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A Review : Recent Technological Advancement in the Field of Optical Filter

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ABSTRACT

The photonic crystal is a spatial dielectric material in which refractive index of material is periodically modulated. Photonic band gap is the characteristics by which wave is propagated inside this crystal. This chromatic gap of photonic crystal is mainly used for the spatial purpose filtering. In the proposed paper review of various types of optical filter which are based on optical fiber, photonic crystal fiber and photonic crystal material has been discussed. The recent advancement of optical filtering technique and also different applications of optical filter has been reviewed. In the paper advance photonic crystal based Add & Drop filter (ADF) is also explained which is mostly used for filtering purpose in optical communication network and wavelength division multiplexing (WDM).

Keywords: Photonic Crystal (PhC); Optical filter; Wavelength Division Multiplexing (WDM); Add & drop filter (ADF), Filter application.

I. INTRODUCTION

Filters are the circuits through which some signal pass while other stops. There are various types of electronics filter such as passive or active, analog or digital, high pass, low pass, band pass, band reject, all pass, discrete or continuous time; infinite impulse response or finite impulse response filter. There are various applications of this device for example, in communication, audio system, spectrum analyzer, signal generator etc. Optical filter is a device which can be used to particularly select or repudiate a wavelength or spectrum of wavelengths. A communication in which luminous is used to exchange data from sender to recipient is known as optical communication. The transmitter, channel and receiver are the three important terms in the field of optical communication. The function of transmitter is to convert the data to an optical signal, a channel is an medium through which information passes, and finally the information is received at the receiver. There are two types of optical filters which are commonly used namely Absorptive and Dichroic filters. The former blocks the light depending upon the glass substrate's absorption properties. While, the latter filter transfers the particular wavelength while rejecting the undesired light by using the principle of interference [1].

Photonic Crystal is a periodic dielectric material which is used for the designing of different optical devices. The photonic crystal has different characteristics like photonic band gap; negative refractive index etc. [2]. In the below figure 1 the different applications of photonic crystal material is shown

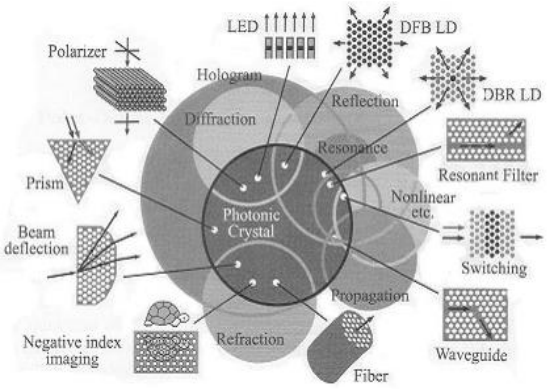

Figure 1. Different applications of photonic crystal material [1]

II. CLASSIFICATION OF OPTICAL FILTERS

Optical filter is a device which is used to send of desire spectrum while eliminating undesirable light. The usage of these types of devices is generally in the field of photography, optical instruments, colour stage lightening and fluorescence.

A. Fiber- Bragg Grating Filter

This type of optical filter is an aspect of wavelength division multiplexing arrangement [3]. When a light travels through a grating filter then interference of some wavelength is effective while other is destructive.

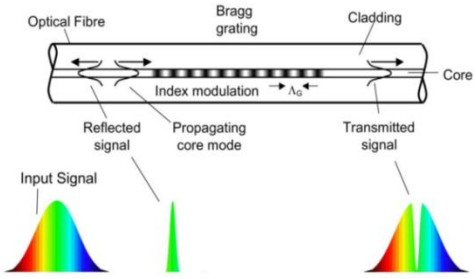

Figure 2. Fiber- Bragg Grating filter [3]

B. Absorptive Filter

This filter is mostly made from glass which consists of composition of many carbon and non organic compound. The compounds utilize few wavelength of light and send the remaining light. These compounds also use plastic in order to yield a gel filter, which is light in weight and also cheaper as compare to filter which is based on glass [4].

C. Dichroic Filter

Depending on the wavelength this filter is used to send light of a particular wavelength range and on the other hand stop the light of a different spectrum. The dichroic filter is vastly used in the field of long pass and short pass [5].

D. Thin Film Filter

It is also known as "fabry-perot filter", in which two plane reflectors are separated by a distance and are also extremely reflective in nature [6]. When light is incident on input side of febry-perot interferometer it travels through a chamber known as cavity, a part of light leave the cavity while rest of the light is reflected [6].

$$T= [1+ 4R/ (1-R)^2 \sin^2(\beta/2)]^{-1}$$

T is a transmission in which there is no absorption of light.

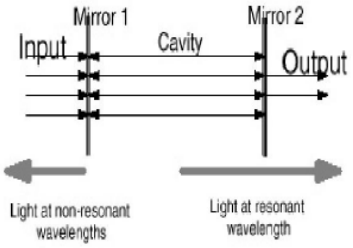

Figure3. Thin Film Filter [6]

E. Band pass Filter

This type of filter permits a particular signal to pass while rejects the other. The range of band pass is less than an angstrom and few hundred nanometres. Band pass filter is made from the consolidation of low pass and high pass filter. This filter when used in optical medium it stops and rejects unwanted signal and allow wavelength of optical medium [7].

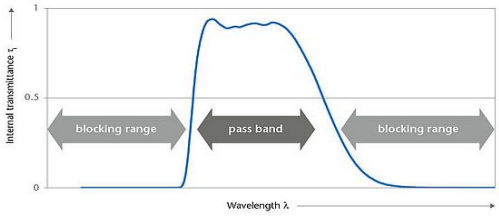

Figure4. Band pass Filter [7]

F. Tunable Filter

MEMS & Bragg grating are the important techniques in the field of tunable filters [8]. There are various types of tunable filters like liquid-crystal, acoustic-optics, and linear variable filters. The application of this type of filters is the field of drug detection, micro plate readers, etc.

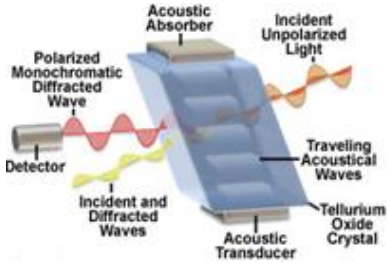

Figure5. Tunable Filters [8]

G. Ultraviolet Filter

The range of ultraviolet is from 100nm to 400nm and is divided into three wavelength namely Ultraviolet A (400-315nm), b (315-280nm), and C (280-100nm) [6]. This light is electromagnetic in nature which is lower than visible light but greater than X-rays. The Ultra violet filters consist of three layers which are RED, GREEN, BLUE and this filter can be used in various applications [9].

H. Infrared Filters

The wavelength of infrared light is more as compare to visible light. The frequency range of infrared is from 300GHz to $30 THz [10]. Infrared filter is classified as near infrared and far infrared. The application of this filter is in the area of photography, metrology, thermograph, etc.

III. OPTICAL FILTER BASED ON PHOTONICS

The basic unit of light is photonics. The photonics deals with the origination, communication, direction and discovery of light by using various types of devices like laser, fiber optics and electro optical. Various photonic based filters can be used in many applications which are associated with medical field, military, telecommunication, communication, optical interconnection network, and ultra high speed information processing [11].

A. Photonics based Interference Mitigation Filter

The interference mitigation filter has three important characteristics such as lateral topology, band pass filter based on bragg grating and double cavity structure which are useful to avoid intervention in signal and also it is useful to lower the complications which arise in narrow stop band and wide pass band with less interference over a vast microwave range [12].

B. Microwave Photonics Filter

The combination of microwave and optical signal give rise to the application of microwave photonics. This photonic based filter can be used in the area of broadband, wireless and sensor network, radar, satellite communication etc. The microwave photonics based filter is advantageous as it has low loss, high bandwidth good tunability. The application of this filter is in the field of radar phase array and also they can be used as an optical coupler, FBGs, array waveguide etc. [13].

C. Photonic Crystal based Add & Drop Filter

Photonic crystal based add and drop filter is one of the most significant devices which are mainly implemented in optical network. The main function of this type of filter is to drop an appropriate wavelength for particular applications. It also acts as an optical multiplexer. The main advantage of this type of filter is that its size is very small, so that this photonic crystal based ADF filters can be easily integrate on the integrated circuits [14].

The photonic crystal based optical ADF works on the principle of resonant wavelength. In the filter two types of linear waveguide i.e. bus waveguide and drop waveguide are coupled with the resonator. The resonator may be ring resonator or cavities [15].

The main application of photonic crystal based ADF is in the wavelength division multiplexing system, where it is filtered or dropped the desired wavelength. In the below figure the basic structure of photonics crystal based add & drop filter is shown

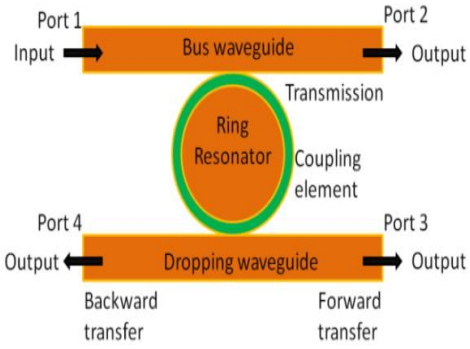

Figure 6. Add & Drop Filter [15]

IV. APPLICATIONS OF OPTICAL FILTERS

Recently the use of optical filter is everywhere like they can be used in telecommunication network, in experimental apparatus, microcomputers, communication related to optical network etc.

A. Optical Bandpass Filters

This filter is widely used in the area of fluorescence microscopy, spectroscopy, clinical chemistry, or imaging. The use of this filter is also in the field of science and research and development area [16].

Figure7. Optical Band-pass Filters [16]

B. Blue Band-pass Filter

This filter when used in lens of camera it stops the ultra violet rays and allow specifically the blue fluorescence which are emerging from 2D pattern [17].

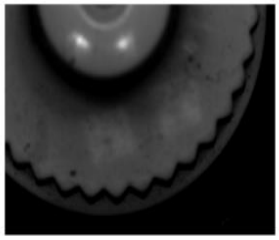

Figure8. Blue Band-pass Filter [17]

C. Short Pass Filter

The use of designing this type of filter is to provide an acute transition from transmitter to reflector so that they can be used in variety of applications. This filter is useful in the field of fluorescence as it is applicable in different cut-off wavelengths. The moderate transmission of 85% and a rejecting optical density of 2.0 are useful for achieving very good contrast in gadgets vision and in the area of calibration [18].

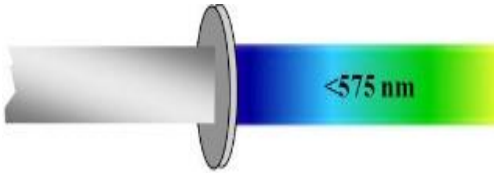

Figure8. Short Pass Filters [18].

D. Colour Imaging Filter

The application of this type of filter is to manage the spectral characteristics of light. The HORIBA group of companies provides different types of colour imaging structure [19].

E. Optical Thin Film Filters

The use of this filter is in the area of lightening and biotechnology instrument. The demand of this filter is continuously increasing [20].

Figure9. Optical Thin Film Filters [20]

F. Infrared Band Pass Filters

The application of this filter is to confine small spectral area by implementing good transmission and wide elimination. This filter is optimum for controlling the environment etc. [21].

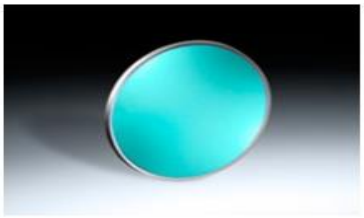

Figure10. Infrared Band-pass Filter [21]

V. FUTURE ASPECTS

A filter is excellent in the field of transmitting and receiving along with good rejection is required.

Recently many single band optical filters are in use. The future demands for optical filter which are multiband in nature in contrast to single band. In medicinal application the optical filter along with infrared light can be used for achieving diagnostic test [22].

VI. CONCLUSION

The purpose of the proposed paper was to give an overview of various types of optical filter and their application in various fields. The paper also provides an outline about primary features of optical filters.

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