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## Research Paper

# All Optical Digital Multiplexer Using Nonlinear Photonic Crystal Ring Resonators

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**Abstract** An all optical multiplexer will be implemented. Two nonlinear ring resonators with different switching thresholds will be utilized for creating the proposed multiplexer. The proposed structure will have two input and one output port. A control port will be utilized to decide which input data can be illustrated at the output port. The rise time for the proposed structure is about 2 ps. The proposed device can be utilized for implementing all optical systems and networks.

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## 1. INTRODUCTION

Optical digital circuits [1–5] are needed for processing optical signals. For creating any kind of optical digital circuit different classes of optical blocks are wanted [6–12]. Some digital circuits like ALUs are designed for multiple functions but only have on output ports. These circuits need a logic device which can provide the user to decide which function has to be delivered to the output port. An optical digital multiplexer can do this work.

Photonic crystals (PCs) can be utilized for implementing different classes of optical devices. They have photonic band gaps (PBGs) which help them to act as optical insulators. Optical waves can be controlled inside optical waveguides that are created by combining defect modes and PBG properties of these periodic structures. Optical wave guiding [13,14], wavelength selecting [15–17] and threshold switching [18] are the main mechanisms that can be utilized for implementing optical devices.

The only PC-based optical digital multiplexer was proposed by Zhao et al [19] that was implemented utilizing two nonlinear ring resonators. This structure has one control port by which one can control which function has be delivered to the output port.

## 2. DESIGN PROCEDURE

At the designed 2*1 digital multiplexer we utilized 2 nonlinear ring resonators. The nonlinear ring resonators are similar to the device presented by Mehdizadeh et al [20]. The nonlinear material utilized inside the resonant rings is doped glass (n=1.4 and $K=10^{-14}$ m2/W, where n represents refractive index and K represents Kerr coefficient respectively) [21]. The value of the structural parameters are listed at table 1.R1 and R2 are low pass and high pass switches respectively. The area of the circuit is 483 $\mu m^2$.

Table 1. The value of the structural parameters

| Parameter | Description | Value |
|---|---|---|
| R1 | Radii of nonlinear rods at R1 | 119 nm |
| R2 | Radii of nonlinear rods at R2 | 114 nm |
| R | Radii of the regular rods | 119 nm |
| A | Lattice constant | 595 nm |
| N | Refractive index of regular rods | 3.46 |

The final structure is shown at figure 1. I0 and I1 are the input ports, S is the control port and O is the output port of the proposed structure. As mentioned in the proposed structure data signals enter the device through I0 and I1. S controls which data must go to O. The wavelength of the signals is 1550 nm.

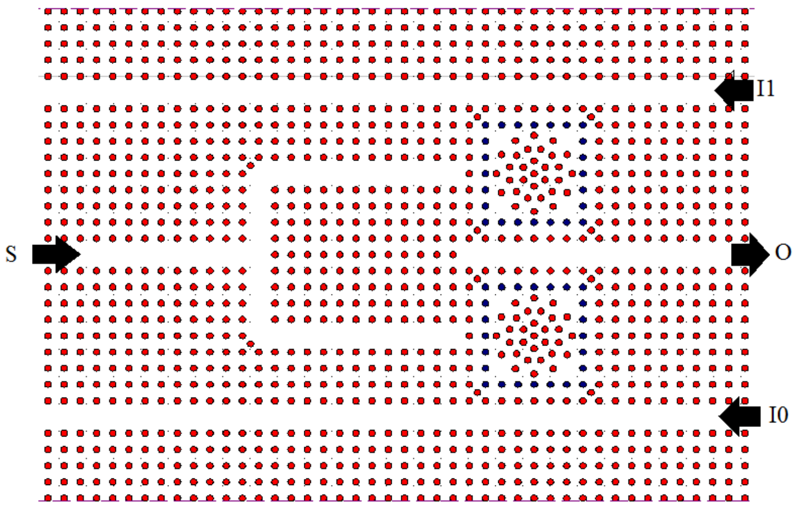
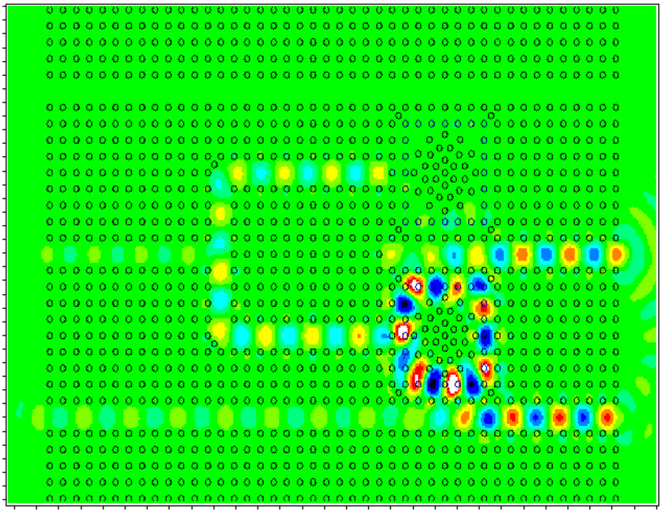


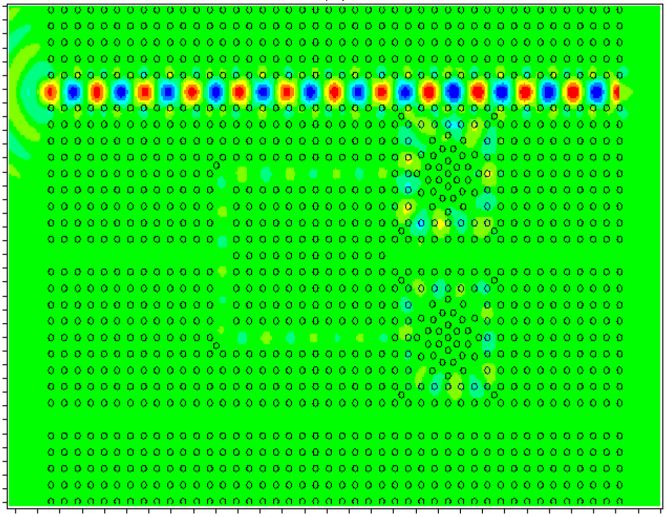

**Fig. 1**. Designed structure for optical digital multiplexer.

## 3. SIMULATION AND RESULTS

The functionality of the presented circuit is illustrated at figure 2 and 3. According to figure 2, For S=0, R1 can transmit the signals, but R2 cannot transmit the signals. So I0 signals can be transferred to O through R1. However I1 signals cannot be transferred to O through R2. We conclude that for S=0, the connection between I0 and O is active.



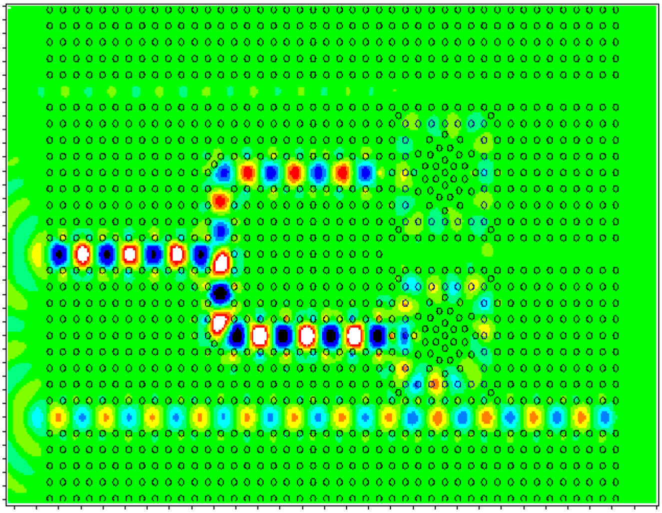
(a)



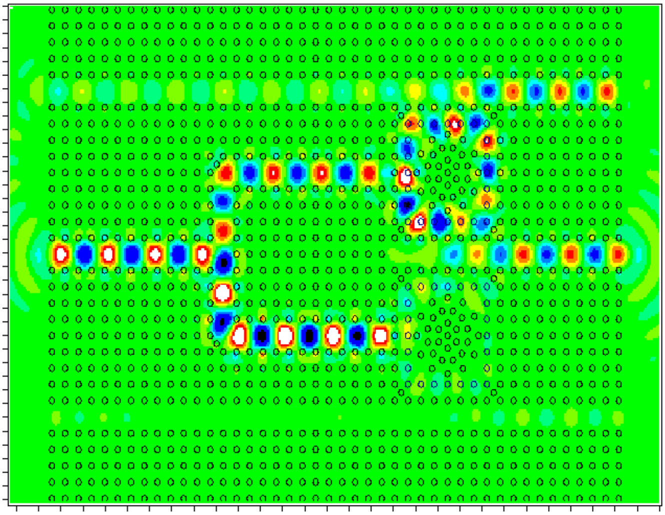
(b)

**Fig. 2**. The functionality of the multiplexer for S=0, if (a) I0 is ON, (b) I1 is ON.

According to figure 3, For S=1, R2 can transmit the signals, but R1 cannot transmit the signals. So I1 signals can be transferred to O through R2. However I0 signals cannot be transferred to O through R1. We conclude that for S=1, the connection between I1 and O is active.



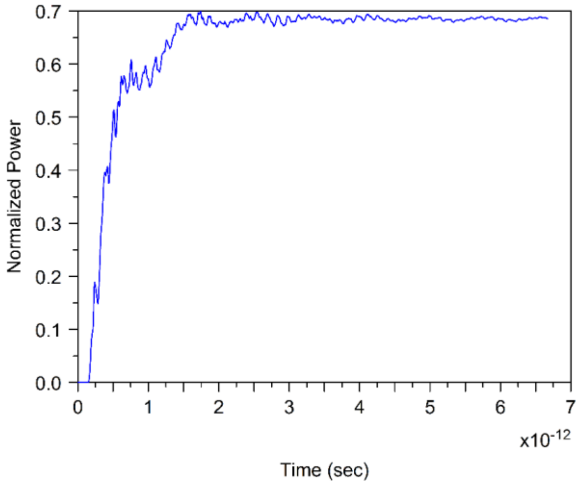
(a)



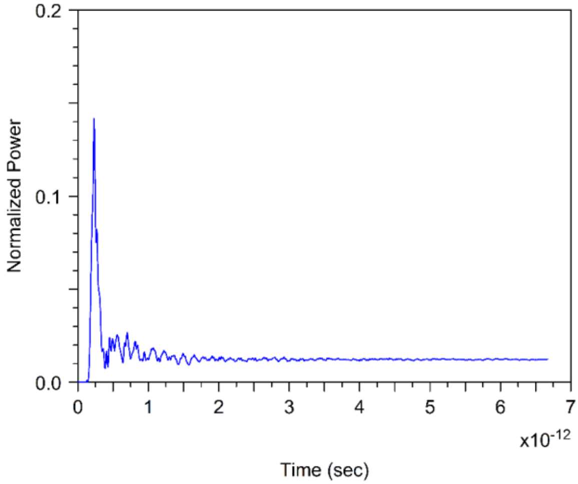
(b)

**Fig. 3**. The functionality of the multiplexer for S=1, if (a) I0 is ON, (b) I1 is ON.

The timing analysis of the multiplexer are depicted at figure 4 and figure 5. For S=0, the normalized intensity at O is 70%, and for S=1 the normalized intensity at O is 100%. For both cases the rise time is 2 ps.

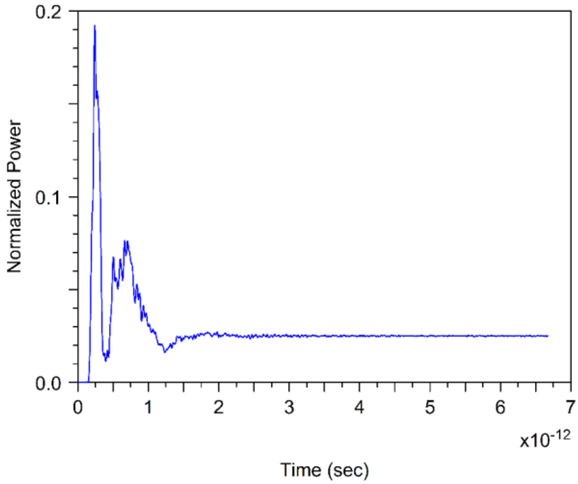



(a)

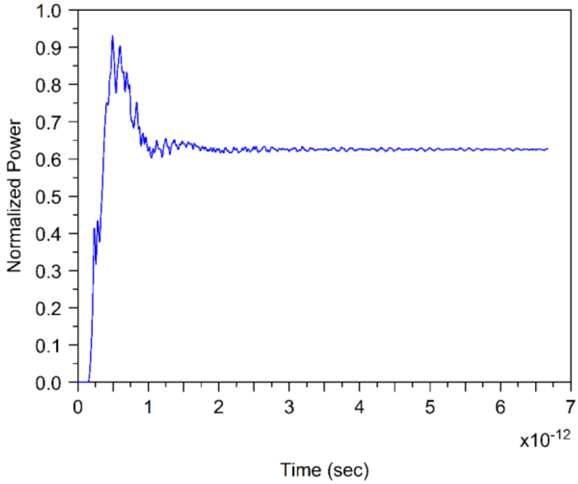



(b)

**Fig. 4**. Timing analysis of the multiplexer for S=0, if (a) I0 is ON, (b) I1 is ON.




(a)




(b)

**Fig. 5**. Timing analysis of the multiplexer for S=1, if (a) I0 is ON, (b) I1 is ON.

## 4. CONCLUSION

Design and simulation of process of an optical multiplexer was presented and discussed. The optical multiplexer was implemented utilizing one low pass and one high pass optical switches. The final structure has two input and one output ports. A control port will be utilized to decide which input data can be illustrated at the output port. The rise time and on/off contrast ratio is 2 ps and15 dB respectively.

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