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Designing Thin Film for Wavelength Division Multiplexing

Madhavi Latha
Department of Electronics and Communication Engineering, JNTUK, Kakinada
Corresponding Author: mlathaece@gmail.com

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***Abstract**: There are two designs of thin film narrow band-pass filters with several cavities. These filters, which are the most used filtering technologies, have been crucial to the advancement of technology in contemporary optical communication systems. This work focusses on a theoretical investigation of optoelectronics physics, which is primarily connected to the design and analysis of this kind of filter. The technology of thin film multicavity filters is briefly introduced. We'll cover some recent developments in thin-film multi-cavity technology design. TiO2 and SiO2 are the two materials used in these designs as high and low index. The three and four wavelengths (730,800 and additionally 835,432,560 and 774 nm) can be detected by these wavelengths, which range from 600 to 900 nm. The filter's function is to filter fused silica with index 4.23.*
***Keywords**: Dense wavelength, division multiplex, band-pass filter*

I. Introduction

Thin film narrow band pass filters are commonly employed in fibre optic communication systems for wavelength division multiplexing applications. Over the wide range of wavelength the applications, of the filter must have an extremely sharp cut-on and -off on each side of the bandpass and almost zero presence across the bandpass. An essential part of these systems is wavelength division multiplexing (WDM), which splits several channels of information encoded on light signals of different wavelengths that are sent on the same fibre and decodes them on the receiver side through divided wavelengths. The Fabery Perot multicavity narrow band pass interference filter is the most used tool for multiplexing and demultiplexing the various wavelengths sent across optical fibre. Narrow band pass filters need to have poor transmittance at wavelengths other than the transmission wavelength and very steep cut on and on transmittance characteristics. The manufacture of these ultra narrowband filters is a highly tough and complex task since, for Dence WDM (DWDM) applications, the passband of an individual filter must be less than 0.5 nm because the distance between adjoining wavelength channels is less than 1 nm. Since adjacent wavelength channels for coarse WDM (CWDM) are spaced 20 nm or more apart, a filter bandpass width of 12–20 nm is possible, making the production of these filters more practical. Thelen and Baumeister go into great detail about the design methods for the multilayer stacks that are used to fabricate narrowband filters for WDM applications. These thin-film filters are made by plasma or ion-assisted electron beam evaporation, plasma impulse chemical vapor deposition, or reactive magnetron sputtering (such as mycoplasma sputtering). There aren't many producers of thin film band pass filters for WDM (CWDM and DWDM).

II. Theory

An explanation of the narrow band interferometer's fundamental design. At the same design substrate, the basic structure is a multilayer stack of thin films with alternating high and low indexes, most of which are around one fourth wave thick. In addition to optical communication technology, fibre optic communication technology has advanced quickly thanks to DWDM technology. The evolution of fibre optic technology and the contribution of DWDM to its advancement are briefly discussed in the latter section. Although fibre optic transmission was demonstrated to be feasible in the eighteenth century, the technology didn't gain traction until the twentieth century. once we were aware of the likelihood that light possesses a frequency of information. Furthermore, fibre optic connection offers the benefits of having long-range signal transmission capabilities, low mistake rates, resistance to electrical interference, portability, and security.

Both of them use cascade and a narrow bandpass filter to accomplish multiplexing and demultiplexing tasks in one way or another. In the case of prism demultiplexing, the methods can be based on arrayed waveguide gratings (AWG), fibre Bragg grating, diffraction gratings, prisms, or thin simple multiplexers or demultiplexers. When a polychromic light beam strikes a prism surface, its constituent wavelengths refract in diverse ways. The "rainbow" effect is this. Each light wavelength is used to segregate the output light.

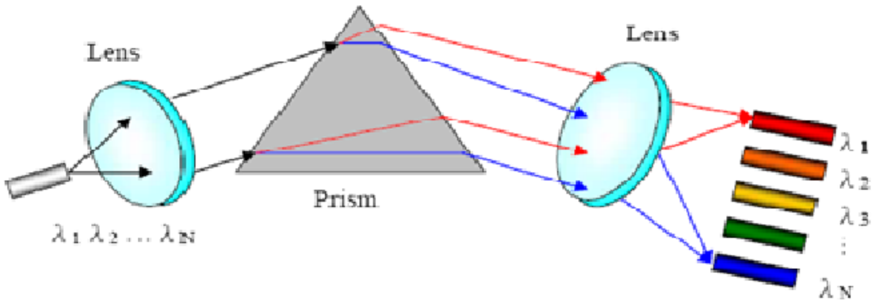

Fig 1: Demultiplexer in the shape of Prism

Another technology uses thin interference filters. Thin film filters comprise several successive layers of thin refractive dielectric films each of about 500 nm thickness with rapidly alternating high and low indices. Stacking of thin film can be performed by one coating technology, such as a plasma deposition, that has long stability life and little losses in chromatic dispersion and polarization system. Only the filter's optical chain number is reduced by thin film filtration and not any other elements from the DWDM signal stack. A thin demultiplexer is depicted in Figure (3). Coming up chapters will explain the details of the attributes.

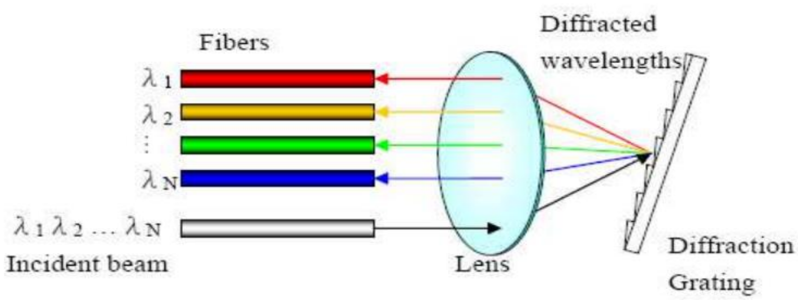

Fig 2: Demultiplexer Diffraction Grating

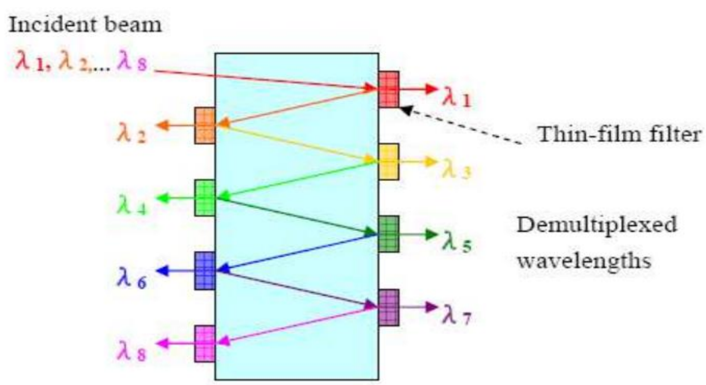

Fig 3: Demultiplexer Thin Film

III. Results and Discussion

Using free filter software, I proposed these theoretical designs and thoroughly examined their profiles for the visible and near-IR regions. As seen in picture (1), the filter transmits (almost) 0.1 between these wavelengths, and between the wavelengths depicted in figure (2), it transmits almost zero. The filter is to be applied to fused silica index 3.55. The filter in question functions at normal incidence. An all-dielectric filter with mirrors a quarter of optical thickness and spacers half or more than half the optical thickness is the most popular narrow band-pass filter configuration, also known as a multi-cavity band pass filter. In order to design the open filter program, we utilize TiO_2 and SiO_2 as the tow coating materials. The layer architectures for the narrow band pass filter for tow designs are displayed below. The center-to-center spacing of the channels on the wavelength units is evident from figures (1) and (2), which clearly display characteristics transmission vs. wavelength. As you can see, there are more channels accessible due to the larger dencer spacing. In addition, figure (2) shows that these filters' bandwidths need to be much smaller than those shown in figure (1).

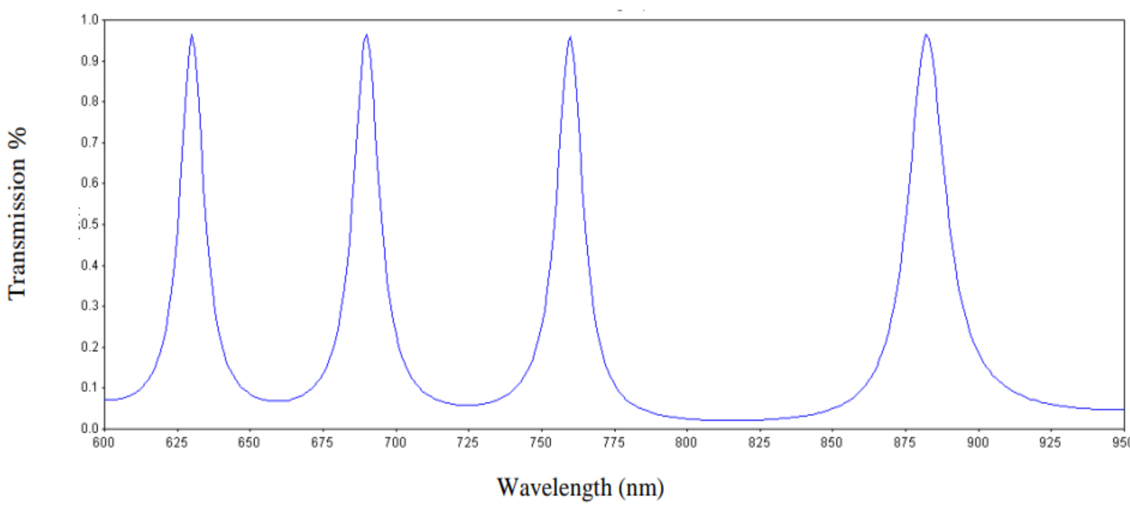

Fig 4: Narrow bandpass filter with four multi-cavity filters, Wavelength vs Transmission

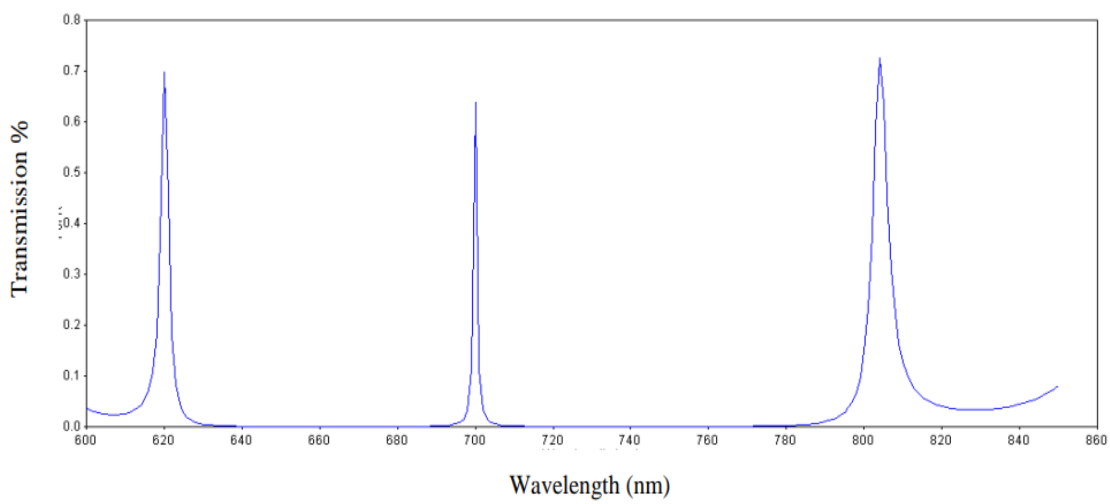

Fig 5: Transmission versus wavelength for designing a multi-cavity narrow bandpass filter

IV. Conclusion

In the communications sector, this kind of bandpass coating is used to regulate the flow of many laser (channel) lines via fibre optic cables. More information is transmitted by the fibre because of the denser gap between the laser wavelengths. A thin film narrow band filter which transmits one channel but reflects all others is one of the most often used components in the addition of a channel or removal of a channel. The most difficult task the optical thin-film industry has ever faced is producing these filters in huge quantities. In this session, we provide an overview of the functions of optical thin film filters, how DWDM systems work, and what is required to actualize them. It is evident from design that optimization is more limited than design.

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