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Design & Analysis of Logic Gates using 2D Photonic Crystals

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Abstract

This paper present new plans of all-optical OR, AND, NOR and NAND rationale gates dependent on the obstruction impact. The plans are constructed utilizing 2D square cross section Photonic Crystal (PhC) structure of dielectric bars inserted in air foundation. The cross-section steady and the bar span are intended to accomplish greatest working scope of frequencies utilizing the hole outline. We utilize the Plane Wave Expansion (PWE) technique to acquire the structure of band and the whole guide of the proposed plans. The working wavelengths accomplish a wide band extend that changes between 1272.06 nm and 1987.40 nm with focus wavelength at 1550nm. Finite-Difference Time-Domain (FDTD) technique is utilized to think about the field conduct inside the PhC gates. The gates fulfill their reality tables with sensible power differentiate proportion between logic '1' and logic '0'.

Keywords; *FDTD, PhC, PWE, Power Differentiation*.

I. INTRODUCTION

Now a day Optical ICs are gaining more importance in computer optical technology, because of their excellent performance in terms of speed data processing availability and designing compact sized embedded devices with optical gate technology. PhC (Photonic Crystals) plays an important role in design techniques of optical integrated circuits, several other design techniques found that the PhC gates with logical technology as self collimated because of many mode interferences, non -linear effects, kinematic liquid crystals and interference based gates. In the addressed paper we introduced a new method for design of complete set of logic gates with optical Technology by considering interference effects by using 2 dimensional lattice PhC structure to minimize power consumption we found that the PhC structure must use linear materials which also exhibits simplicity of fabrication and cost effective. This type of design operating with very wide band of wave length at a center wavelength of 1550nm, which is very suitable for different applications, actually foot printers of each gate may be reduced by phase shifters, in this design we were not used the phase shifters.

II. DESIGN METHODOLOGY

We introduce a new method of 2 dimensional square lattice PhC structures with Germanium (Ge) rods having relative permittivity of 6 and Refractive index of 4 which contain background as air when embedding it produced high contrast ratio between the dielectric constants of air and Ge as a result the operating wave lengths of PhC structure are enhanced. Ge is also having a quality of compatible with the conventional method of CMOS fabrication technology, gap map method used to identify the constant of lattice and the radius of the rods, to estimate the gap map and band structure we

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introduce a PWE (Plane Wave Expansion) method, by varying the parameters as **C/R** of PhC structure the changes will appear in photonic band gap (PBG), this variations are also appeared in gap map plots. The following graphs show the gap map picture for the PhCstructure of a Square Lattice of Ge rods in air background with 2 dimensional Euclidian space .

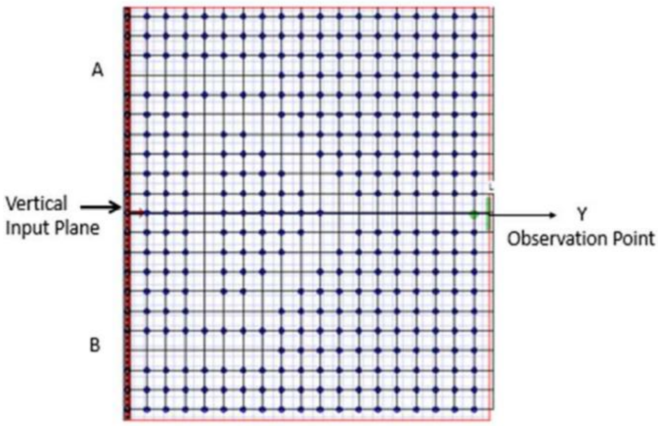
Photonic Crystal: Photonic crystals (PhCs) are a novel class of optical media characterized by natural or synthetic structures with distinctive modulation of the refractive index. Such optical media have some peculiar properties which give an opportunity for a numeral application to be applied on their basis. Photonic crystals are of 3 types. They are 1-dimensional, 2-dimensional and 3- dimensional simply 1D, 2D & 3D type. Generally, we call it a 1D photonic crystal, 2D and 3D photonic crystals, corresponding to the respective instances where varies along two and three self- determining directors, it is arranging by according to the dimensionality of the stack.

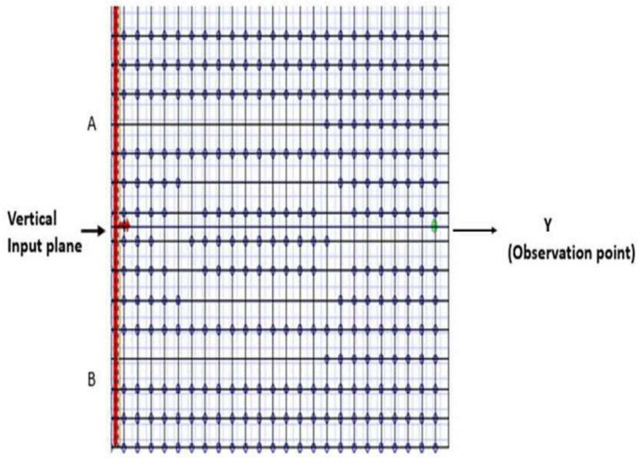
PhotonicBandgap (PBG): This crystal is an array crystal that could influence beams of light in the same way semiconductors to control electric currents. It relates to the reflection of light by a periodic object which period is equivalent to half the wavelength of the light that descents onto it. It is the outcome of an interference of the numerous wavelets that are reflected by the periodic individual elements of the object. No light is absorbed in the process. The wavelengths not identical with the periodicity of the object just do pass through the object.

Optical Interference*: It is the*the interaction of two or more light waves. Optical interference is beneficial in many applications, so it is needed to comprehend some fundamental equations related to this optical phenomenon. The following equations permit to compute numerous quantities correlated to optical interference in the two most usual interference array crystal, The location of the bright and dark fringes in Young's two-slit interference array crystal. The phase shift due to the film thickness in thin film interference.

Plane Wave Expansion (PWE) Method: Plane wave expansion technique (PWE) refers to a computational process in electromagnetics to solve Maxwell's equivalence by formulating a characteristic root of a square matrix problem. This is a popular among the photonic crystal community as a method of resolution for the band social system (dispersion relation) of specific photonic crystal geometry. PWE is conspicuous to the analytical expression and is useful in computing modal auxiliary results of Maxwell's equations, over an inhomogeneous or periodic geometry. It is exclusively for solving complications in a meter - harmonic forms, with non-dispersive media.

III. Experimental Results





Proposed 2D AND Gate, the input ports are A and B.

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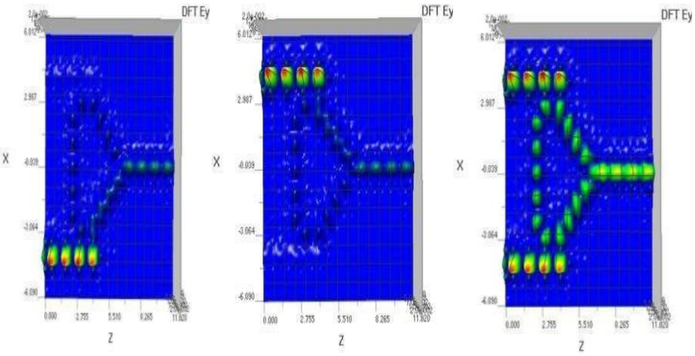
Fig **1** Layout of optical logic AND gate in Optical FDTD with the input port A and B and output is Y (Observation point)



A=0, B=1 *A=1, B=0* *A=1, B=1*

Fig 2 : The refractive index viewof the logic AND gate

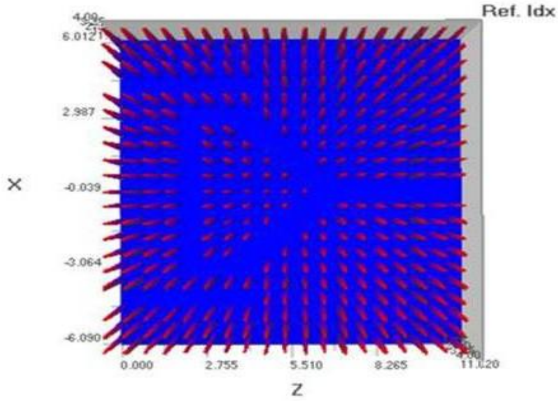


Fig 3 Electric Field distributions for optical AND logic gate for different cases

Fig **4** Layout of optical logic OR gate in Optical FDTD with the input port A and B and output is Y.

Proposed 2D OR Gate, Input ports are **A** and **B**

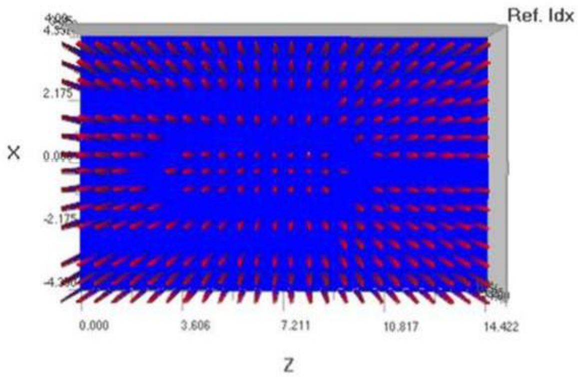
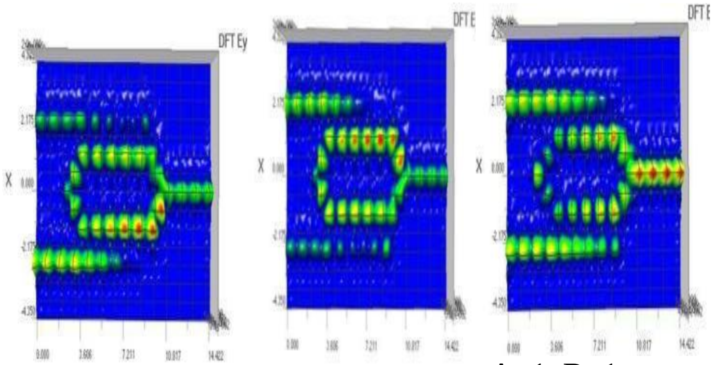
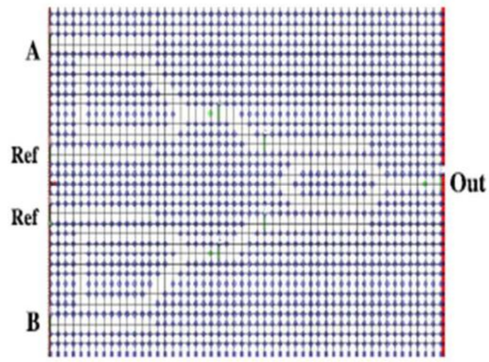


Fig 5 Refractive Index view of the logic OR Gate



A=0, B=1 A=1, B=0 A=1, B=1

Fig 6 Electric Field distributions for optical OR logic gate for different cases



Proposed 2D NAND Gate, The input ports are **A** and **B**

Ports

*Fig 7*Layout of optical logic NANAD gate in Optical FDTD with the input port A and B and output is OUT

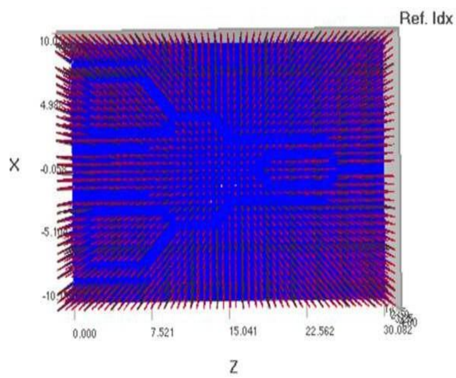


***Fig 8* Refractive Index view of the logic NAND Gate**

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ISSN: 0193 - 4120 Page No. 9505 - 9509

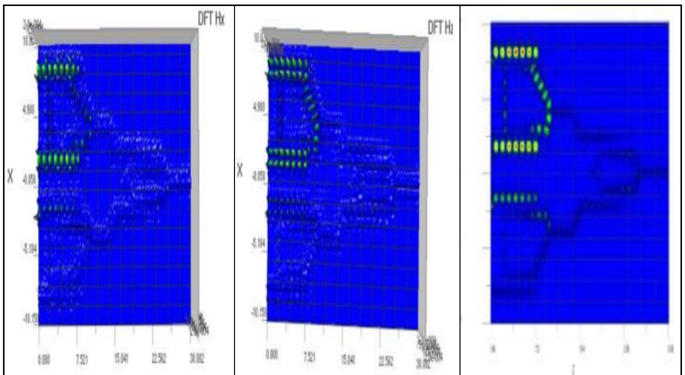
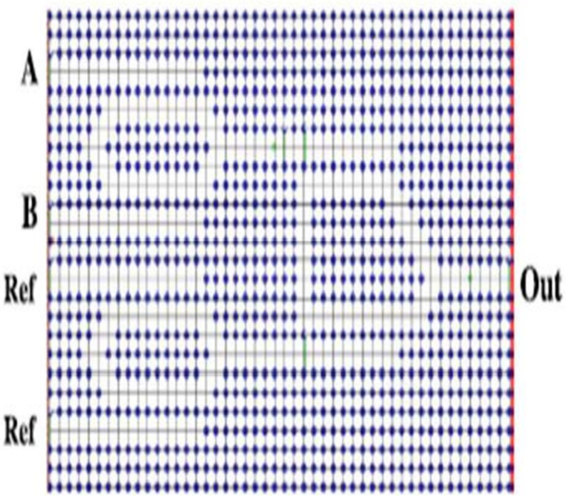


Fig 9 **Electric Field distributions for optical NAND logic gate for different cases**



Proposed 2D NOR Gate, The input ports are **A** and **B**

*Fig 10*Layout of optical logic NOR gate in Optical FDTD with the input port A and B and output is OUT.

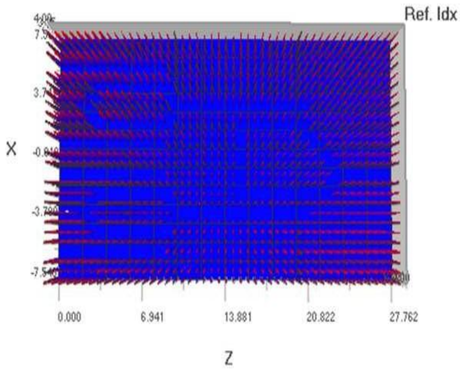


Fig 11 Refractive Index view of the logical NOR Gate

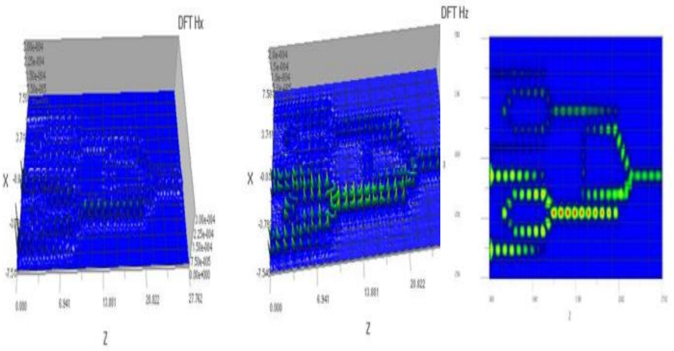


Fig 12 Electric Field distributions for optical NOR logic gate for different cases

IV. DISCUSSION ON RESULTS

OR Gate: The designed OR Gate should consist of Resonator Comprised of two arms made with expelling poles of dielectric material looks like a PhC structure to frame an imperfections in this way, when a flood of a working reference with inside to the PBG is propelled inside to the structure this kind of wave would be found and required to guided. The designed two arms are of the wave guides of information signals the resonator may be coupled to the information signals by means of a straight line of bars flag is at long last entirely guided with a line deformity by yielding the port. The designed OR Gate on the other hand has an in exact size of 14um X 9.44um.

AND Gate: The thought of the designed AND Gate is appeared, the configuration is basically viewed as a resonator with square structure exactly supplanted on correct side that to with a shape of triangular for improving the directivity of flag towards the yielded port and also controlling the wavelength, the designed AND Gate should have estimated structure of 10.6um X 11.6um.

NAND Gate: The plan of designed NAND Gate acknowledgement should have possible utilizing numerous methodologies for logic gate mixes along with the proposed structure NAND Gate is appeared, the plan essentially comprises XOR gate on upper mode and bring down where it countered to produce the combination of OR Gate. The

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reference flag utilized has an intensity of 2Po, the structure design of NAND gate is appeared the designed NAND structure has summarized size of 28.4um X 19.8um.

NOR Gate: The proposed NOR Gate executed with numerous methodologies, The designed NOR structure mainly focused on two fundamental steps, the initial one is constructing NOR Gate and utilizing it for fundamental meaning that is an OR gate operation associated with inverter operation. The next and the most important to confirm the falling idea of gate which guarantees the likelihood to construct rationale gates who can work together with a perfect manner, the schematic of OR gate and NOT gate helped for constructing NOR gate. The NOR gate structure essentially associated with information of XOR gate structure with port and other is associated with a settled flag of reference information control Po.

V. CONCLUSION

We introduce a new structure of Optical rationale gates in particular all logical basic and universal gates utilizing 2 Dimensional Square cross sections in PhC. The proposed plans depend on the optical obstruction marvel, the 2 Dimensional PhC structures comprises dielectric poles of Ge surrounded through air, the designed rationale gate displays extensive variety of working b/w the wavelengths of $1272.06X10^{-9}$m and $1987.40X10^{-9}$m, with focused working wavelength $1550X10^{-9}$m to satisfy the different prerequisites of different applications. The conduct of wave and the circulation of the field signs inside the PhC gates were observed and estimated for utilizing FTDT strategy. Every gate shows a sensible complexity proportion b/w rationale '1' and rationale '0' at the yield of the gate. It is observed that the difference proportion b/w NAND and XOR fluctuates 5.036dB to 12.155dB.

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