Optical NOR Logic Gate Design on Square Lattice Photonic Crystal Platform

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Abstract. We numerically demonstrate a new configuration of all-optical NOR logic gate with square lattice photonic crystal (PhC) waveguide using finite difference time domain (FDTD) method. The logic operations are based on interference effect of optical waves. We have determined the operating frequency range by calculating the band structure for a perfectly periodic PhC using plane wave expansion (PWE) method. Response time of this logic gate is 1.98 ps and it can be operated with speed about 513 GB/s. The proposed device consists of four linear waveguides and a square ring resonator waveguides on PhC platform.

INTRODUCTION

Photonic crystals facilitate control of light on a nano and microscopic levels. Moreover it provides strong confinement effect as well as diffraction less guidance of light in three dimensions. So it is considered as one of the versatile platform to make optical devices at the nano and micro level [1]. Photonic crystal based many optical devices in the field of signal processing and optical networks have already been proposed [2]. All optical logic gates are one of the key component in the future all optical telecommunication system [3]. Considering this many optical logic gates based on various phenomenons and with different logic operations were proposed [4-6].

Here we are proposing a interference based square lattice photonic crystal optical NOR logic gate. This device can be operated with multiple wavelengths. It has no external phase shifters, nonlinear materials etc. This gate has response time 1.9 ps operating speed 513 Gb/s. We have used FDTD method to study the logic operations. Using plane wave expansion method we have explored the operating frequency range. Logic operations are achieved by the interference effect between the signal waves.

THEORY

Interference effect is the working principle of our optical NOR gate. The structure is designed on a 2D square lattice photonic crystal platform. The PhC is made up of square lattice arrangement of dielectric rods of silicon in air. Using plane wave expansion method we have plotted the band structure, which gives the information about the photonic band gap (PBG). PBG is a range of frequency, which is not allowed through the perfectly periodic photonic crystal. However these frequencies can be guided through the photonic crystal by introducing defect in it. Here we are introducing defect by removing some dielectric rods and creating the linear and ring shaped waveguides for the operation of NOR logic functions as shown in Fig. 1(a). Signals from various inputs interfere and will give the output. A variation in output intensity occurs depending upon the constructive and destructive interference and result in various logic operations.

According optics wave theory, if the phase difference between two incident optical waves is $2n\pi$, where n=0, 1,

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