



A Review on Different Optical Filters

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Abstract – Filters by its name suggests that it is a type of device which let some signal to pass and stop others depending on the properties of filters. Optical filters is a type of filter which filters light of different wavelengths. Absorptive filters, Dichroic filters, Fabry – Perot filters, neutral density filters, band pass filters and photonics based filters are some of the filters discussed in this paper along with their types and applications.

Keywords – ND filters, RF photonics, CMDS, WDM, DWDM, MEMS, IC configuration.

I. INTRODUCTION

Optical communication Is a type of communication which uses light to transfer an information from one point (transmitter) to another point (receiver) instead of electrical current to carry signals. Fiber optic technology as a great solution to counter problems like capacity, speed, signal losses, distortion etc. (1) In optical communication, the transmitter converts information into optical signal and transmit the signal to optical receiver via optical fibers. Transmitter generally use LED's or laser diodes. To selectively transmit or block certain wavelengths within optical systems, different types of optical filters are used. (2)

This paper gives an overview of different optical filters and their applications.

II. OPTICAL FILTERS

Optical filters are those passive devices which allows the transmission of a specific wavelength or set of wavelengths of light. (3)

Filters are simple, rough and of low cost. One filter can isolate only one band of wavelength, a new filter must be used for a different band. (4)

These are two categories of optical filters that have different mechanisms of working: absorptive filters and dichroic filters. Absorptive filters blocks lights based on absorptive properties of glass substrate used whereas a dichroic filter blocks the unwanted light and transmit desire spectrum and uses principle of interference.

1. ABSORPTIVE FILTER

Absorptive filters are glass filters that are dyed or pigmented gelatin resins and pass specific wavelength of light while attenuating other. Absorptive filters are useful for filtering unwanted wavelengths, blocking a certain band of wavelengths, transmitting long wavelengths and blocking shorter one. These filters are available in the form of glass, acetate or gelatin bases that have been coated with organic and inorganic dyes and plastic coated glass. (5)

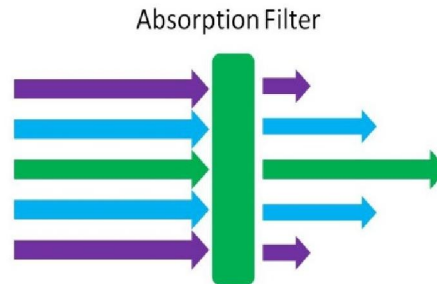


Fig. 1 Absorptive Filter

2. DICHROIC FILTER

Dichroic filters, thin – film filter or interference filters consist of thin film dielectric coatings on glass and works on the principle of destructive interference. Dichroic is a greek word meaning bicoloured and refers that the transmitted light and reflected light are two different colours. These are often characterized by the colour of light that they transmit than the colour they reflect. The types of dichroic filters are: Red filter, Yellow filter, Green filter, Blue filter. (6)

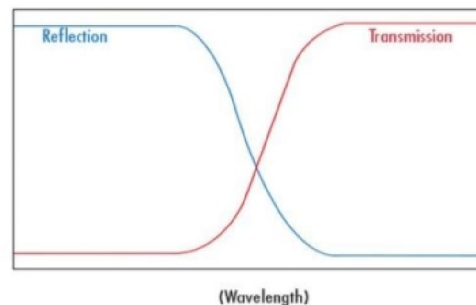


Fig. 2 illustration of Dichroic Filter coating
Source: <https://www.edmundoptics.com/knowledge-center/application-notes/optics/optical-filters/>



Fig. 3 Dichroic Filters

Source: <https://www.newport.com/c/optical-filters>

III. FEBRY – PEROT FILTER

In Febry – Perot filters, two mirrors of high reflectivity are used and these mirrors are separated by some cavity and facing towards each other. (7)

When a light falls on left side of filter, then some wavelength transmitted through resonant cavity, some of them get free from that whereas remaining are reflected. (8)

Fabry – Parot interference was given by Fabry and Perot in 1899. (9)

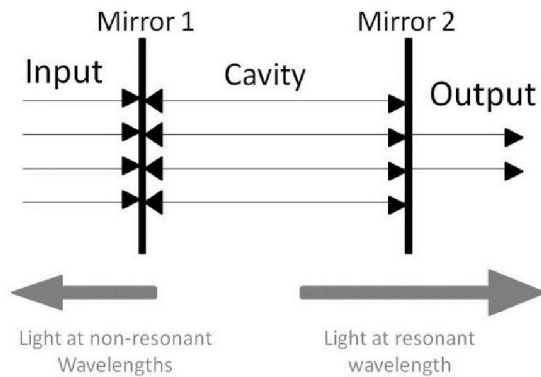


Fig. 4 Febry – Perot Filter

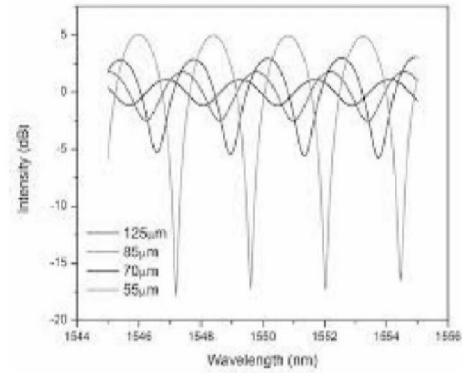


Fig. 5 The behavior of wavelength in a Fabry – Perot Filter
Source: <https://www.google.co.in/search?q=fabry+perot+filter>

The condition for the Febry – Perot to transmit light incident on cavity at an angle is

$$2d \cos \theta = m \lambda$$

Where, m = integer

d = cavity spacity

λ = wavelength

n = refractive index of air

θ = angle of incidence (10)

The author in (11) has told that the optical performance of FP filter can be made better by integration of anti-reflecting grating.

IV. NEUTRAL DENSITY FILTERS

These are the filters which control the light intensity across a certain spectrum. No filter reduce transmission. This is classify in two categories: Absorptive ND filters and Reflective ND filters. It can prevent damage to some detectors and also light exposure in camera. (12)





Fig. 6 Neutral Density Filter

Source: <https://www.newport.com/c/optical-filters>

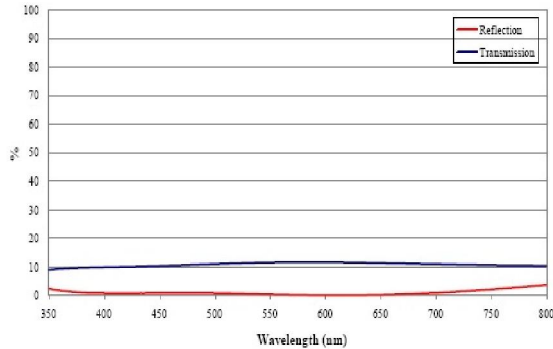


Fig. 7 Performance coating curve of neutral density filter

Source: <https://www.edmundoptics.com/knowledge-center/application-notes/optics/optical-filters/>

V. BANDPASS FILTER

It allows to reflect or transmit particular wavelength and attenuate others. Band pass filter is of two types : Absorption filters and Optical interference filters. Band pass filter is used in optical communication. (13)

In optical computers and color displays development narrow band pass optical filter is used. (14) In multiplexing, narrow band optical filter is used. (15)

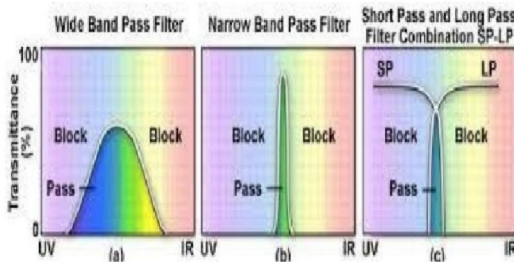


Fig. 8 Wide band pass filter, narrow band pass filter, short pass and long pass filter

Source:

<https://www.olympusmicro.com/primer/techniques/fluorescence/filters.html>

VI. NOTCH FILTERS

It attenuates a certain laser wavelength and gives narrow blocking band. In Raman spectroscopy narrow notch filters are used for improving it. (16)

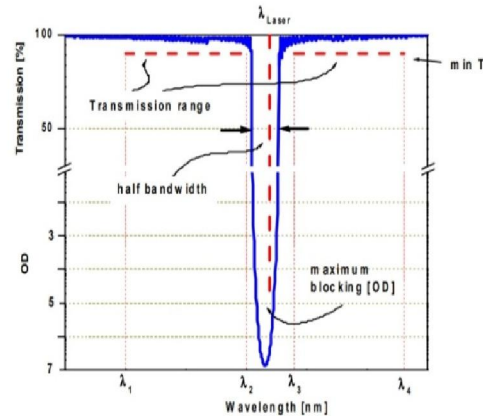


Fig. 9 In this solid curve transmission curve and dashed lines are typical notch filters representation (16)

VII. PHOTONICS BASED OPTICAL FILTERS

Photonics is related with the generation, transmission and detection of light. (2) Photonics crystals have ability to control light wave propagation. (17)

Three categories are there of photonics based optical filters:

- i.) Microwave photonics filter
- ii.) Silicon RF photonics filter
- iii.) Photonics based interference mitigation filter

1. MICROWAVE PHOTONICS FILTER

Microwave photonics is study of interaction of microwave and optical signal. Microwave photonics filters have some advantages such as high bandwidth, high tune ability, almost no heating effect, etc. These microwave photonics filters are used in optical communication, satellite communication, radar and optical networks. (18)

2. SILICON RF PHOTONICS FILTERS

RF photonics systems have high time bandwidth product. Silicon CMOS (complementary metal oxide semiconductor) reduces photonics waveguide losses. RF photonics filters filter 1.25 GHz RF signal processing 20 db stop-band attenuation and 20 GHz tuning range. (19)

3. PHOTONICS BASED INTERFERENCE MITIGATION FILTERS

For interference mitigation of microwave signals, these are two topologies based upon photonics filter. A parallel topology comprises a single grating based photonics band pass filters



and it can synthesis a flat and broad pass band. The second topology is based on non-commensurate delay line approach and improve shape factor of stop band.

These types of photonics based filters gives high resolution interference mitigation. (20)

VIII. APPLICATIONS OF OPTICAL FILTERS

Optical filters have many applications which are given below:

1. IN RAMAN SPECTROSCOPY: In Raman spectroscopy holographic notch filter is used to reject Rayleigh line and allow stokes and anti-stokes operation near to the Rayleigh line. (21)
2. Infrared band pass filters are used to remove interference in barcode's background. Ink is used in beverage reflects infrared. (22)
3. Liquid crystal tunable filter is used in agriculture for precision farming, medical spectral imaging, true colour night vision, forensics, military target detection. (23)
4. According to author in (24) thin film filters exhibit a very low temperature coefficient long stability and small losses of chromatic dispersion and polarization related dispersion and in DWDM applications the separation between neighboring channels is less than 1nm and so the width of pass band of an individual filter must be less than 0.5nm which makes the fabrication of these ultra-narrow band filters very challenging and difficult task. In DWDM system, a thin filter would only transmit the wavelength of optical channel which was designed for filter and would reflect all others in the DWDM signal. In this author gave an overview of how a DWDM system works, where optical thin filters fit in and how they are made.

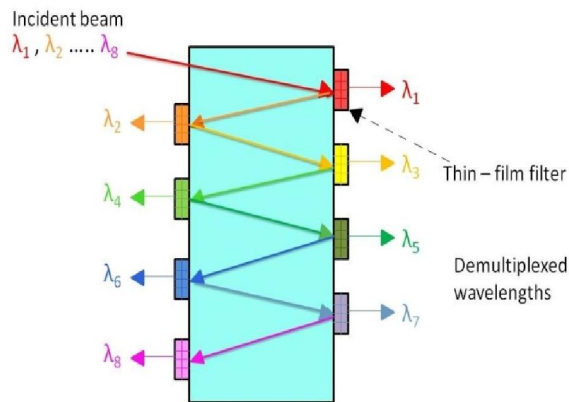


Fig.10 Thin – film filter type of de-multiplexer

5. The authors in (15) presented MEMS – based concept for tunable thermo – optical filters for use in WDM systems as tunable filters are suited for wavelength monitoring, fast and flexible IC configuration of optical networks which are some of the growing requirements of WDM systems and WDM

increases the transmission capacity of complex communication system. (25)

6. Absorptive filter is used in infrared and ultraviolet blocking, fluorescence microscopy, stage lighting, projection devices and photographic enlargers.

7. Dichroic filter is used in fluorescence microscopy, LCD projectors, laser harmonic separators.

IX. CONCLUSION

In this review paper we have presented comprehensive advancement in field of optical filters and recent work reported in the literature. This paper also gives overview of various filters like Absorptive filter, Dichroic filter, Fabry – Perot filter, neutral density filters, band pass filters and photonics based filters along with its applications. This paper will give direction to the researchers to take their work achieve new levels in field of optical filters efficiently and effectively.

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