Issue 6, December 2018, Online ISSN: 2394 - 8124
Impact Factor: 4.564 (2015) | Index Copernicus - ICV 2016 = 51.4
Website: www.jmeit.com | E-mail : editorjmeit@outlook.com | jmeit@outlook.com

Design of a Two Dimensional Optical Biosensor Using Nanocavity

Vijay Laxmi Kalyani, PinkyJhakhar, Varsha Sharma

Pinky Jhakhar, *Government Women Engineering College Ajmer, India*
Pinkyjhakhar11@gmail.com
Varsha Sharma, *Government Women Engineering College Ajmer, India*
12varshasharma@gmail.com
Vijay Laxmi Kalyani, *Government Women Engineering College, Ajmer, India*
vijaylaxmikalyani@yahoo.com

Abstract— in this research paper a two dimensional photonic crystal which is based on biosensor. The structure of biosensor consists a nano cavity with a linear waveguide which is useful for sensing purpose, their refractive index changes according to their sensing material. Here the plane wave expansion method is used to find out the bandgap. For the purpose input wavelength is 1550nm and structure bandgap is 1339 to 1981nm. By using finite difference time domain (FDTD) method. The simulation result have analyzed.

I. INTRODUCTION

The term “biosensor” is a biological sensor. Biosensor made a transducer and biological element like enzyme and antibody or a nucleic acid. Biosensor is sense a biological element connected to a transducer and converts a measureable signal. Biosensor is an analytical device used for the detection of an analyte that amalgamate biological component with physicochemical detector. Biosensor is classified as electrochemical, blood glucose biosensor, conduct metric biosensor, potentiometric biosensor, optical biosensor, thermometric biosensor etc.

II. THEORY

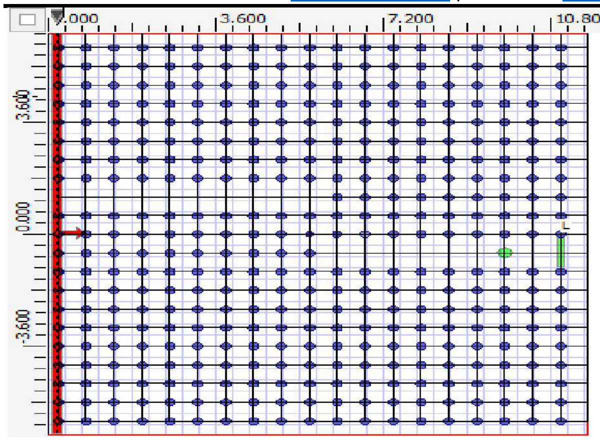
Photonic crystals have periodic structures that made up of dielectric material and classified into three structures 1D, 2D, 3D based on their refractive index distribution function [1]. Because 1D structure have scarcity of complete bandgap and crucial to make 3D structure because of their small constant lattices [2], therefore 2D structure are used because they have full bandgap and simpler to make 2D structures rather than the 3D structures. Usually there are two mechanisms in 2D structures: air holes in present in dielectric substrate and dielectric cylindrical rods engaged in air. In optical field the photonic based biosensor is a new research direction. Photonic crystal is a reasonable and the periodicity of reasonable material is maintaining various background materials. It is periodic dielectric structure with lattice parameter based on propagated electromagnetic wave’s order wavelength. Its light confinement and controlling characteristics is one of the major important characteristics. These characteristics made the crystal to use in different type of applications [3]. There are two method to design a biosensor: one is to vary a refractive index and sense the shift in wavelength, and another method is to vary the thickness on the surface level and changes are measured [4] recently S.H. Kwon et al. proposed a photonic crystal chemical sensor based on a cavity [5]. Also Wang et al. designed a sensor based on refractive index for bio layers and chemical sensing, subsisting of two waveguides and a micro cavity [6].

In this paper, we design a linear waveguide based biosensor with nano cavities with FDTD tool. Finite Difference Time Domain (FDTD) or Yee’s method is based on numerical analysis method which is used to create differential equation. FDTD is a time domain method with broad range and gratified as nonlinear material property. FDTD method established on Maxwell equation.

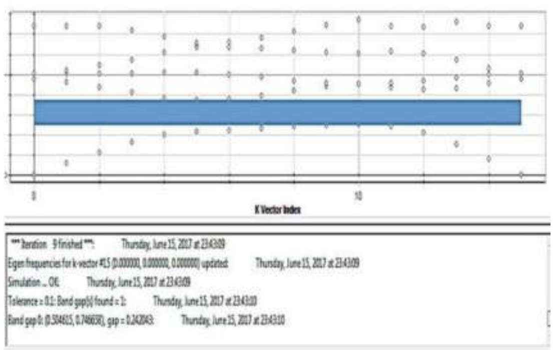
III. DESIGNING OF BIOSENSOR

The layout of photonic crystal sensor is situated on a linear waveguide with 2D photonic crystal and two nano crystal which have a 19 silicon rods in X direction and 21 silicon rods in Z direction. 1550nm Gaussian wavelength is used for propagation of light inside the lattice structure. Optical detector is used to detect the wave at another end. The designing layout of biosensor structure is based on the square lattice shape and air is background wafer with si rods. The refractive index of silicon material is 3.42 and refractive index of air is 1. The radius is 110nm and lattice constant of structure is a=600nm. In this research paper we design a 2D photonic crystal biosensor with three different cavities and the cavity is creating to change a rods radius. We present a structure for bio sensing application. When sensing analytes is induced to nanocavity the refractive index of nanocavity is changed and transmission spectra is vary according to sensing analytes which can determine a property of sensing analytes. In this paper we design an ultra-small novel biosensor for bio sensing application based on photonic crystal. Fig 1 shows a 2D photonic crystal biosensor with linear waveguide and nanocavity.

Journal of Management Engineering and Information Technology (JMEIT)
Volume 5 Issue 6, December 2018, Online ISSN: 2394 - 8124
Impact Factor: 4.564 (2015) | Index Copernicus - ICV 2016 = 51.4
Website: www.jmeit.com | E-mail : editorjmeit@outlook.com | jmeit@outlook.com



In Fig. 2, the band diagram of sensor structure is showing which is given the photonic bandgap for transverse electric modes. The whole structure has one bandgap. The range of PBG in between the wavelength 1339nm and 1981nm. The plane wave expansion (PWE) method is used to measure the bandgap and modes of the propagation of PC structure without and with the defects.



Value used in biosensor and its design parameters

S.No.	Name of Parameter	Values
1.	Radius of Silicon (rod)	110nm
2.	Lattice constant	600nm
3.	Refractive index of Silicon	3.42
4.	Refractive index of wafer (air)	1
5.	PBG range	1339-1981
6.	Polarization	TE

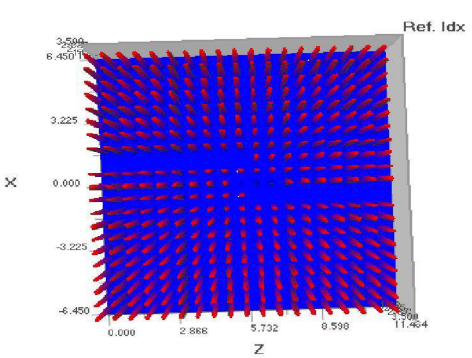


Fig: 3 Refractive index of structure

IV. SIMULATION AND RESULT

The performance of sensor has estimated by 2D finite difference time-domain (FDTD) method. When we observe that the refractive index (RI) of the nano-cavities has been changed, it means that the sensing molecules flow in an aqueous medium. The presence of target molecules varies the ERI. The change in the ERI is utilized to calculate the presence of target molecules. This sensing mechanism is based on homogenous sensing. So the output spectrum is changed. In this section, we suppose *n*1=1.2, *n*2=1.25, *n3=1.33*. With the variation of the nano-cavities size 0.11 um to 0.08um, 0.1um, 0.101 um the transmission spectra changes with respect to the RI variation as shown in Fig. 4(a). Fig shows a transmission 24 % with 1550 nm wavelength and 1.20 refractive index.

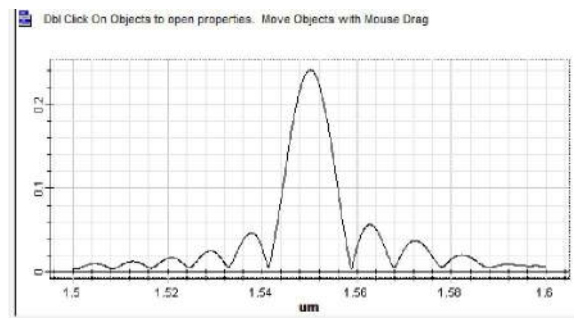
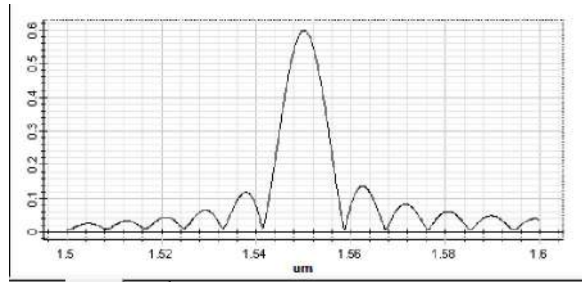


Fig 4: Transmission spectrum with refractive index (1.2)

Fig 5 shows transmission spectra with wavelength 1550 nm and refractive index 1.25. In this wavelength and refractive index transmission is 60%.



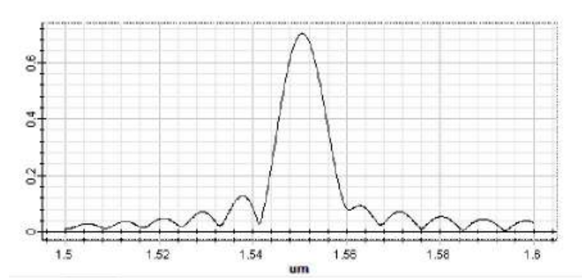


Fig. 5 showing transmission spectra with wavelength

Fig 5 shows transmission spectra with wavelength 1550 nm and refractive index 1.33. In this wavelength and refractive index transmission is 70%.

Journal of Management Engineering and Information Technology (JMEIT)
Volume 5 Issue 6, December 2018, Online ISSN: 2394 - 8124
Impact Factor: 4.564 (2015) | Index Copernicus - ICV 2016 = 51.4
Website: www.jmeit.com | E-mail : editorjmeit@outlook.com | jmeit@outlook.com

V. CONCLUSION

In conclusion, a novel compact linear waveguide biosensor has been designed. The three defects of this sensor can measure three different refractive indices in a special time. The biosensing mechanism is based on the effective refractive index Change of the sensing rods. The bio-molecules have been filled within the nano-cavities and transmission spectrum studied the output terminal. The structure has been optimized in good transmission. By filling an analyte into the nanocavity, the transmission shifted, and this process was utilized for determining the properties of the analyte.

REFERENCES

[1] J. Sun and C. C. Chan, "Photonic bandgap fiber for refractive index measurement," *Sensors and Actuators B: Chemical*, 2007, 128(1): 46–50.

[2] O. Levy, B. Z. Steinberg, M. Nathan, and A. Boag, "Ultrasensitive displacement sensing using photonic crystal waveguides," *Applied Physics Letters*, 2005, 86(10): 104102–104104.

[3] John D Joannopoulos, " Photonic crystals molding the flow of light" , Second Edition, Princeton University of press,2008.

[4] S. H. Kwon, T. Sünner, M. Kamp, and A. Forchel, "Optimization of photonic crystal cavity for chemical sensing," *Optics Express*, vol. 16, no. 16, pp. 11709–11717, 2008.

[5] X. Wang, Z. Xu, N. Lu, J. Zhu, and G. Jin, "Ultracompact refractive index sensor based on microcavity in the sandwiched photonic crystal waveguide structure," *Optics Communications*, vol. 281, no. 6, pp. 1725–1731, 2008.

[6] K. Manoharan, "Design and analysis of high-Q, amorphousmicroring resonator sensors for gaseous and biological species detection," M.S. thesis, Russ College of Engineering and Technology of Ohio University, America, 2009.

[7] H.Z. Wang, W.M. Zhou, J.P. Zheng, A 2D rods-in-air squarelattice photonic crystal optical switch, *Optik*, *121*, 2010, 1988- 1993.

[8] Insu Park, Hyun-Shik Lee, Hyun-Jun Kim, Kyung-Mi Moon, Seung-Gol Lee, Beom Hoan O, Se-Geun Park, and El-Hang Lee, Photonic crystal power-splitter based on directional coupling, *Optics Express*, *12*, 2004, 3599-3604.

Author's Details

Vijay Laxmi Kalyani is currently working as Assistant Professor in the department of ECE in GWECA, Ajmer. She has attended various workshops, conferences, FDP, STC etc. and also published many research papers in various International Journals, National Journals and Conferences; she is also a member of IAENG.

Varsha Sharma M.tech from GWECA, attends a national and international conference and presents a research paper in international conference.

Pinky Jhakhar is pursuing B.TECH in Electronics and Communication,VII semester in GWEC,Ajmer