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Omnidirectional Reflection Characteristics of Photonic Crystal

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Abstract: *In this paper the reflection characteristics of photonic crystal is observed. Under certain condition, one dimensional dielectric lattice displays total reflection of the incident light. The thickness of the layers, the refractive indices should be carefully chosen for better reflections. This will find application in photonic reflector mirrors. The simulation results show the reflection coefficient for different cases.The wavelengths which are blocked are said to be in photonic bandgap.The signal outside the photonic band gap are transmitted. It is possible to design photonic crystals to transmit a single frequency or to reflect a single frequency or signal with narrow bandwidth. Defects are introduced for improving the performance.*

Keywords *- Reflection coefficient, Transmission coefficient, Photonic Bandgap*

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I. Introduction

Photonic crystal consists of periodic Nanostructure which contain regularly repeating regions of low and high refractive indices. Light propagates through this structure or not depends on the wavelength. A spectral range of large reflectivity is known as stop band. In this way light can be controlled and manipulated in any way. This finds application in LEDs and LASERs.

II. Design

To start with quarter wave stack is taken into consideration. The number of layers ie, period is taken as 10.The materials taken for observation is alternate layers of SiO_2 and TiO_2 with refractive index 1.45 and 2.65.The thickness of each layer is varied and the reflection coefficient is calculated.The Optics interfaces are used to compute electric and magnetic fields for systems where the wavelength is comparable to or much smaller than the studied device or system. The Wave Optics interfaces are used to compute electric and magnetic fields for systems where the wavelength is comparable to or much smaller than the studied device or system.

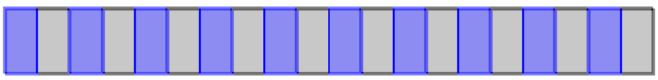
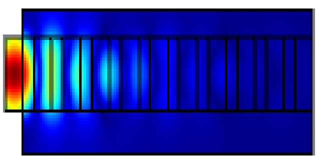
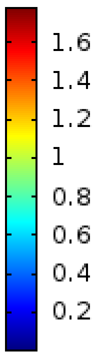


Fig 1: Alternate layers of Sio2 Tio2

III. Results





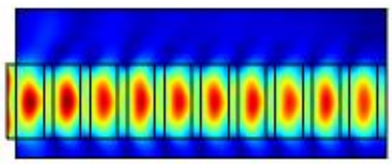


Fig 2: Reflected signal Fig 3:Amplitude Scale Fig 4:Transmitted signal

When the signal is in the bandgap,it gets reflected as in fig 1.fig 2 indicates the amplitude level. Red color indicates high amplitude and blue color indicates low amplitude. When the signal is outside the bandgap,it gets transmitted as shown in fig 3.

The graph of reflection coefficient for different wavelengths is drawn. In this quarter wave stacks are considered.

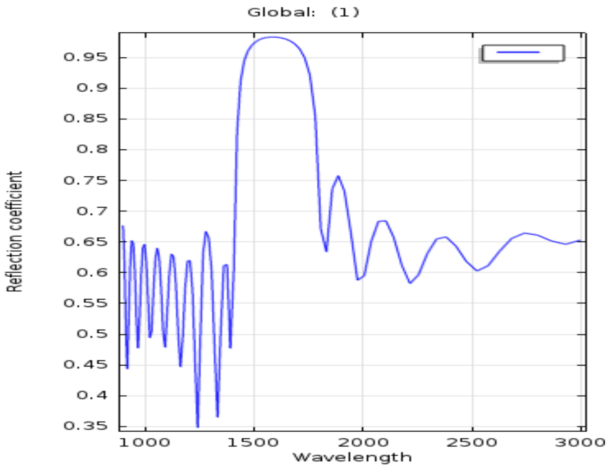


Fig5: Reflection spectrum

Reflection is maximum for the range 1500nm to 2000nm.For optical communication lasers using this wavelength can be used. The bandwidth of the reflecting signal is 400nm cantered at 1600nm. For optical communication lasers using this wavelength can be used. In lasers amplification

TABLE 1

Thickness of two layers	Reflection coefficient
2:1	0.836
1:1	0.637
1:2	0.562
3:4	0.537
4:3	0.751
2:3	0.609
3:2	0.872
3:1	0.833
1:3	0.538

The best reflection is obtained when the ratio is 3:1 or 2:1 and 3:2. Our aim is to design photonic crystal with 100% reflection with reflection coefficient of 1.Only then it acts as a perfect mirror.

When the number of layers is changed there is an improvement in the reflection coefficient.

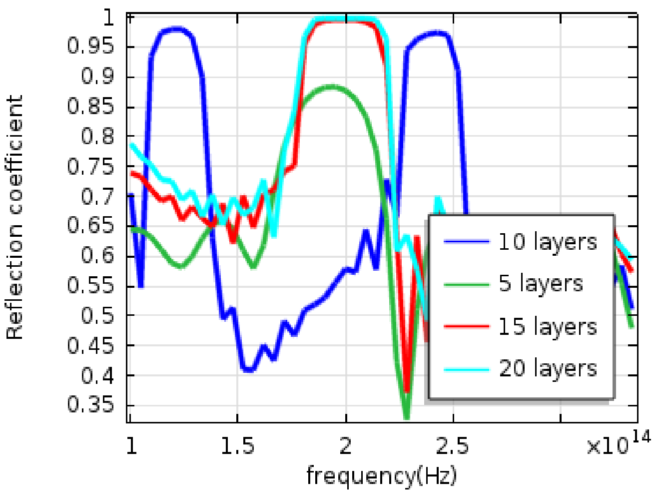


Fig 6: Reflection coefficient for different number of layers.

When there are 5 layers Reflection coefficient is less than 90%,When there are 10 layers,the photonic bandgap is obtained for two different wavelengths.The best result is obtained when there are 15 layers.

Table 2

Material	Reflection coefficient
1.34 and 2.65	0.99956
1.34 and 3.4	0.99970
1.46 and 3.4	0.99948
1 and 3.4	0.99911
1 and 2	0.61615
1.34 and 4.2	0.73869
2 and 4	0.65952
1.47 and 2.32	0.99771
1.7 and 3.4	0.24813

The best reflection is obtained for the combination of the materials with refractive indices 1.34 and 3.4 ,1.34 and 2.65 and 1.46 and 3.4.

When metal and dielectric photonic crystal is used it produces evanescent field everywhere. The transmission depends on wavelength, lattice constant and excitation conditions. Metal and dielectric composites behave as saturable absorbers.

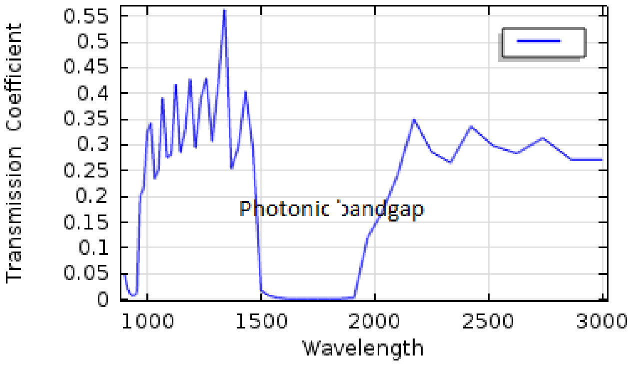


Fig 7: Transmission Spectrum of photonic crystal

When different wavelengths are transmitted some wavelengths are completely blocked which are in photonic bandgap.Here the photonic crystal acts as a perfect reflector or mirror which may find application in lasers for amplification.

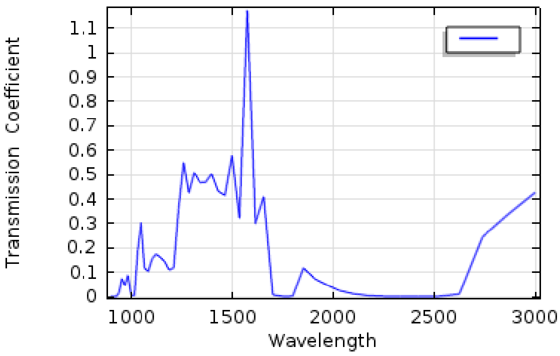


Fig 8: Transmission Spectrum of photonic crystal with defect.

When a defect is introduced it is possible to design a photonic crystal which transmits one particular frequency and reject all other. The reflection of a certain wavelength can be used in lasers for amplification of the signalThe optyical signal can be guided efficiently.This can be designed for any frequency and photonic crystal acts as a mirror and other optical devices such as switches,modulators,filters and interconnects.Many other designs include simple index grating with a constant period and a constant amplitude of index modulation

2)A chirped index grating with a constant amplitude of index modulation
3)A chirped index grating with a tapered amplitude of index modulation.

The parameters are varied and maximum reflection can be obtained for any wavelength.

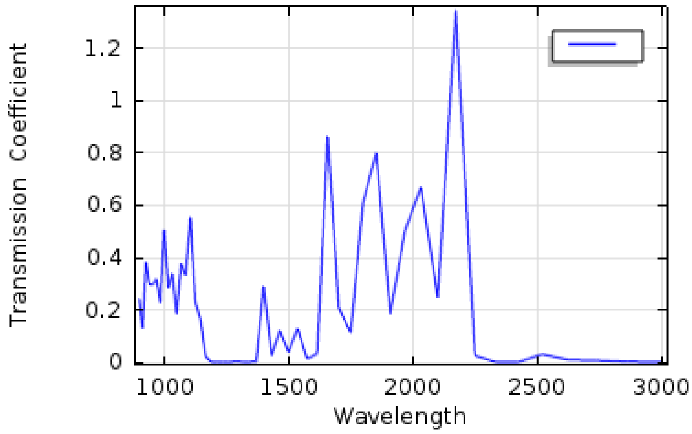


Fig 9: Transmission Spectrum of photonic crystal

By changing the parameter photonic crystal can be designed to transmit or reflect any wavelength.

IV. Conclusion

Thus we can design photonic crystals for reflecting any wavelength by properly designing the materials, the number of layers and the thickness of each layer.

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