WAVELENGTH DIVISION MULTI/DEMULTIPLEXER BASED ON STACKED OPTICAL CIRCUIT SCHEME

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1. Introduction

Recently, dense wavelength division multiplexing (DWDM) [1] is introduced into trunk line communication systems, and also coarse WDM (CWDM) [2] system is considered for high speed local area networks. Dielectric multilayer filters have an important role for such systems because of their good filtering characteristics and flexibility in filter design. However, the alignment of filter chip and microlens for multi/demultiplexer (Mux/Demux) channel is very complex and it causes the costly packaging of dielectric multilayer filter circuit.

In this study, we proposed a wavelength division Mux/Demux based on stacked optical circuit[3]. And we analyzed the characteristics of dielectric multilayer filters by an improved transfer matrix analysis[4].

2. Wavelength Division Multi/Demultiplexer Based on Stacked Optical Circuit

The scheme of a wavelength division multi/demultiplexer based on stacked optical circuit is shown in Fig. 1. Dielectric multilayer filter and mirrors are evaporated on glass substrate and the substrate is sandwiched by angled facet planar microlens (PML) substrate by means of stacked optical circuit. Collimated beam is propagated in the filter circuit and the pitch of PML array is well defined by the photolithographic process, so the alignment of each substrate is simple. A collimated beam system using PML array can realize low loss and low crosstalk optical circuit by just stacking each components[5]. This scheme can be easily applied to multi-mode fiber system. The combination of this optical circuit and multi-channel vertical cavity surface emitting lasers (VCSELs) [6] array and resonant-cavity photodetectors[7] can make

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a high speed and large capacity WDM local area network system by simple formation.

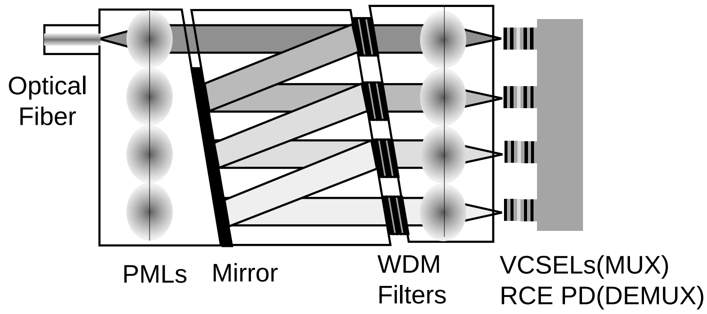
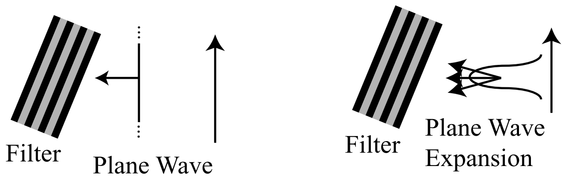


Fig. 1 WDM Optical Circuit Based on Stacked Optical Circuit

3. Design of WDM Filter Using Improved Transfer Matrix Method

The transfer matrix method has been widely used for designing of dielectric filters under the assumption with an incident plane wave. However, an actual input beam with finite spot size has divergent angle components that should be considered for narrow channel spacing filters, especially for large incident angle condition. A theoretical model for the improved transfer matrix analysis is shown in Fig. 2. The conventional matrix method has been used under the assumption with an incident plane wave. Here, the input Gaussian beam is expressed by the summation of plane waves with various spatial frequency components. The angle components of different plane waves are taken into account by using this analytical method.



(a) Conventional (b) Improved

Fig. 2 Theoretical Model of Improved Matrix Method

The filtering characteristics for 75 μm spotsize Gaussian input beam are shown in Figs. 3 and 4. This filter is designed for a 100 GHz channel spacing WDM system. Incident angle is assumed to be 2 degrees for Fig. 3 and 5 degrees for Fig. 4. The solid line shows the theoretical result of incident plane wave and the bold line shows the result of incident Gaussian beam. Increase of insertion loss at center wavelength and the broadening of the pass-band width are estimated by the improved transfer matrix method. These degradations are caused by relatively large angle plane wave components of the input Gaussian beam.

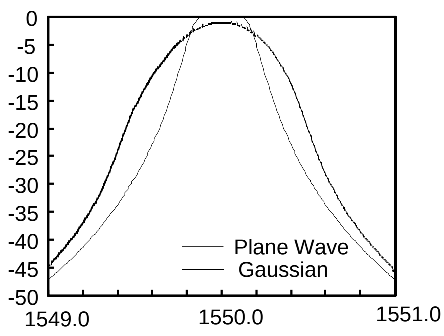


Fig. 3 Filter characteristics (2 degrees)

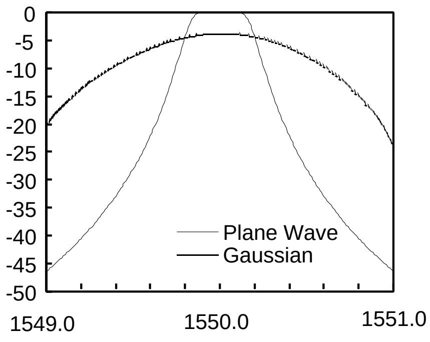


Fig. 4 Filter characteristics (5 degrees)

The excess loss of WDM filters at the center wavelength (1550.0 nm) is shown in Fig 5. The tolerable angle for 1dB insertion loss is 2.0 degrees for 75 μm input beam. The optical crosstalk at 100GHz spaced neighboring channel is shown in Fig. 6. It is expected that –30dB crosstalk can be obtained for 75 μm input beam at 3 degrees incident angle. The polarization dependent loss of this WDM filter is less than 0.3dB when the incident angle is smaller than 5 degrees. These filtering characteristics can be improved by larger incident beam size because the plane wave components corresponding the input beam may have smaller angles. Thus, a large diameter (>250 μm) array can be needed in microlens for this purpose.

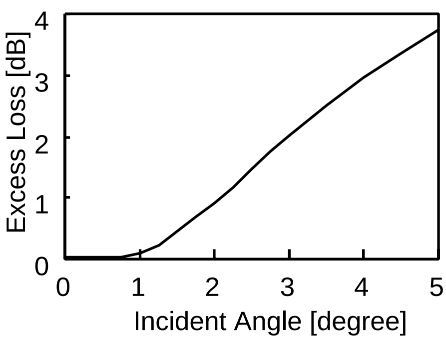


Fig. 5 Excess loss at 1550.0nm

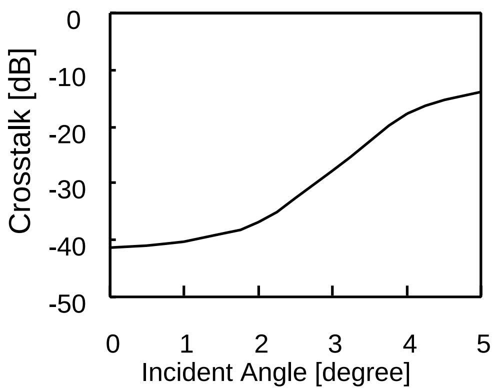


Fig. 6 WDM crosstalk

4. Conclusion

We have presented a wavelength division multi/demultiplexer based on stacked optical circuit. The integration of multi-channel dielectric filters and microlens array can be simply realized. And we analyzed the characteristics of dielectric multilayer filters by an improved transfer matrix analysis. The incident angle should be carefully controlled for 100GHz channel spacing WDM to realize low insertion loss and crosstalk. In this study, we showed the fundamental design for stacked WDM optical circuit for future WDM networks, and an experimental verification is under studying. The result will be presented at the meeting.

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