Performance Analysis of Optical AND Gate Using T-Shaped Waveguide

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Abstract

Ultra-compact all-optical AND logic gate is realized for optical processing and photonic integrated devices with two-dimensional photonic crystal waveguides based on beam interference principle. The performance of the structure is examined and evaluated by optimized parameters such as refractive index and silicon rod radius. The results obtained from a numerical calculation using the finite-difference time-domain (FDTD) method and plane wave expansion method. The photonic crystal based all-optical AND logic gate has benefits of compact size as $38.88 \mu m^2$, operated at low power levels, high transmission ratio and good time response as 0.124 ps. Associated with conventional semiconductor optical amplifiers, Mach-Zehnder interferometer and photonic crystal ring resonators proposed methodology provides better performance with a high achieved more than 97% transmission ratio, at a wavelength of $1.55 \mu m$.

Full-text

Due to technical limitations, full-text HTML conversion of this manuscript could not be completed. However, the manuscript can be downloaded and accessed as a PDF.

Tables

Due to technical limitations, table 1 is only available as a download in the Supplemental Files section.

Table 2. All-optical AND logic gate for different RI values with normalized input and output power values

Input		Output Power			
		Refractive Index Variations			
A	B	3.42	3.44	3.46	3.48
0	0	0.02	0.042	0.024	0.032
0	1	0.14	0.12	0.088	0.03
1	0	0.010	0.017	0.012	0.021
1	1	0.75	0.75	0.731	0.671

Table 3. All-optical AND logic gate for different silicon rod radius values with normalized input and output power values while optimized RI of 3.42

Input		Output Power			
		Silicon rod radius values			
A	B	0.16a	0.18a	0.2a	0.22a
0	0	0.08	0.05	0.02	0.04
0	1	0.18	0.21	0.14	0.16
1	0	0.017	0.015	0.010	0.02
1	1	0.7	0.72	0.75	0.65

Table 4. Comparison of proposed design with earlier designs in terms of various parameters

Dimensions	Contrast ratio	Transmission ratio	Response time	Ref
9.45×13.5 μ	6.7 dB	-	-	16
9×9 μ	6.017 dB	-	0.63 ps	22
8.64 × 5.64 μ	19.46 dB	-	0.15 ps	23
8.1×12.5 μ	-	92%	-	26
7.2× 5.4 μ	18.7 dB	97%	0.124 ps	Proposed

Figures

Figure 1

Diagram of all-optical AND logic gate with two T-shaped photonic crystals

Figure 2

Light propagation for input condition A and B is '0'

Figure 3

Light propagation for input condition A is '0' and B is '1'

Figure 4

Light propagation for input condition A is '1' and B is '0'

Figure 5

Light propagation for input condition $A = 1$ and $B = 1$

Figure 6

Contrast ratio of all-optical AND logic gate for different (a) refractive index

Figure 7

Contrast ratio of all-optical AND logic gate for different (a) silicon rod radius

Figure 8

Time response curve of the output power for input condition '11'

Supplementary Files

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- [Table1.docx](#)