1-D Photonic Crystal Design in Visible Range with Metamaterials

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Introduction

- Past research have demonstrated the possibility of affecting photons with structures known as photonic crystals (PC) due to their photonic band gaps akin to how semiconductor devices affect electrons.
- PCs are extensively used in various areas such as optical communications, laser applications, temperature and pressure sensing, healthcare etc.
- There are several ways to design PCs. One of them is to implement mathematical series such as Fibonacci Series, Thue-Morse Sequence to design.
- In this project, 1-D PCs are designed according to Look and Say Sequence (LSS) for the first time.
- Results show that, Look and Say Sequence which has not been applied to designs of PCs before can be used as a new alternative to the popular series mentioned above.

Specifications and Structure Design

- In the design of the PC structure, two materials A and B used. Where A is the material having high refractive index and B having low refractive index i.e. $n_A = 6$ and $n_B = 1.5$. Their thicknesses are taken as $\lambda_0/(4n_A)$ and $\lambda_0/(4n_B)$, respectively, where λ_0 is the central wavelength which is the main focused area and taken as 600 nm in this project. The material order of the PC is $(AAABBA)^n$, where n is the repeat number. The number of the transmittance peaks in characteristics is controllable with the repeat number n. The model of the structure is shown in Figure 1 with n = 1.

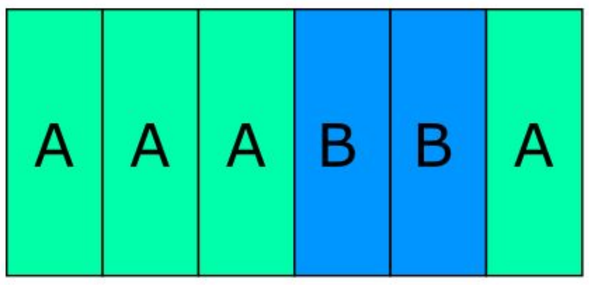


Figure 1: The model of the PC with n = 1

- Transfer Matrix Method (TMM) is used for the calculations.
- TMM is generally used to analyze the propagation of the electromagnetic waves in multilayered systems. For N-layer system, there are N different transfer matrices. These matrices are multiplied to obtain 1 transfer matrix for the whole system.

Methodology

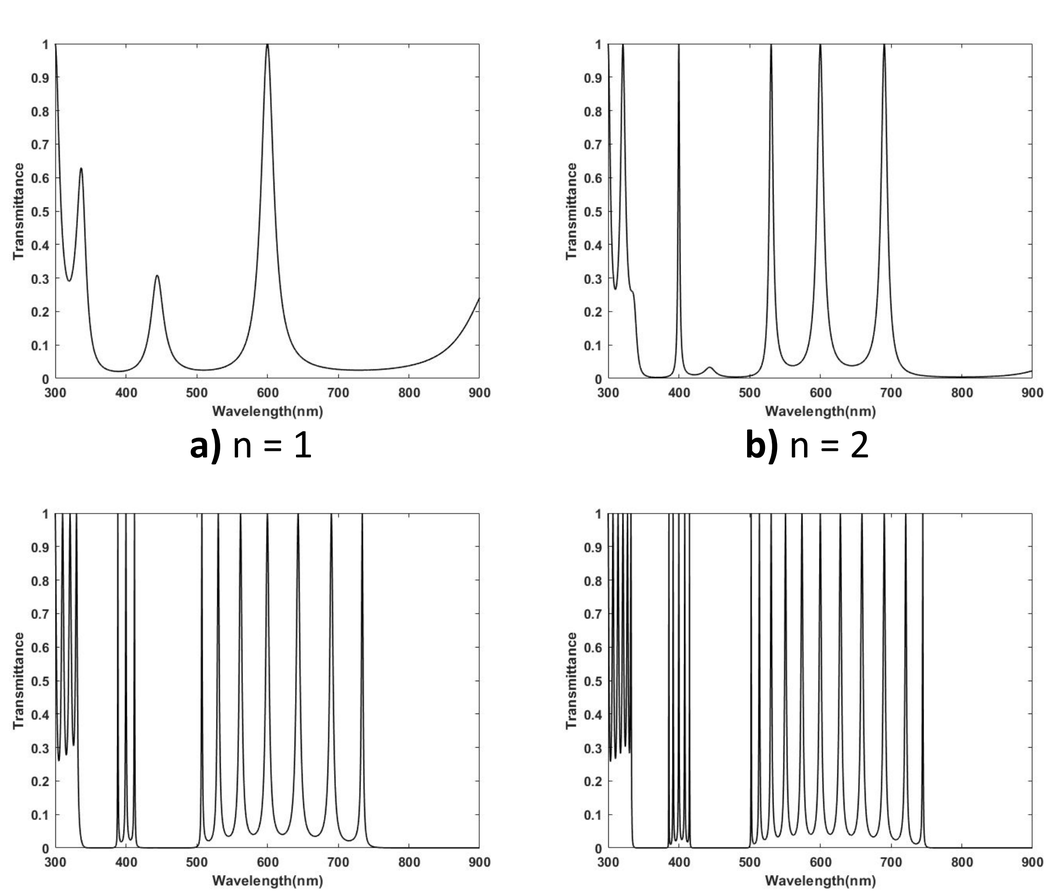
- The designed structure is modeled and simulated in MATLAB by using Transfer Matrix Method.
- The algorithms for simulation are developed in MATLAB.
- The simulations were performed by increasing n step by step.

Application Areas

- The designed PC structure is suitable for controlling the place and the number of the transmittance peaks. It can be used as channel multiplexer, optical communication component etc.

Results and Discussion

- As mentioned before, the simulations were performed by increasing the repeat number n. Some of the results are shown in Figure 2.



a) n = 1 **b)** n = 2

c) n = 4 **d)** n = 6

Figure 2: Transmittance characteristics

- Figure 2 indicates that; if the repeat number n is increased, number of transmittance peaks around central wavelength (600 nm) and around two-thirds of the central wavelength (400 nm) increases.
- If Figure 2 is analyzed in more detail, we can see that the number of transmittance peaks are increasing linearly with 2n - 1 around central wavelength and n - 1 around two-thirds of the central wavelength.
- As it is seen from the transmittance characteristics, the structure is very useful due to the controllable peaks property. In the future this project is expected to lead research about PC designs using alternative mathematical series, especially LSS, to the popular series i.e. Fibonacci Series, Thue-Morse Sequence, Cantor Set etc.

References

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