Optical Component Design for Various Optical Applications in Visible to Terahertz Regions

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Introduction

❖ Optical components are structures that changes the behavior of light according to their designs and purposes. Optical components are designed to work in specific regions of light spectrum.

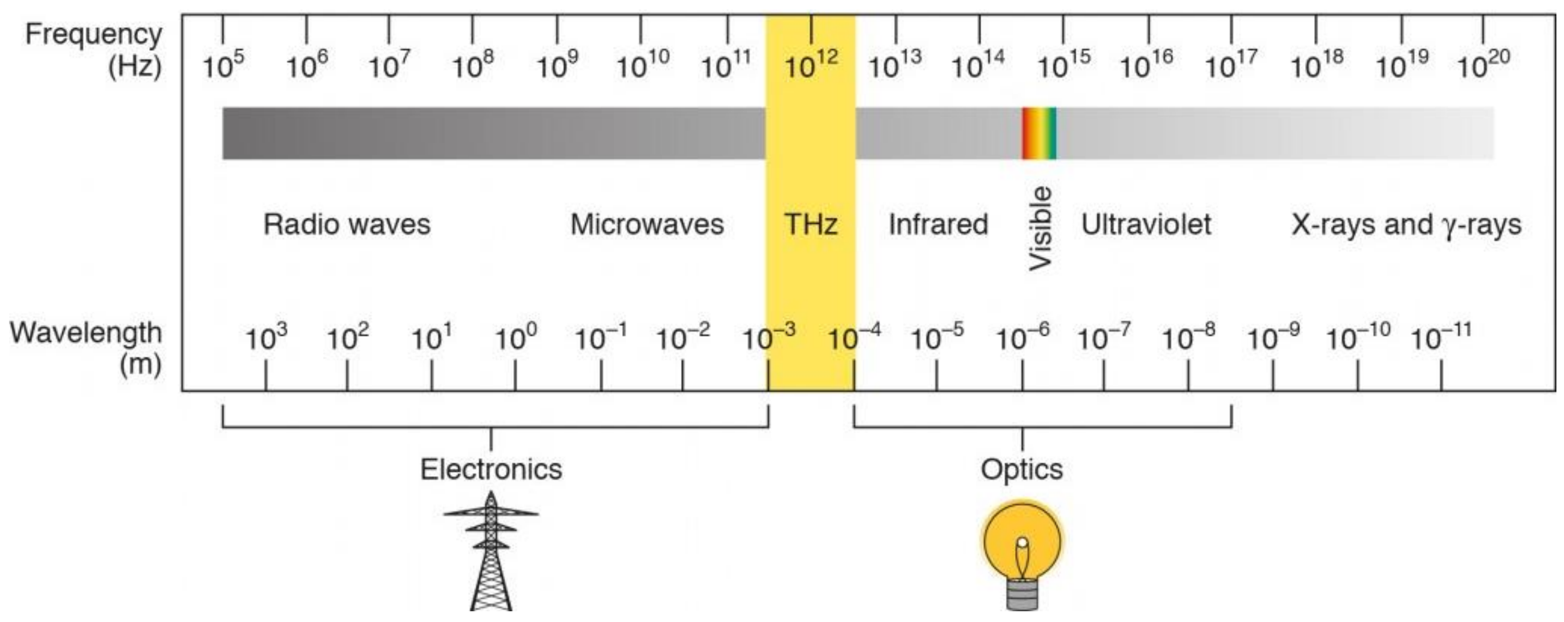


Figure 1: Electromagnetic Wave Spectrum

❖ In this project, I designed a hybrid multilayer optical filter that behaves like a reflector in visible and sub-infrared regions.

❖ Fibonacci and Thue-Morse series are used together in the layer configuration and effects of each sequence investigated separately.

Solution Methodology

❖ Transfer Matrix Method is used to find the reflected power ratio of the optical filter.

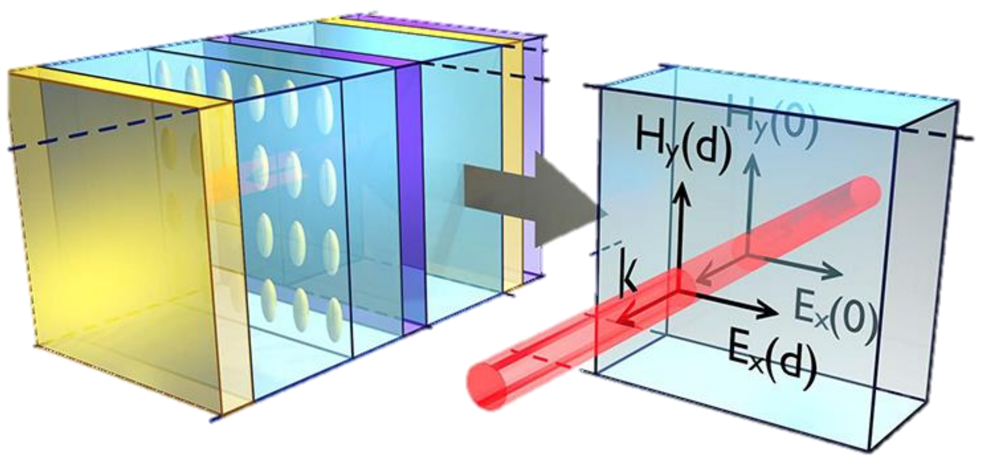


Figure 2: Transfer Matrix Method Demonstration.

❖ According to Transfer Matrix Method, each filter layer can be represented with matrixes. With combination of these matrixes overall transfer matrix can be found as presented in the figure 2 and equation 1.

$$M = M_1 M_2 M_3 \ldots = \begin{bmatrix} M_{11} & M_{12} \\ M_{21} & M_{22} \end{bmatrix} \quad \textbf{(1)}$$

❖ Reflected power ratio can be calculated with transfer matrix elements as equation 2 shows.

$$\frac{P_r}{P_i} = |r|^2 = \left|\frac{M_{21}}{M_{11}}\right|^2 \quad \textbf{(2)}$$

Optical Filter Design

❖ The filter layer arrangement was made according to the 6th cell of Fibonacci and 4th cell of Thue-Morse.

❖ Filter consists 2 dielectric materials which are SiO_2 (n_{SiO_2} = 1.45=L) and Te (n_{Te} = 4.234=H).

❖ Center wavelength is 600 nm. Thicknesses are calculated according to quarter center wavelength and refractive indexes.

❖ Overall layer sequence :
air/(HLLHLLHLHLLHL)^{N1}/(LHHLHLLHHLLHLHHL)^{N2}/air

❖ N_1 represents the repeat number of Fibonacci block and N_2 represents the repeat number of Thue-Morse block.

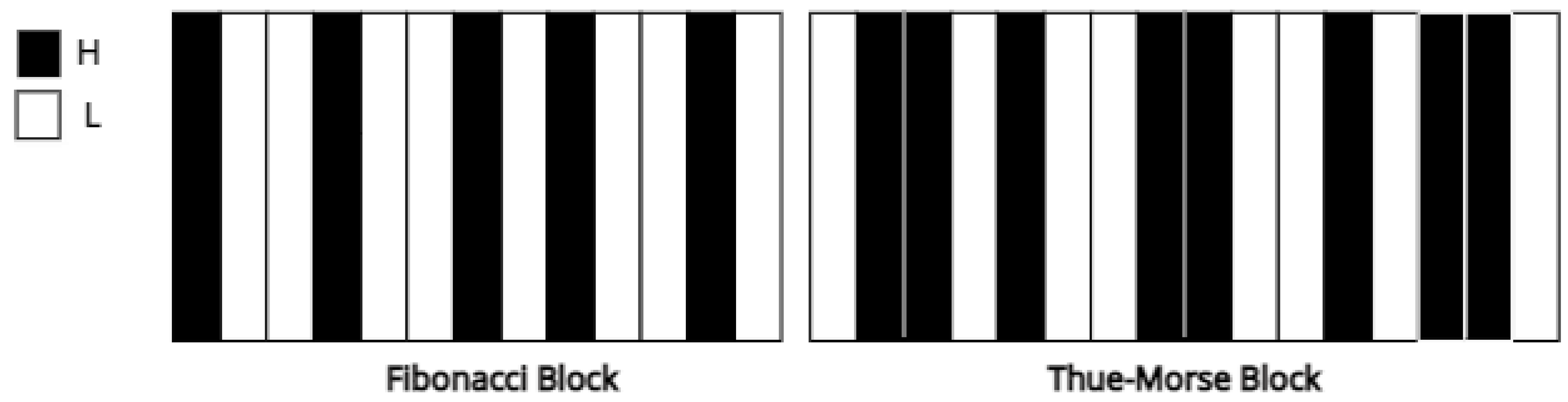


Figure 3: Filter Layer Blocks

Results and Discussion

❖ Figure 4 represents the reflected power ratio (RPR) of the filter when repetition numbers of each block is 1. Filter behaves as reflector in most of the visible region and sub-infrared region. Around center wavelength RPR decrease to half.

❖ Figure 5.a shows that when repetition number of the Fibonacci block increases, in visible region and between 1400-1600 nm filter behaves as better reflector. Around center wavelength narrow zero reflection bands observed.

❖ Figure 5.a shows that when repetition number of the Thue-Morse block increases, around center wavelength and between 1300-1600 nm filter's reflector behavior decreases. However, between 650-1300 nm it behaves like a perfect reflector.

❖ It has been observed that, Fibonacci and Thue-Morse series have separate effects on the characteristic of the filter.

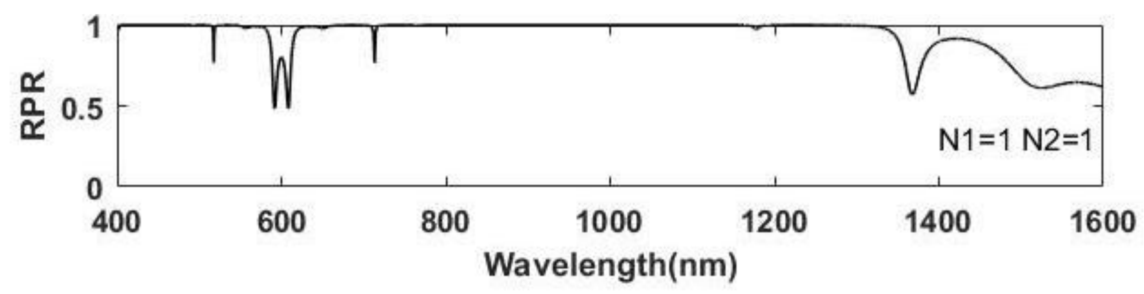
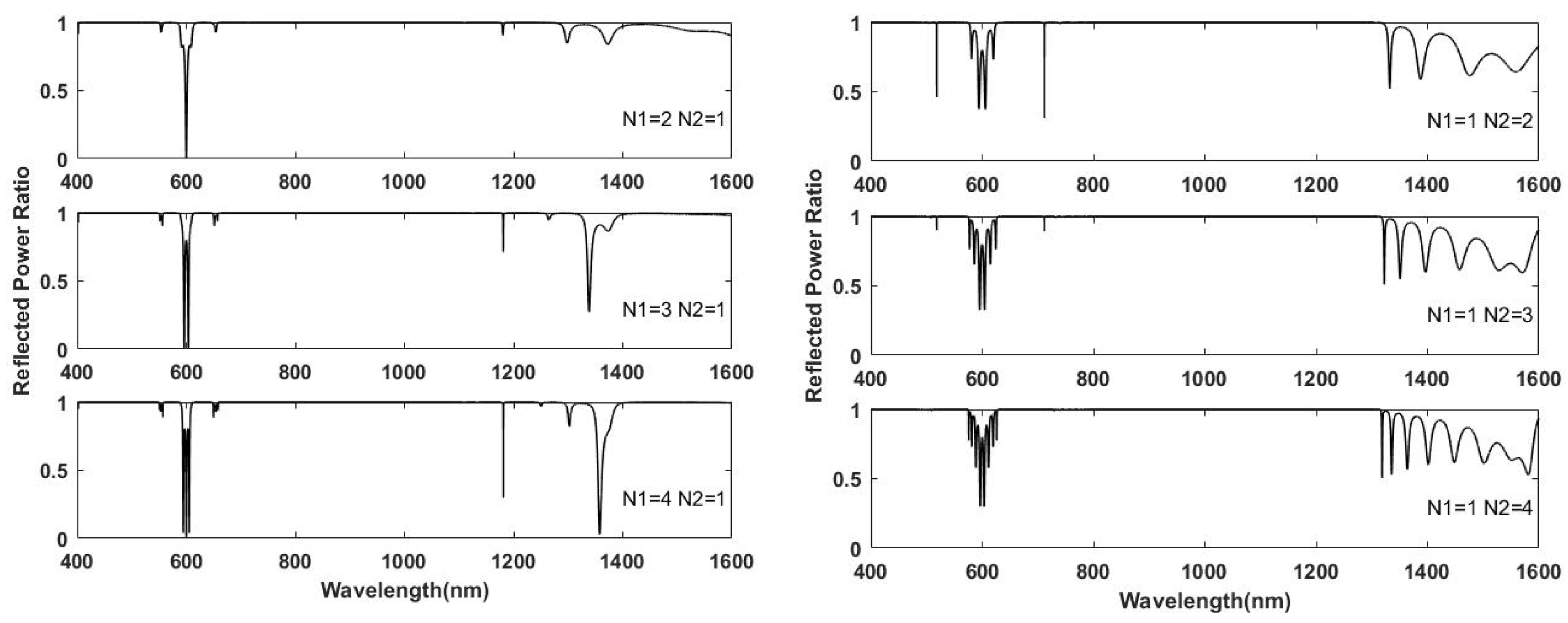


Figure 4: Reflected Power Ratio vs Wavelength (N_1 = 1 N_2 = 1)



(a) (b)

Figure 5: a)Reflected Power Ratio vs Wavelength (N_1 = 2, 3, 4 N_2 = 1), b) Reflected Power Ratio vs Wavelength (N_1 = 1 N_2 = 2, 3, 4)

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