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Simulation Based Study of Photonic Crystal Ring Resonator of Same Perimeter But Different Aspect Ratio:-Rectangular Lattice with Dielectric Rods in Air Configuration

Neeraj Sunil, Jayakrishnan V, Harish Somanathan, Alok Kumar Jha
Dept. of Electronics & Communication Engineering
Amrita School of Engineering, Bengaluru, Amrita Vishwa Vidyapeetham, Amrita University India

ABSTRACT-
In this paper the output transmission efficiency of Photonic Crystal based Ring Resonators are investigated and studied. In addition keeping the perimeter of the ring constant, structures of different dimensions are explored and designed. In the end, we compare the transmission spectrum of all the structures. The algorithm used is Finite Difference Time Domain (FDTD)

***Keywords**:*
Photonic Crystals, FDTD, MEEP, Ring Resonator.

INTRODUCTION

Photonic crystal is a periodically arranged dielectric material. The periodic variation of the refractive index gives rise to a unique band structure, and may have a Photonic Band Gap. [1][2]

The Band Gap of the crystal depends upon various parameters such as difference in refractive index, lattice structure etc. It is possible to control the propagation of light waves in certain frequency ranges by introducing defects in the Crystal which cause defect modes in the band gap. The research in designing ring resonators in photonic crystals has been growing in recent years. [3][4] Already Band Pass Filtering using PCCR (Photonic Crystal Ring Resonator) has been thoroughly studied and also its advantages like being compact in size, flexibility in mode design, and having better selectivity, has been studied and documented. [5][6][7][8]

In this paper, a 2-D ring resonator using photonic crystals in rectangular lattice with dielectric rods in air configuration was designed and its transmission spectrum studied. The perimeter of the ring in a ring resonator decides the frequency selection. Hence, keeping the perimeter of the structure same, we vary the resonator dimensions (length and breadth) and investigate and observe the changes, if any, in the output spectrum of all the structures. Simulation has been done through FDTD (Finite Difference Time Domain) method.

STRUCTURE DESIGN

A square lattice consisting of rods in air, of dimensions 30X30 is taken for all considerations. The lattice constant is 0.58 µm, and the radius of the rods is taken to be as 0.1044 µm. The relative permittivity of the dielectric rods in the structure is taken as 11.57. Figure 1 shows the basic structure with dimensions of the inside ring being 3*11 units.

Keeping the perimeter of the inside ring constant (i.e. 13.92 µm), other structures of altering length and width were designed as shown in the subsequent figures.

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As shown in Figure 1 the output of each structure is taken at the through port and is used to calculate the transmission spectrum. The normalized transmission spectrum at this port is obtained by conducting the Fast Fourier Transform (FFT) that is calculated using the FDTD algorithm.

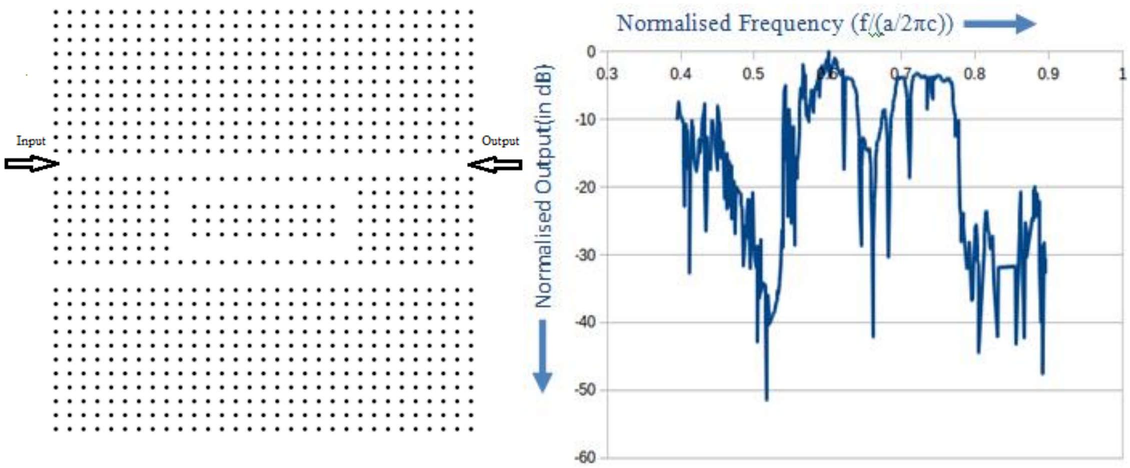

Figure 1 – Structure with dimensions 3X11 and its transmission properties

UNITS

The units of amplitude and frequency are normalized. Frequency value when multiplied with (2πc/a) gives a frequency in SI units, where ‘c’ is the velocity of light in vacuum, and ‘a’ is the lattice periodicity. Power obtained in the output spectra is normalized (i.e. output/input flux) in dB (10*log (output/input flux)). The frequency of the source ranges from 0.4 to 0.9 in normalized units, which when multiplied by the conversion factor(2πc/a) gives us a value of 753 THz to 1696 THz, which converted to wavelength gives us a value of 397 nm to 176 nm.

LATTICE STRUCTURE

The Various structures designed and their transmission spectra are presented side-by-side for a better comparison.

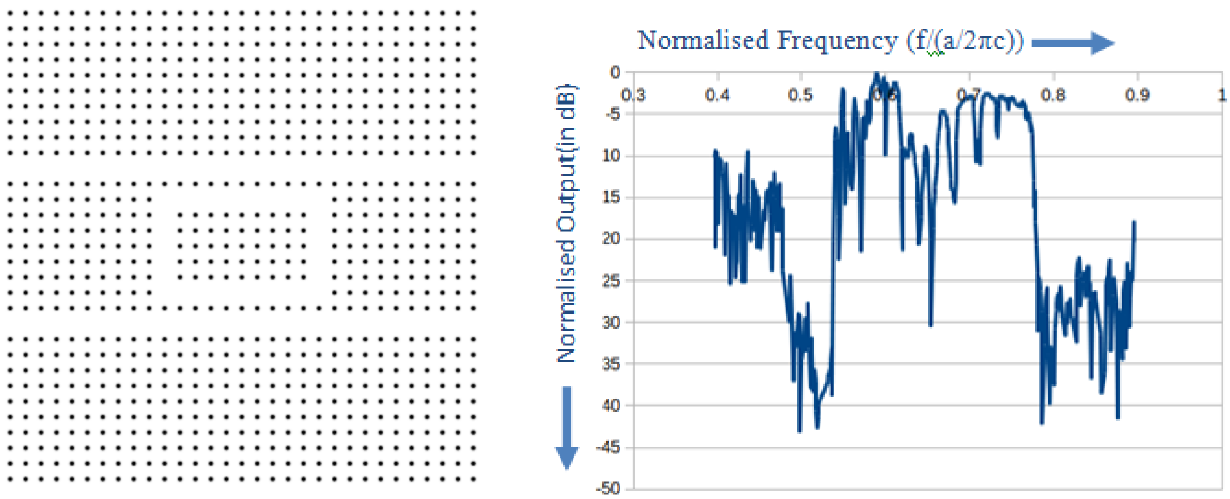

Figure 2 – Structure with dimension 5X9 and its transmission properties

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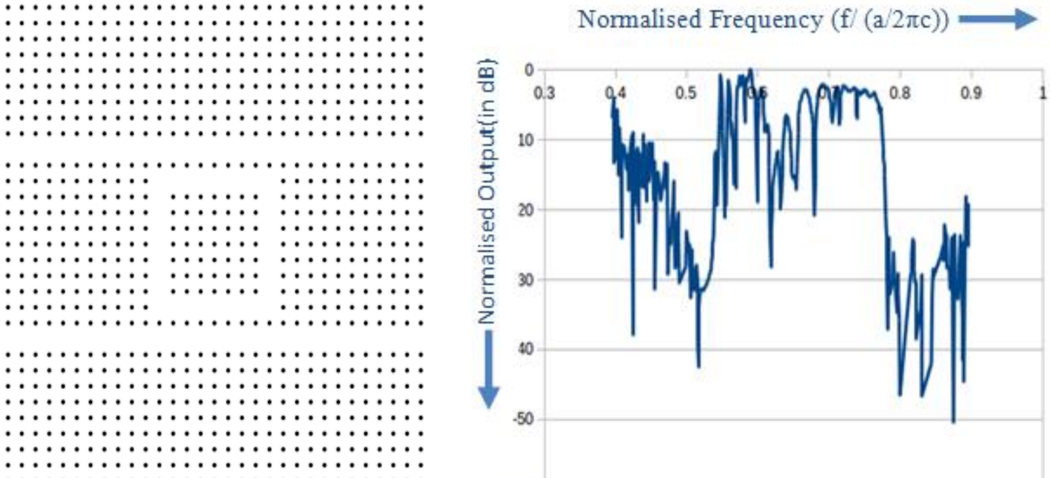

Figure 3 - Structure with dimensions 7X7 and its transmission properties

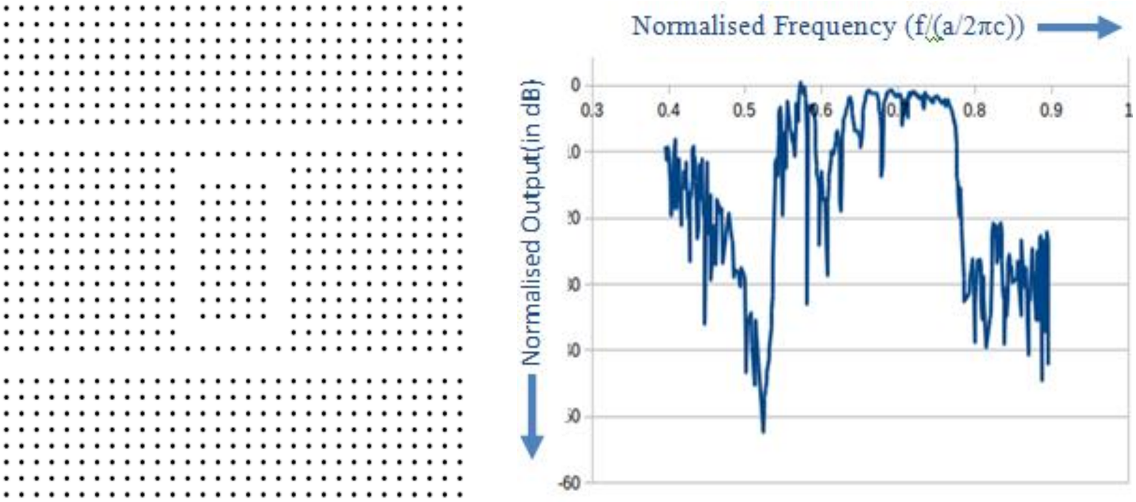

Figure 4 - Structure with dimension 9X5 and its transmission properties

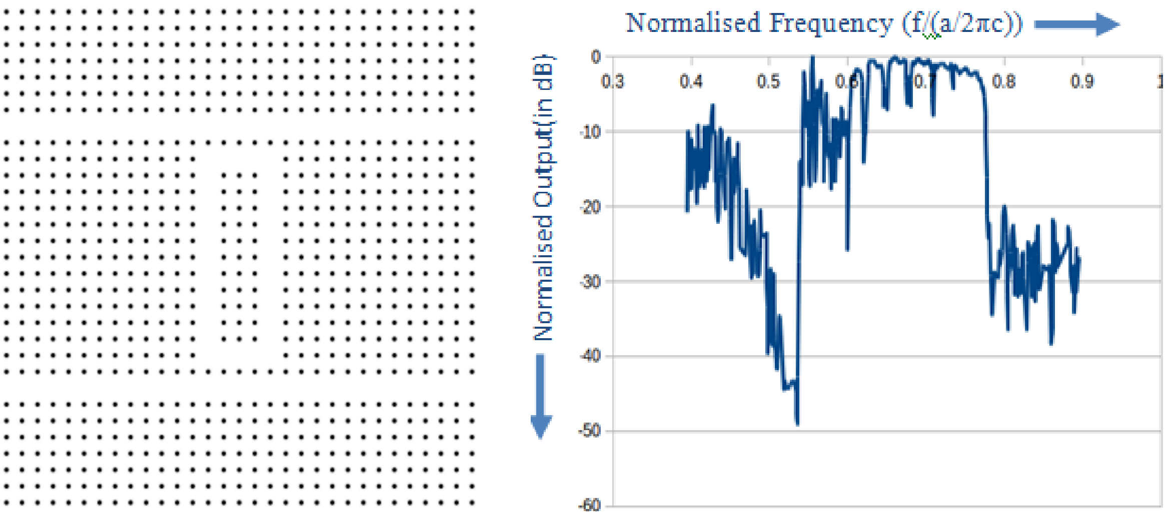

Figure 5 - Structure with dimensions 11X3 and its transmission properties

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RESULTS AND CONCLUSION

The transmission spectrum for all the ring resonators with constant perimeters and varying aspect ratio is obtained. We know that the frequency selection in any ring resonator depends upon the perimeter of the ring. However keeping perimeter constant we can see transmission spectrum varying as the as the amount of wave coupled in to the ring also depends on the size of the part of the ring adjacent to the bus. Analyzing the different spectra qualitatively we can conclude that the ring with aspect ratio of 5:9 has the best transmission spectrum for its resolution. Here the ring is neither a square nor a very flat rectangle. As such, length and width are not equal but a little longer length adjacent to the bus results in better spectrum. We can also conclude that the nature of the transmission spectrum depends not only on the perimeter of the ring but also on the aspect ratio.

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