Band-Blocking Optical Filter Design Using Binomial Series

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Optical Filters

Multilayer optical filters are specially designed structures It affects how light behaves when used and the reflection absorption and varios transmission properties of wavelengths.

Therefore,it becomes easier to design optical filters that make light behave in certain ways at certain wavelengths.This is achieved by carefully selecting the material and their arraning.

Design of Filter Structure

Each layer is labeled with the letters L and H representing low and high refractive index materials. We used capital L for low refractive index and capital H for high refractive index and created an algorithm to generate appropriate number sequences. Refractive indeces of this low and high index materials are choosen as L=1.45, H=2.17.

In this study, materials are arranged according to the Bionamial Series.Binomial Series refers to the number of binomial coefficients in each line in Pascal's Triangle.

Pascal's Triangle can be seen in Figure 1.Since this structure can be modelled with materials with high (H) and low (L) refractive coefficients, the binary equivalent of each element has been adapted to this structure.In this way, the material with a low coefficient of refraction (L) is used to correspond to the number 0 in the binary system, and the material with a high coefficient of refraction (H) is used to correspond to the number1.

$$\begin{array}{ccccccc} & & & 1 & & & \\ & & 1 & & 1 & & \\ & 1 & & 2 & & 1 & \\ 1 & & 3 & & 3 & & 1 \\ 1 & 4 & & 6 & & 4 & 1 \\ 1 & 5 & 10 & & 10 & 5 & 1 \end{array}$$

Figure 1. Pascal Triangle

Solution Methodology

The Transfer Matrix Method (TMM) is a mathematical and computational technique used to analyze the behavior of electromagnetic waves as they pass through multiple layers of different materials with varying refractive indices.

All layers are represented by a matrix using parameters such as refractive index and thickness.

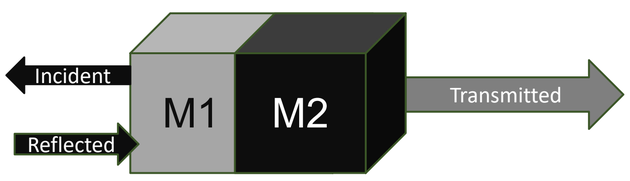


Figure 2. TMM (Transfer Matris Method)

$$M1 = \begin{vmatrix} \cos(k_1 \times d_1) & \frac{-i \times \sin(k_1 \times d_1)}{n_1} \\ -i \times n_1 \times \sin(k_1 \times d_1) & \cos(k_1 \times d_1) \end{vmatrix}$$

$$M2 = \begin{vmatrix} \cos(k_2 \times d_2) & \frac{-i \times \sin(k_2 \times d_2)}{n_2} \\ -i \times n_2 \times \sin(k_2 \times d_2) & \cos(k_2 \times d_2) \end{vmatrix}$$

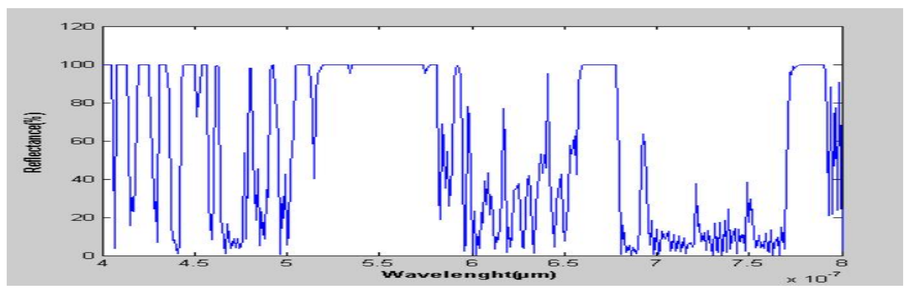
$$M_{TOTAL} = M1 \times M2 = \begin{vmatrix} A & B \\ C & D \end{vmatrix}$$

Similation Tools

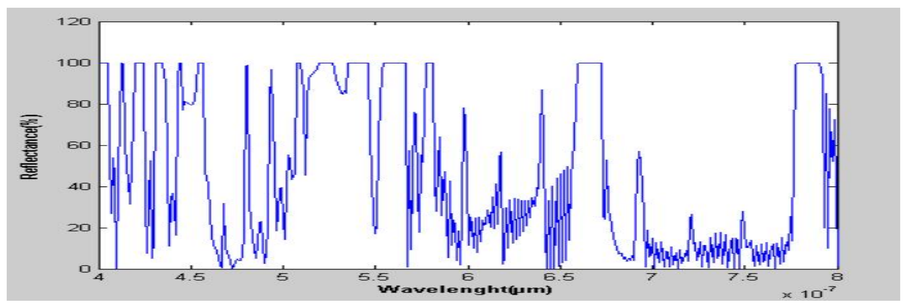
A Matlab programme was developed and used to find reflected power ratio for different cell repetition numbers of the designed tructures.

Results and Discussion

a)



b)



c)

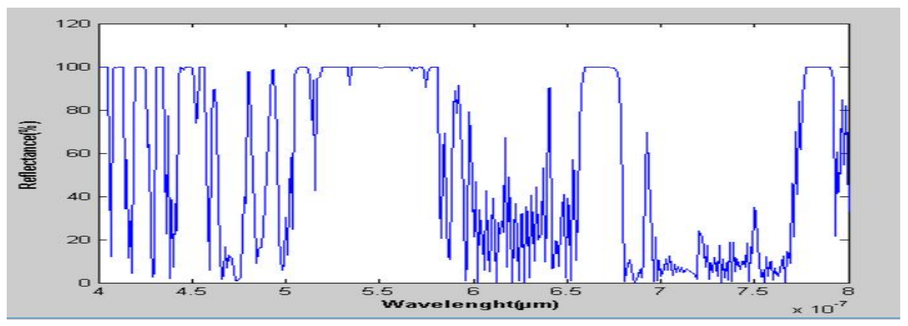


Figure 3. : For a) N1=10,N2=10 b) N1=10,N2=1 c) N1=10,N2=5

For different repetation numbers , designed filter responses are shown in Fig 3. a,b,c. These figure indicate that some special wavelenght intervals multiple full reflactance band are useful in some special optical aplications.

References

1.Liu C. C., Chang Y. H., Yang T.J., Wu C.J., “Narrowband filter in a heterostructured multilayer containing ultrathin metallic films”, Progress In Electromagnetics Research, PIER 96, s.329-346, 2009.

2.Wang Q. H., Li D. H., Peng B. J., Tao Y. H., Zhao W. X., “Multilayer dielectric color filters for optically written display using up-conversion of near infrared light”, Journal of Display Technology, Cilt. 4, No. 2, 2008.

Acknowledgements

1.This project was completed within the context of ELE401-402 Graduation Project courses in Hacettepe University, Faculty of Engineering, Department of Electrical and Electronics Engineering.
2.I thank to Prof. Dr. Çiğdem Seçkin Gürel for her invaluable contributions to our project.