ISSN (Online) 2394-6849

International Journal of Engineering Research in Electronics and Communication Engineering (IJERECE)
Vol 4, Issue 3, March 2017

All optical NOT Gate using modified Photonic Crystal Platform

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Abstract: **-- This paper deals with designing and simulation of all optical NOT gate constructed by using 2-D modified Photonic Crystal. A typical NOT Gate can be constructed on square lattice of 8 µm*8 µm photonic crystal of silicon rods in doped substrate with refractive index of 3.40 and 1.1 respectively. The lattice constant Λ= 1µm and radius of the rods r= 0.2Λµm. Not gate is realized by combining the cross-waveguide geometries and varying its diameter by pitch (d/Λ). The gate is implemented for the operating wavelength of 1.55µm using Rsoft's Fullwave simulator.**

Index Terms**—— Logic gates, Photonic Crystal (PhC), Square cavity, Cross Waveguide, Finite Difference Time Domain (FDTD).**

I. INTRODUCTION

In recent years there is a tremendous increase in communication traffic. Electronic devices used for communication imposes speed limitations. To overcome this problem all optical communication can be used. Optical fiber communication has many advantages like more bandwidth, long distance communication, low losses. To make the system as all optical, all the components used in the optical network such as logic gates, multiplexer, demultiplexer, couplers, signal generation, splitter, storage devices such as buffers, flip-flop and memory should be all- optical elements.

All optical data processing with integrated nano-photonic circuits increases the data-rate capacity and reduces the power consumption as it eliminates the need of optical-to-electrical conversion. All optical data processing can be done by Photonic Crystals (PhC).

Photonic Crystal is a platform on which we can construct several devices operating with several wavelengths which can be integrated on a single chip. These are dielectric media with sporadic variation of the refractive index. Photonic Band gap in a PhC is the range of frequencies through which light cannot propagate. Using this type of structures we can manipulate the light . By removing rods in Photonic Crystal structure we can create defect in the structure through which light is made to propagate. This behavior of Photonic Crystal can be used to design and realize many Photonic Crystal devices.

The organization of this paper is following the introduction, in section 2 structural design for NOT gate is discussed and analyzed. Logic function is maintained by using constructive and destructive interference of light in the cavity. Section 3 discusses about the simulated results for different d/Λ of the cross waveguide followed by conclusion in section 4 .

II. STRUCTURAL DESIGN AND ANALYSIS

All optical logic NOT gate can be constructed using 2-D Photonic Crystal square lattice. Square lattice structure can be constructed by using Silicon rods with refractive index n_1 =3.40 in the doped host with refractive index n_2=1.1. The number of rods in X directions are 13 and 13 respectively. The distance between two adjacent rods (Λ) is 1µm. Cross waveguide is formed by removing some si rods called as line defects. One input waveguide is marked as control signal (C). Another waveguide is main input marked as (I). The output is measured at output waveguide marked as (Y) as shown in figure 1.

III. SIMULATION RESULTS

To maintain the logic operation Gaussian continuous signal with operating wavelength of λ = 1.55µm is launched at control port (C) which is always high and it acts as a reference input. To provide logic 1 signal as input Gaussian continuous signal with operating wavelength of λ = 1.55µm is launched ports I. Output is measured at output port Y. To provide logic 0 input Gaussian continuous signal of 1V with operating wavelength of λ = 1.55µm is launched at control port C and 0V (OFF) optical signal is launched at input port I. When light propagates it can be seen in figure 3 that logic 1 signal from control port couples with cavity and gives the output Y= 0.6 which can be treated as logic 1 (ON state). Figure 3 (a) shows the electrical field distribution and

ISSN (Online) 2394-6849

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figure 3 (b) shows the output power.

Analysis of NOT Gate is done by varying the radius of rods in cross waveguide. Table.1. gives the truth table of NOT gate

The simulation is carried out by using Rsoft Fullwave simulator. Table 1 gives the output for different input.

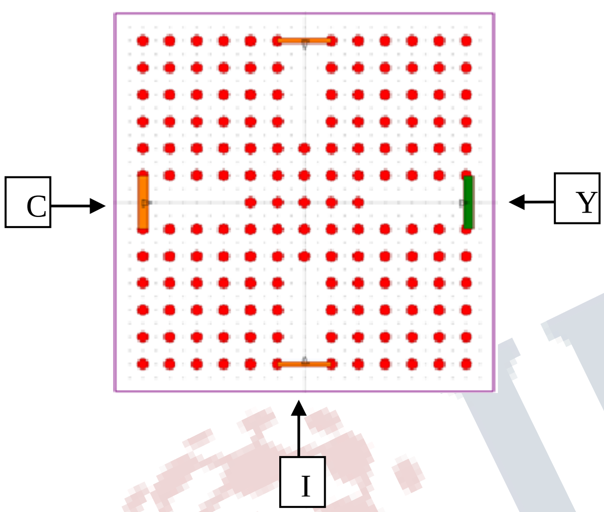

Figure 1: NOT gate structure using PhC

Table.1 Truth table of NOT Gate

Input (I)	Output (Y)
0	1
1	0

With radius of rods in cross waveguide 0.19, Gaussian continuous signal of 1V with operating wavelength of λ = 1.55µm is launched at control port C and 1V with operating wavelength of λ = 1.55µm is launched at input port I. When light propagates it can be seen in figure 2 that constructive interference occurs between two port signal and light is trapped in the cavity and light at the output port is Y= 0.18 which is almost logic 0 (OFF state). Figure 2 (a) shows the electrical field distribution and figure 2 (b) shows the output power.

To provide logic 0 input Gaussian continuous signal of 1V with operating wavelength of λ = 1.55µm is launched at control port C and 0V (OFF) optical signal is launched at input port I. When light propagates it can be seen in figure 3 that logic 1 signal from control port couples with cavity and

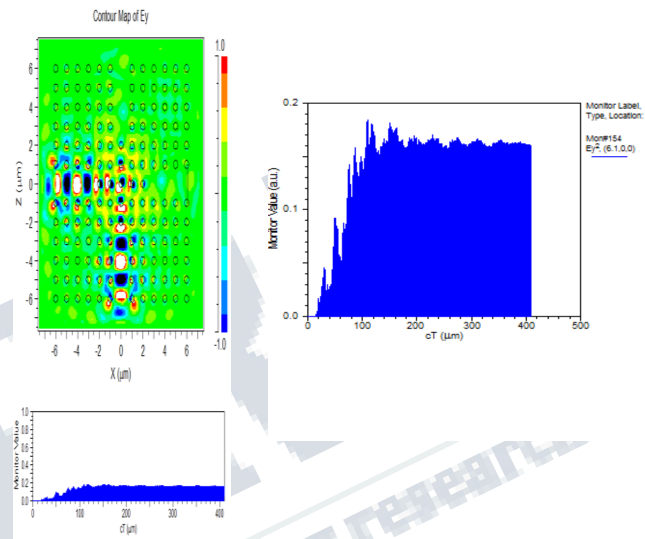

Figure 2: (a) Electric field distribution of NOT gate when input I=1, (b) Output power

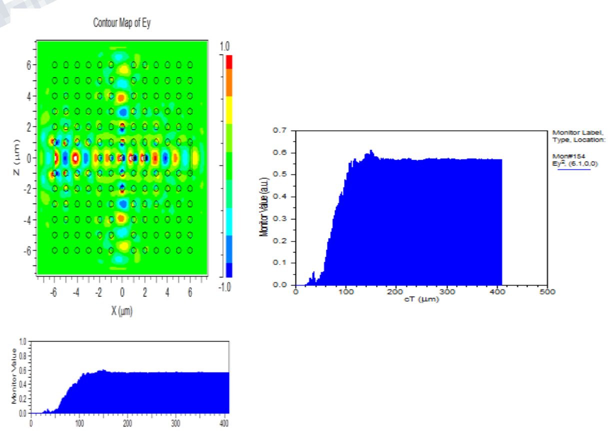

Figure 3: (a) Electric field distribution of NOT gate when input I=0, (b) Output power

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gives the output Y= 0.6 which can be treated as logic 1 (ON state). Figure 3 (a) shows the electrical field distribution and figure 3 (b) shows the output power.
Output of logic NOT Gate for different values of radius of rods in cross waveguide for different d/Λ is shown in table.2.

Table.2. Truth table of NOT Gate

Input I = 1			Input I = 0		
Radius	d/Λ	Output Y	Radius	d/Λ	Output Y
0.17	0.34	0.04	0.17	0.34	0.04
0.18	0.36	0.21	0.18	0.36	0.26
0.19	**0.39**	**0.18**	**0.19**	**0.39**	**0.6**
0.2	0.4	0.69	0.2	0.4	0.13
0.21	0.42	0.3	0.21	0.42	0.06
0.22	0.44	0.15	0.22	0.44	0.01

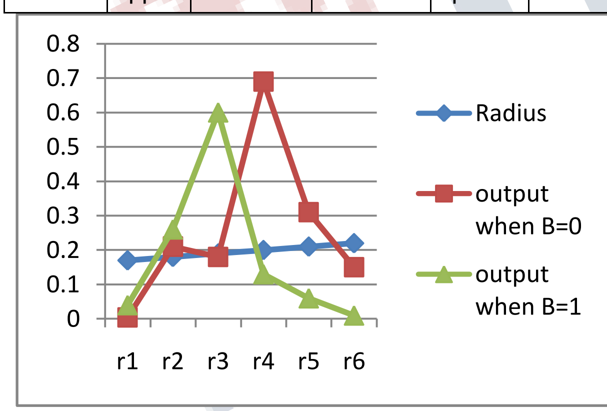

FIG.5. Output power for different cross waveguide radius

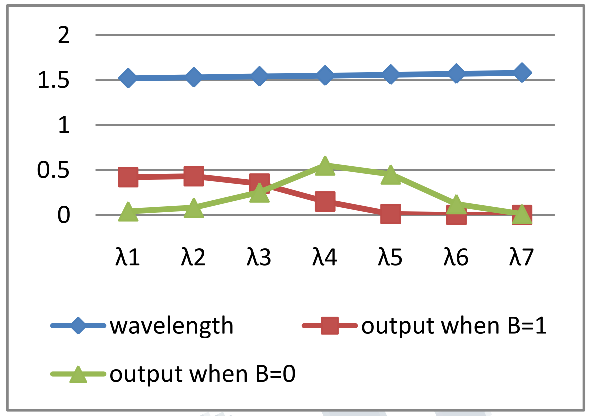

FIG.6. Output power for different wavelength

Fig.5 shows the output of logic NOT Gate for different values of radius and different diameter by pitch,d/a when Input I = 1, I = 0. and Fig.6 shows the output of logic NOT Gate for differentvalues of wavelength when Input I = 1,I = 0

IV. CONCLUSION

In this paper it is proposed and realized all optical NOT gate based on 2-D Photonic Crystal square cavity with cross waveguide. The analysis is done by varying the radius of rods and diameter by pitch in the cross waveguide. It is observed that the output is at its maximum level when radius is 0.19µm and diameter be pitch is 0.39µm. The optimum performance is obtained at operating wavelength of 1.55µm.

ACKNOWLEDGMENT

This work is supported by Vision Group of Science & Technology, Bangalore, Karnataka State under Award no. VGST/K-FIST (L1) (2014-15)/2015-16/373.

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