DESIGN OF MICRORING RESONATOR WITH AIR-HOLE METHOD USING2D PHOTONIC CRYSTAL

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Abstract- The all-optical signal processing for the networks can handle large bandwidth signals and large information with very high speed. This optical computing makes the system high efficient. So the ultrafast optical devices based on nonlinear photonic crystal(NPC) are the key device in optical processing systems and future optical networks. This paper proposes the design of ring resonator where the propagation of electromagnetic wave is simulated in dielectric material Si (silicon) with square lattice in 2D photonic crystal. It has been designed for TE polarized light wave with a lattice constant of 250 nm. Using the Finite Difference Time Domain (FDTD) method and Plane Wave Expansion method, we can compute the propagation of EM wave and photonic bandgap of the structure.

Keywords-*Lattice, photonic crystal, air hole, microring resonator, Finite difference time domain, bandgap, plane wave expansion.*

I. INTRODUCTION

Conventional electronic technology will very soon reach its speed limit. All optical networks are very often considered to be the main candidate for constituting the backbone that will carry global data traffic whose volume has been growing at astounding rates that are not expected to slow down in the near future.In recent years, the demand for all-optical signal processing techniques and all-optical networks in telecommunication systems are rapidly increasing due to speed and large amount of data that are needed for transmission. In order to response these demands, many efforts have been performed. Current fiber networks use electronic switching and are therefore limited to electronic speeds of a few gigabits per second. For higher speeds, it is important that the signal remain photonic throughout its path. Such networks, which use optical switching and routing, are called all-optical.The optical computing has many advantages over electronic interference and short circuits, lower transmission loss, higher bandwidth and easier computing. Optoelectronic devices use 30% of their energy in converting electronic energy to photons and back. This conversion slows down the transmission of messages. All optical computers eliminate the need for optical – electrical – optical (OEO) conversion,thus lessening the need for electrical power. To meet those purposes optical waveguides are used to control lights than electronics. So ultrafast optical devices based on nonlinear photonic crystal (NPC) are the key device in optical processing systems and future networks.

II. PHOTONIC CRYSTAL AND PHOTONIC BANDGAP

To design the network with above requirements a nano structured element known as photonic crystal is used. Those are the periodic dielectric structure that have bandgaps. This property enables to control light with amazing facility which produce effects that are impossible with conventional optics. With photonic crystals, it is possible to create waveguides that permit 90 degree bends with 100% transmission.The photonic band gap (PBG) is, essentially, the gap between the air-line and the dielectric-line in the dispersion relation of the PBG system. To design photonic crystal systems, it is essential to engineer the location and size of the bandgapby computational modelling where we use Plane wave Expansion (PWE) here.The plane wave expansion method can be used to calculate the band structure using an Eigen formulation of the Maxwell's equations, and thus solving for the Eigen frequencies for each of the propagation directions, of the wave vectors. Electric field strength values can also be calculated over the spatial domain using the eigen vectors.

III. MICRORING RESONTAOR

Silicon photonics has become one of the most promising photonic integration platforms in the last years. Ring resonators play an important role in the success of silicon photonics, because silicon enables ring resonators of an unprecedented small size.A generic ring resonator consists of an optical waveguide which is looped back on itself, such that a resonance occurs when the optical path length of the resonator is exactly a whole number of wavelengths. Ring resonators therefore support multiple resonances, and the spacing between these resonances.As there is a very high refractive index contrast between silicon and air, single-mode strip waveguides can have bend radii below 5 µm. This allows for extremely compact rings, even with an FSR (Free Spectral Range) over 20 nm at telecom wavelengths around 1550 nm. This is in stark contrast with lower contrast material systems where rings need to be much larger. A ring resonator as a device is known as coupling element. The coupling mechanism used here is codirectional evanescent coupling between the adjacent ring and linear waveguide.

This proposed model uses 2D photonic crystal and simulation is performed through 2D Finite Difference Time Domain (FDTD) method. This method is mainly used to simulate electromagnetic wave in any kind of materials in discrete time domain. Since it is a time domain method, FDTD solutions can cover a wide frequency range with a single simulation run and treat nonlinear material properties in natural way. Also the photonic bandgap (PBG) can be derived by Plane Wave Expansion Method (PWE).

IV. LAYOUT DESIGN OF MICRORING RESONATOR

The microring resonator is designed in optiFDTD 32-bit software package which is 20×20 square lattice in 2D photonic crystal. The main methodology used in this photonic crystal is Air hole method. In this method, the core is air which acts as a low dielectric rod whose refractive index is 1.00. The low dielectric air rods are surrounded by high dielectric material Si (silicon) whose refractive index is 3.9.

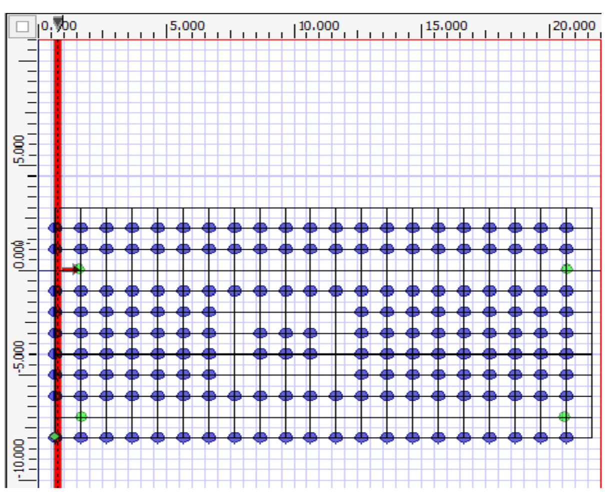

Figure.1.Design layout of microring resonator.

This 4 port ring resonator is mainly used for distributing power in the optical network. Figure. 1. Shows the designed layout of microring resonator in photonic crystal. Scattering is produced due to the defects that are created in photonic crystal structure.

V. SIMULATION AND BANDGAP

A ring resonator is positioned between two optical waveguides to provide an ideal structure of microring resonator. By finite difference time domain simulation, the output has been generated and is shown in Figure. 2. It shows that the electromagnetic wave propagated through port B and port C and partially propagated through port D when then input is applied at port A.

That is, at resonance condition, the light is dropped from the linear waveguide (top) and is sent to the dropping waveguide (bottom) through ring resonator. The light will decay through both waveguides along the forward and backward directions which introduces the reflection.

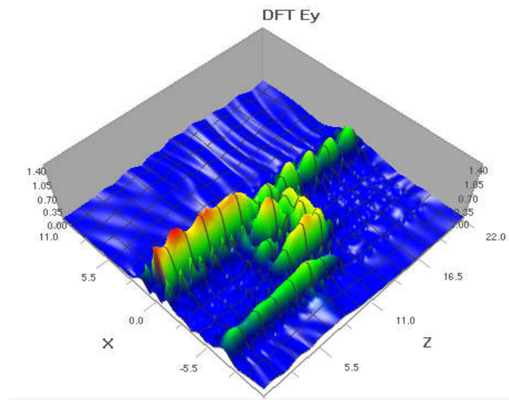

Figure. 2. Simulated microring resonator.

The propagation of the wave is observed in TE field in which the magnetic field is perpendicular to the plane. Using the plane Wave Expansion(PWE) method photonic bandgap (PBG) is generated and the normalized frequency (a/λ) is observed from 0.66Hz to 0.668Hz for bandgap 1, 0.428Hz to 0.46Hz for bandgap 2 and 0.225Hz to 0.28Hz for bandgap 3 which is shown in Figure. 3.

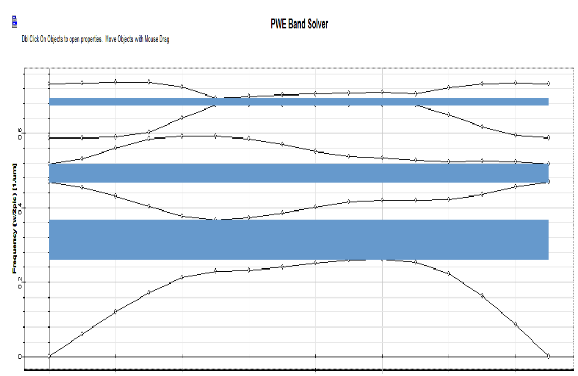

Figure. 3. Bandgap of microring resonator.

VI. CONCLUSION

The Finite Difference Time Domain method (FDTD) solution technique gained popularity in computational electrodynamics (CEM) over the past decade due to its relatively straight forward and effective formulation. The analysis of microring resonator is kept for future computation. Thus the microring resonator using air hole method is designed in photonic crystal and its bandgap is observed. This designed microring resonator is the most efficient way to transfer energy with minimal loss. Thereby supporting high bandwidth of data with low dispersion.

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