



Design of an Optical Ring Resonator Using Chalcogenide Based PHC of Single Input and Double Output Decoder with Low Back Propagation

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Abstract: In this paper we combined an optical mixer via photonic crystal ring resonator to propose an all optical single input and multi (two) output decoder. The main purpose of this paper is to have an efficient all optical based ring resonator that can be used for faster far data transmission as well as to achieve low back propagation towards the input signal applied. The final structure has two output ports whose working states can be controlled by one input port. The proposed design resulted a very low amount of back propagation towards input port '1' which is valued 6% and also achieved a very high value of normalized power i.e. 1.94 at the output port 1 when both Carrier and Input signal is given to the system.

Keywords: Back Propagation, Finite Difference Time Domain (FDTD), Photonic Bandgap (PBG), Ring resonator, Photonic Crystal (PHC).

I. Introduction

Photonic crystal ring resonators (PHCRRs) are basic structures employed for realizing the effects of different kinds of all optical devices. PHCRR is a wavelength-selective structure which can drop optical waves from BUS to DROP waveguide in a certain wavelength called resonant mode or resonant wavelength [1]. The PHCRRs resonant wavelength of depend on the lattice constant, radius and refractive index of dielectric rods [2]. These makes PHCRRs suitable mechanisms for designing all optical devices such as optical filters [3], DE-MUX [4], and logic gates [5, 6]. In order to get along with fast data transferring wide band width communication links, we are in need of migration from microwave networks to optical communication networks and systems. Optical decoder is an optical switch with multiple input and multiple output ports, by which one can control 2n output ports by n input ports. All optical decoders play a crucial role in analyzing all optical circuits and logic systems used for all optical data processing and all optical communication networks. Z. Chen et al. [7] proposed an 2 to 4 optical device based on electro optical multimode interference.

By combining nonlinear Kerr effect with PHCRRs, two all optical decoders have been proposed S. Seraj mohammadi et al. [8] proposed an optical decoder by combining nonlinear Kerr's effect. T. A. Monem [10] also proposed an all optical based decoder, combining a T waveguide and set of Y and T splitters. The main problem of above structures is the back propagation towards input. More than 60% of input signal from input ports would be reflected toward the input ports which is not acceptable but in this work this back reflection was reduced down to 6%. Our proposed design also resulted in getting higher normalized power at shortest time compared to the existing designs.

II. Methodology

At first We are declaring the bandgap value that is used in this paper. As shown in Fig. 1 the band gap is from $0.32 < a/\lambda < 0.44$ for TM mode (Where 'a' is termed as lattice constant and ' λ ' stands for center wavelength). Values of 'a' and ' λ ' of my proposed design is given in table 1. As we are dealing with TM mode propagation, so this BG (bandgap) value can be used. For simulation FDTD method is used because Of ease of simulation technique applying boundary condition.

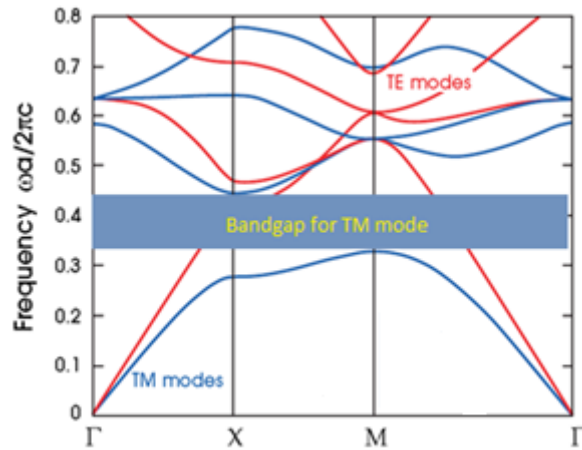


Figure 1: Bandgap for TM mode in a PHC lattice [1].

III. Proposed Design

Our proposed design is given at Fig. 2 identifying the input port (I), Carrier signal (C) & two output ports (O₁ & O₂).

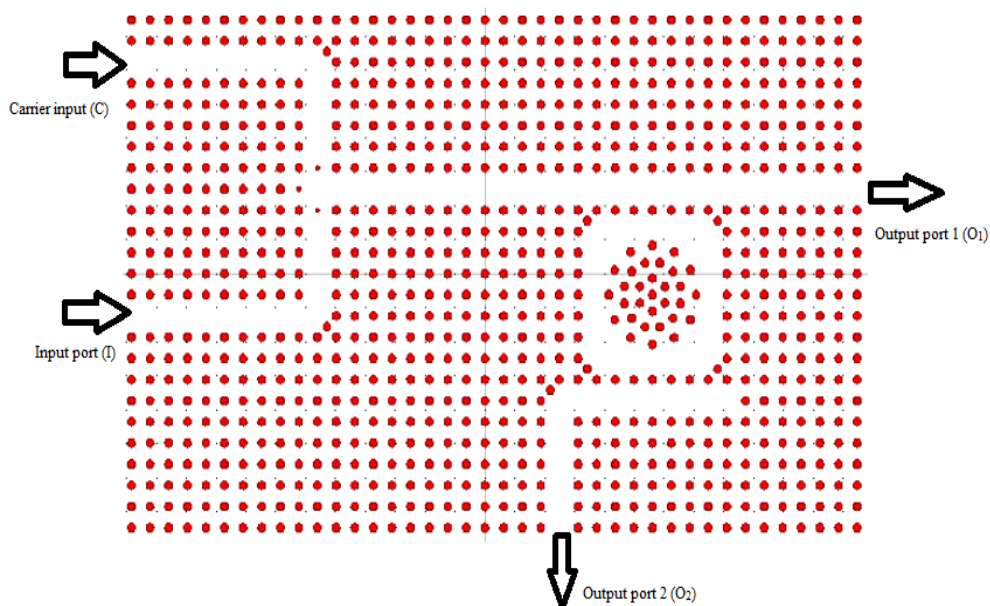


Figure 2: Proposed Design of PHC ring resonator

A. Materials

The materials we using for dielectric rods of Fig. 2 is made of chalcogenide glass and the rest of the object is filled with air. Chalcogenide glass has a refractive index valued 3.1 and air has a refractive index valued 1. We are using a square lattice of 40×25 matrix of the rods. The chalcogenide glasses Kerr coefficient is $9 \times 10^{-17} \text{ m}^2/\text{W}$.

B. Parameters

Parameters of the proposed design is given in Table I.

Table I: Parameters of the Proposed Design.

Symbol	Expression	Description
a	650 nm	Lattice constant
r	0.223a	Radius of the pillars
w _x	49a+2r	Width of the boundary (horizontal)
w _y	24a+2r	Width of the boundary (vertical)
λ	1550 nm	Center wavelength

IV. Simulation and Results

For our simulation carrier input is always on. Fig. 3 shows when C is ON and I is OFF the resulted simulation shows that we should have minimum output at O₂ port and O₁ should have maximum output. The normalized power versus time curve corresponding of this condition is given in Fig. 4. The power intensity for C signal is used as a value of $1 \text{ kW}\mu\text{m}^{-2}$ and λ is used as the value of center wavelength i.e. 1550 nm.

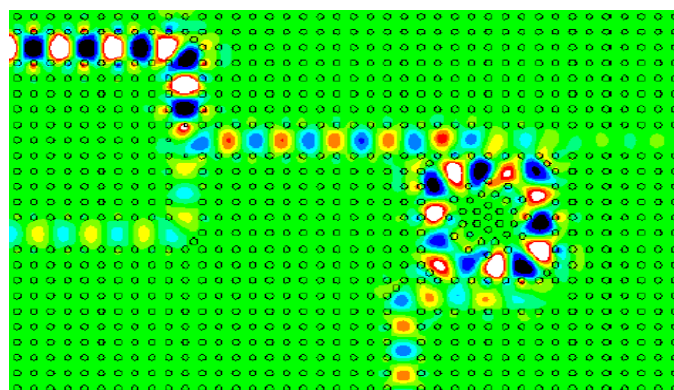


Figure 3: Output spectrum when C is ON and I is OFF.

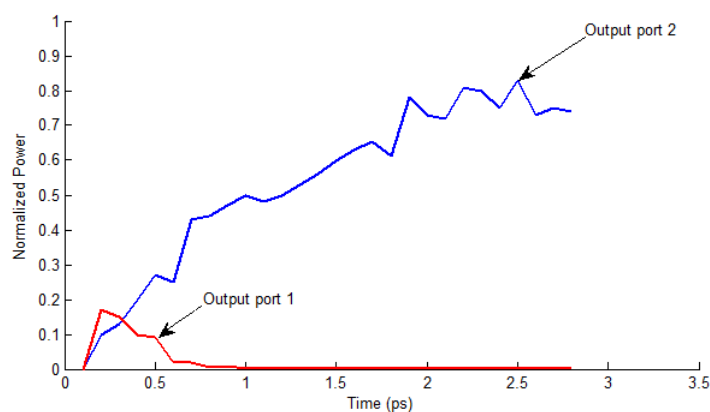


Figure 4: Normalized power vs. Time curve when C is ON and I is OFF.

In the next step I is ON regardless of C is also kept ON. The power spectrum is given in Fig. 5 and in the respective condition the figure of normalized power versus time curve is given at Fig. 6.

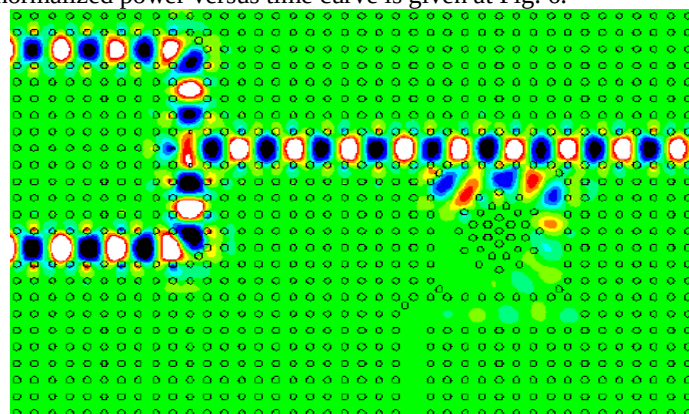


Figure 5: Output spectrum when both C and I is ON.

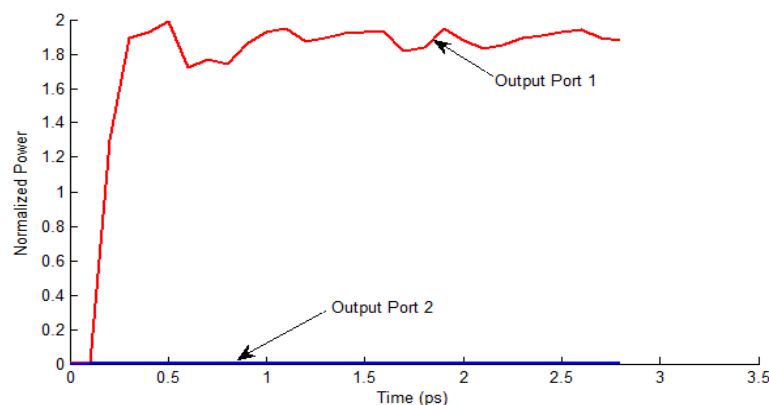


Figure 6: Normalized power vs. Time curve when both C and I is ON.

The back propagation signal towards input port is given in Fig. 7. Now to summarize the paper we can say that when C is ON and I is OFF we get approximately 0.83 of normalized power at O_2 and 0.01 power at O_1 . But when both C and I is ON the normalized power at O_1 and O_2 is 1.94 and 0.001 respectively. The back propagation towards input is 6%. Another valuable point can be made that the steady state condition of the system is achieved at a relatively low time i.e. approximately 2.5 ps which can be result in high speed data transmission in optical waveguide. There is a comparison table is given in Table II to compare my proposed design to other existing designs.

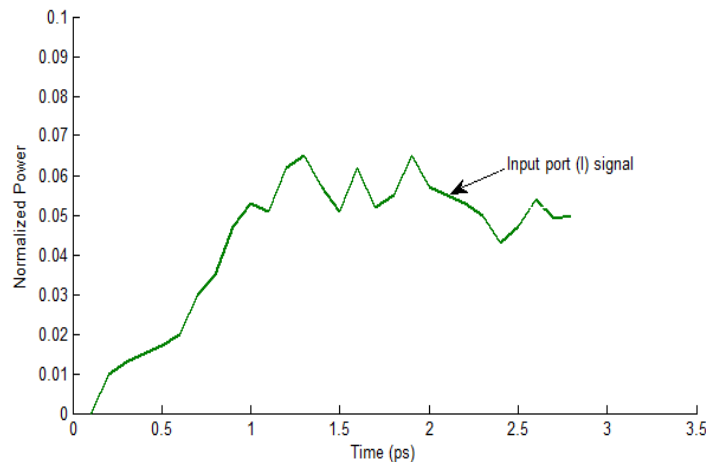


Figure 7: Back propagation towards input port (I).

Table II : Comparison Table

Designs	Back Propagation	Time required to reach steady state condition
H. Alipour-Banaei et al. [8]	60%	-
F. Mehdizadeh et al. [9]	10%	3 ps
S. Serajmohammadi et al. [12]	60%	-
Proposed Design	6%	2.5 ps

V. Conclusion

The main purpose of this paper lies in controlling the light intensity of the incoming optical beam to have maximum output when both C and I signal is ON. The designed object has a positive site that it requires less time to reach steady state condition which is in picosecond range (i.e. 6 ps). The simulation of the proposed object also results in higher normalized power i.e. 1.94, which is highest compared to existing designs. This paper could be a path for the future high speed network systems. As the process we used is basically a trial and error method so, by changing the parameters better results can be achieved. In this paper we are dealing with only single input decoder. Multi input decoders can also be designed in respective procedures to have higher efficiency and lower back propagation.

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