Wavelength Division Multiplexing Optical Filter Design with Fibonacci Series for Optical Communication Systems

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Optical Filter and DWDM Systems

- Multilayer optical filters are structures that affect the reflection, absorption and transmission behavior of light at different wavelengths when interacting with light.
- Accordingly, optical filters can be designed that allow light to exhibit the desired behavior at certain wavelengths with different materials and arrays selected.
- Wavelength multiplexer systems (WDM) are systems that multiplex multiple optical carrier signals used in fiber-optic communication onto a single optical fiber using different wavelengths [1].
- In this study, the defined C band for DWDM systems in the 1530nm and 1565nm range was preferred due to its frequent use and low transmission attenuation loss, and an optical filter was designed for this band gap.

Design of the Filter Structure

- The filter layer arrangement was made according to the 2nd, 3rd and 6th cell of Fibonacci sequence.
- An intermediate material is placed at the beginning of the 6th cell of the Fibonacci series used in the structure.

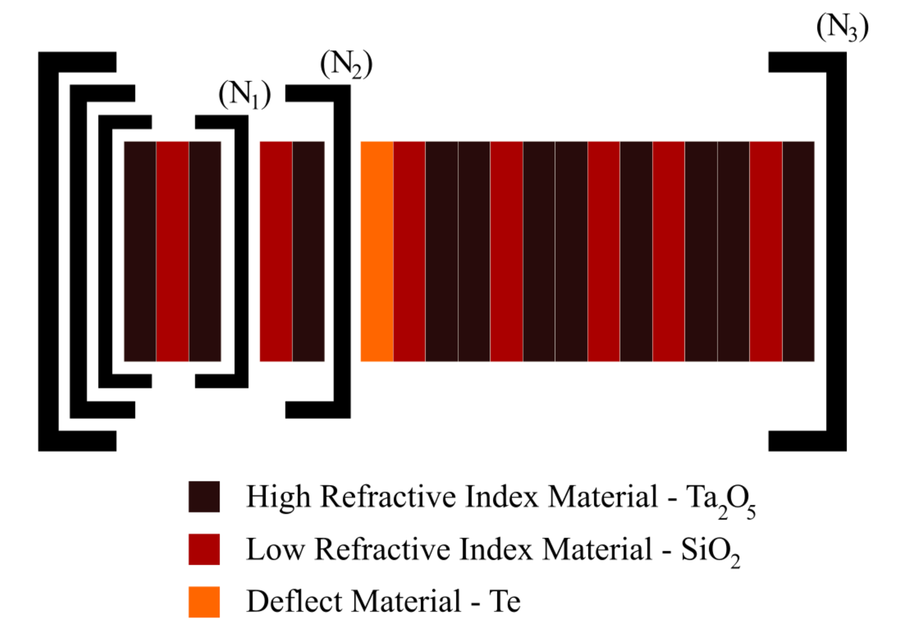


Figure 1: Layer structure of the designed filter.

Parameters of the Filter Structure

Table 1: The properties of the materials used in the designed building and the general properties of the filter.

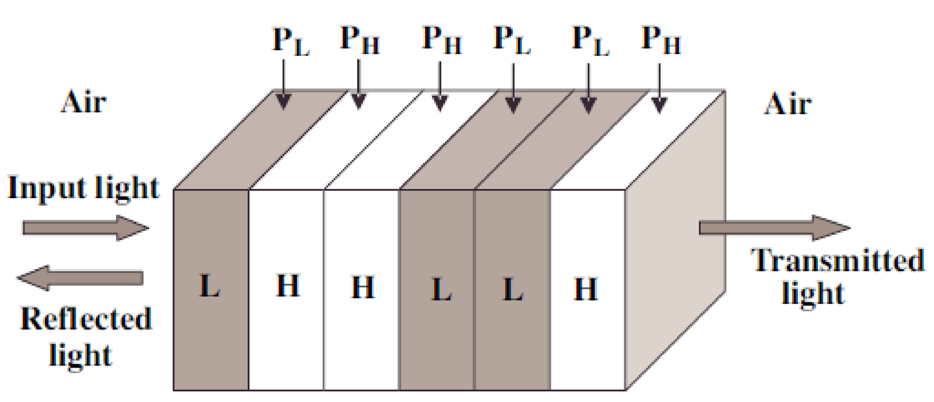
Material	Refractive Index	Thickness
High Index Material	$n_{Ta_2O_5}$ = 2.235	λ_0 / (4 x $n_{Ta_2O_5}$)
Low Index Material	n_{SiO_2} = 1.450	λ_0 / (4 x n_{SiO_2})
Deflect Material	n_{Te} = 4.234	λ_0 / (4 x n_{Te})

Central Wavelength (λ_0) = 600nm

Air/$[[[HLH]^{N1}LH]^{N2}DLHHLHHLHLHHLH]^{N3}$/Air

Solution Methodology

- Transfer Matrix Method (TMM) was used for the reflected power ratio analysis of the structure [2].



$$M = M_1 M_2 M_3 M_4 M_5 M_7 \dots M_n = \begin{bmatrix} M_{11} & M_{12} \\ M_{21} & M_{22} \end{bmatrix}$$

$$M_l = D_l P_l D_l^{-1} \quad D_l = \begin{bmatrix} 1 & 1 \\ n_l & -n_l \end{bmatrix} \quad P_l = \begin{bmatrix} e^{i\varphi} & 0 \\ 0 & e^{-i\varphi} \end{bmatrix} \quad \varphi_l = k_l d_l = \frac{2\pi d_l n_l}{\lambda}$$

- For 3rd cell of the Fibonacci sequence total system matrix:

$$M_T = [D_H P_H D_H^{-1} D_L P_L D_L^{-1} D_H P_H D_H^{-1}] \quad \frac{P_r}{P_i} = |r|^2 = \left|\frac{M_{21}}{M_{11}}\right|^2$$

Simulation Tool

- A desktop application developed with Python was used in the reflected power ratio analysis for different repetition numbers of the designed structure.

Results and Discussion

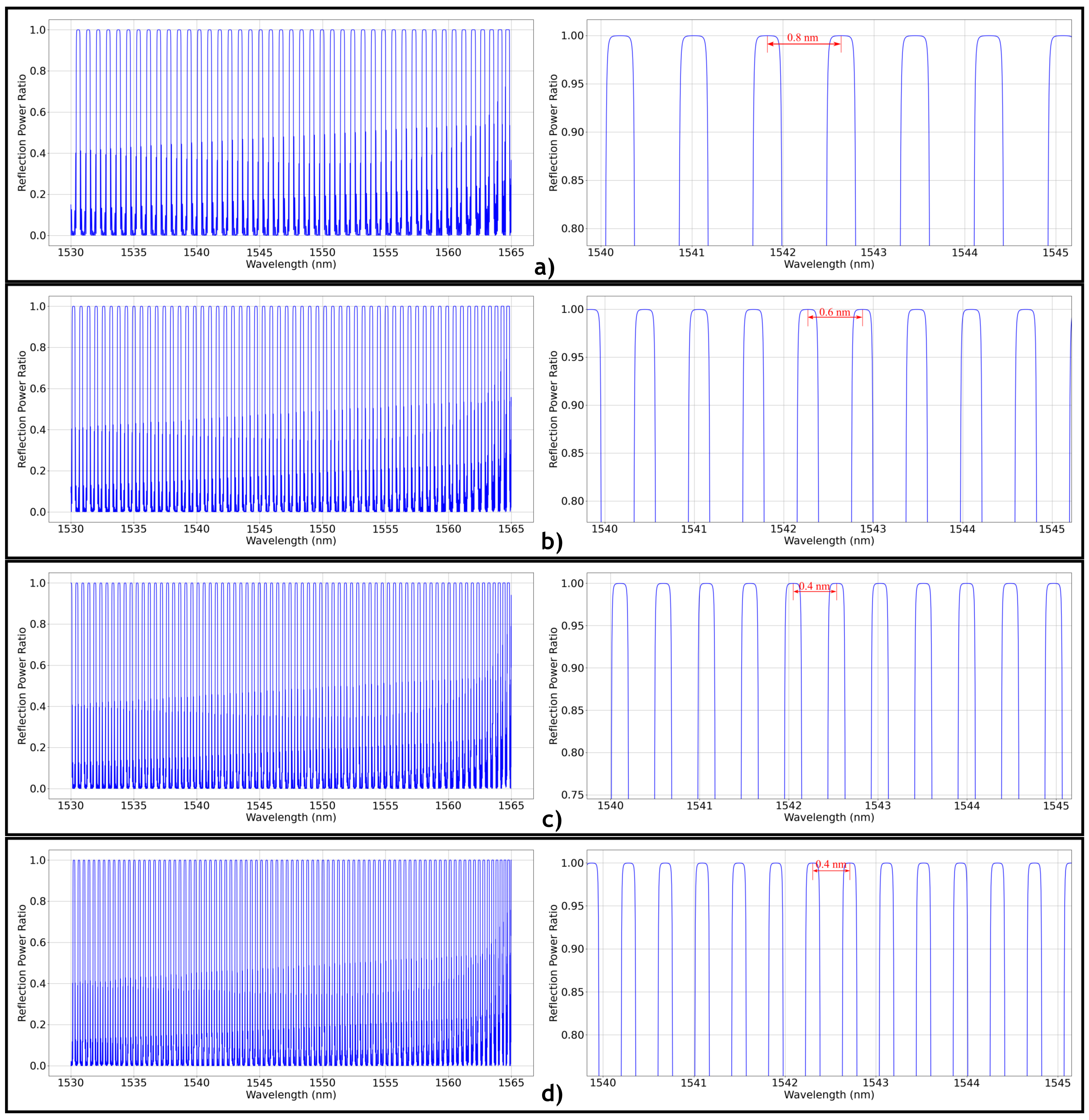


Figure 2: For **a)** N_2 = 75 **b)** N_2 = 100 **c)** N_2 = 125 **d)** N_2 = 150 reflection power ratio (N_1 = 40, N_3 = 8)

- In Figure 2, the number of channels defined in the C band were obtained as 44, 58, 73 and 88, respectively. Likewise, the wavelength ranges of the channels defined in the C band are 0.806, 0.608, 0.491, 0.407nm, respectively.
- Accordingly, the structure can be used as a new and adjustable filter in DWDM systems, which is an important part of current optical communication applications.
- In addition, by changing the number of repetitions of the blocks used in the designed structure, DWDM filters can be designed in different wavelength ranges and different channel numbers in accordance with different ITU-T standards.

References

[1] ‘Introduction to DWDM Technology (Technical Report)’, Cisco Systems, June 4, 2001.

[2] Charalambos C. Katsidis and Dimitrios I. Siapkas, ‘General transfer-matrix method for optical multilayer systems with coherent, partially coherent, and incoherent interference, Applied Optics’, Vol. 41, No. 19, 1 July 2002.

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