All-Optical AND Gate for Optical Processing Based on Photonic Crystals

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Abstract --- *An original all-optical AND gate based on photonic crystals structure has been proposed for the first time. In order to develop the photonic integrated circuits in the future, the device sizes are expected to be drastically reduced to a scale of a few tens of micrometers. Different from conventional waveguide methods, the Photonic Crystals structure is employed to realize the AND logic function. It takes advantages of the device sizes are drastically reduced to a scale of a few tens of micrometers and the easy-to-implement logic function.*

In our study, the minute schemes such as configuration of the logic gate, design essentials of photonic crystals structure and simulation essentials have been considered. We propose a AND logic gate based on photonic crystal with cylindrical silicon structure. The simulation results confirm the optical logic gate can show their capabilities. Furthermore, the multi-input AND gate can apply to all-optical Arithmetic Logic Unit (ALU) devices of photon computer in the future.

Keywords*: Photonic Crystals, logic gate*

INTRODUCTION

In recent years, all-optical signal processing techniques have attracted many researchers and stimulated great developments in high-speed and high-capacity telecommunication systems. All-optical logic gates are key elements in all-optical signal processing techniques such as addressing, switching, header recognition, data encoding, and encryption. Several schemes that focused on investigated to realize various optoelectronic logic operations has been successfully completed in the near future [1-6]. In general, the most familiar used techniques for the all-optical logic gates were the conventional waveguide devices. These approaches have showed some advantages, but these methods still present some difficulties for practical considered. Base on the above reasons, photonic crystal based have attracted considerable interest due to advantageous characteristics such as the device sizes are drastically reduced to a scale of a few tens of micrometers, curves angle, and photorefractive materials selections. Therefore, photonic crystal structures also have been found applications as variable-ratio power splitters, optical taper, mode splitters, and so on.

RESULTS AND DISCUSSION

In this paper, we will concentrate on the study of a AND logic gate based on photonic crystal with cylindrical silicon structure. Difference from conventional method, a photonic crystal is a revolutionary class of artificially periodic electromagnetic media, in which a fundamentally new electromagnetic phenomenon can be achieved. By changing the length(L) of the Mach-Zehnder section and length(I) and width(J) of the trapezoid interference section installed in the photonic crystal waveguide structure, the AND logic function can be realized.

The circuit configuration and truth table of the All-optical AND gate is shown in Figure 1 and Table 1, respectively. The simulation results show in Figure 2. From the Figure 2(a)(b), the output power is less than 23 percentage transferred, and the transferred power is more than 70 percentage in Figure 2(c). The simulation results confirm our optical logic gate can show their capabilities.

Table 1. Truth table for AND logic gate.

INPUT		OUTPUT
A	B	Y
0	0	0
0	1	0
1	0	0
1	1	1

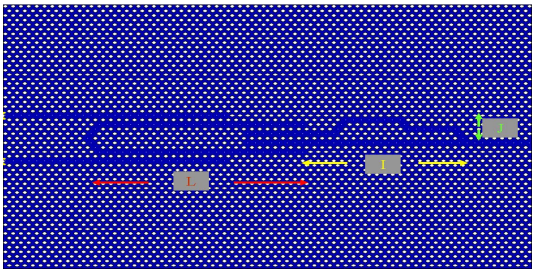

Figure 1. Schematic diagram of the proposed AND optical logic gate.

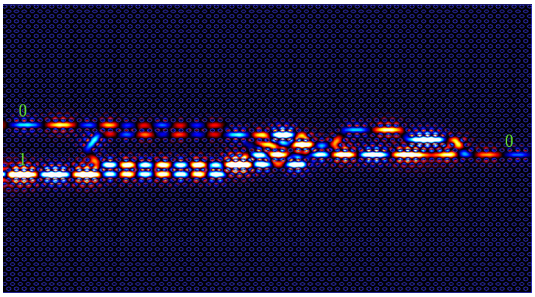

Figure 2(a). The action of the proposed AND optical logic gate for input (0,1).

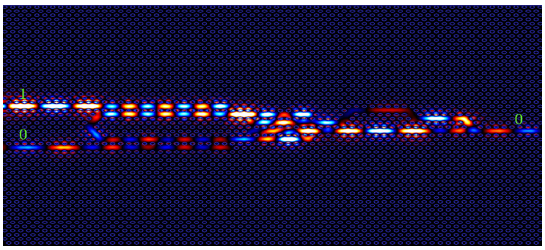

Figure 2(b). The action of the proposed AND optical logic gate for input (1,0).

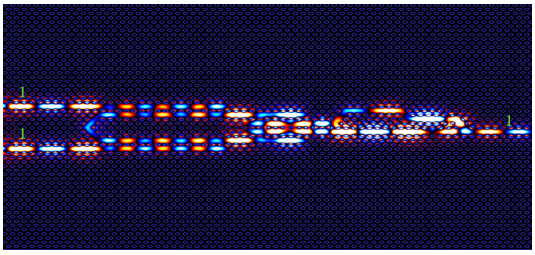

Figure 2(c). The action of the proposed AND optical logic gate for input (1,1).

CONCLUSION

In this paper, the novel optoelectronic AND gate has been proposed for the first time. It takes advantages of the device sizes are drastically reduced to a scale of a few tens of micrometers and curves angle is superior to conventional waveguide methods. Moreover, the high count port AND gate can be extend by cascading the following optical digital scheme in the future.

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