Wide-channel-spacing wavelength division multiplexer and demultiplexer consisting of stacked dielectric filters and diffractive optical elements

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I. INTRODUCTION

Demands for large capacity transmission services necessitate high-speed optical interconnections. It is also crucial to develop reliable and compact packaging technologies to utilize the potential of opto-electronic devices involved. "Ultra High-Density Electronics System Integration R&D Project" is the consortium of a government-industry-university collaboration supported by the New Energy and Industrial Technology Development Organization (NEDO) and started in September 1999 by the Association of Super- Advanced Electronics Technologies (ASET).[1)] It is one of the project goals to realize new opto-electronic packaging technologies at an intra-cabinet level with the transmission throughput of more than Tbps (terabit/sec). To increase the interconnection bandwidth, wavelength division multiplexing (WDM) is an important technology. However, dense WDM used in long-distance telecommunication is not suitable for the intra-cabinet-level interconnections due to its system complexity and inevitable high production cost. Instead, we chose wide-channel-spacing wavelength division multiplexing (WWDM) [2)] since it is expected to reduce fabrication cost by allowing uncooled lasers and simpler wavelength multiplexing devices than DWDM scheme. To realize WWDM systems, wavelength multiplexing and demultiplexing devices are key components. In this paper, we discuss the fabrication of a simple WWDM multi/demultiplexer based on a stack of WDM filters and diffractive optical elements. Experimental results are also reported.

II. OPTICAL SYSTEM DESIGN

The proposed WWDM multi/demultiplexer consists of three layers of dielectric interference filters, a reflecting mirror and an aspheric lens array. A schematic diagram of the optical system is shown in Fig. 1. The lens array pitch is set to be 250 m to fit the optical fiber geometry at the end facet of conventional MT connecters. Three dielectric interference filters (DIF) are stacked to perform wavelength multiplexing and demultiplexing functionalities. An incident signal light from Port 1 of an MT connector has four different wavelengths (1280nm, 1300nm, 1320nm, 1340nm). Three filters of DIF1, DIF2 and DIF3 reflect the wavelengths in the range of 1330-1350nm, 1310-1330nm and 1290-1310nm, respectively. The incident light is collimated by an off-axis lens. Four wavelengths are differentiated by being reflected by three DIFs and a mirror at different locations. After the reflections, four collimated beams are again focused by corresponding off-axis lenses onto four channels of the MT connector, Port 2, 3, 4, and 5, respectively. Five off-axis lenses are of diffractive types fabricated on a fused-silica substrate. [3] Entire optical system was designed and simulated using Code V. [4] Above explanation is based on a demultiplexer configuration. However, the same optical system is also used for a multiplexer by simply entering four different wavelengths lights from Port 2, 3, 4, and 5, and the multiplexed optical signal is obtained at the Port 1.

III. Experimental Results

A photograph of an assembled WWDM multi/demultiplexer based on a stack of dielectric interference filters and diffractive optical elements is shown on the coin in Fig.2. These WWDM multi/demultiplexer size is 6.4mm by 2.5mm with 8.124mm thickness as compact as an MT connector. The dielectric interference filters do not require stringent alignment process since the propagating beams are collimated.

Therefore, an entire optical system can be assembled by simply stacking multiple layers of dielectric interference filters and off-axis lens arrays. After the wafers are stacked, each optical system is obtained by simply dicing the substrate.

The transmission spectrum of the wavelength demultiplexer is measured using a wavelength scanning method. The wavelength spectrums of the output ports in case of multiplexed four wavelengths are shown in Fig.3. The worst-case insertion loss is below 3dB and the cross-talk among wavelengths is lower than -30dB demonstrating the potential of the proposed optical system for the WWDM multi/demultiplexer.

IV. Conclusions

We have demonstrated the fabrication of a simple WWDM multi/demultiplexer based on a stack of dielectric interference filters and off-axis diffractive optical elements. The reported devices have the following advantages:

1) Devices are mass-produced by dicing the stacked dielectric filters and a lens layers leading to the potential low cost in fabrication.
2) Experimental results confirmed low insertion loss and low cross-talk among wavelengths demonstrating the potential of the proposed optical system for WWDM applications.

The proposed technology is attractive in new opto-electronic packaging technologies at an intra-cabinet level with the transmission throughput of more than Tbps

Acknowledgments

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References

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2. Brian E. Lemoff et al., “A Compact, Low-Cost WDM Transceiver for the LAN,” in Proc. Of 50th ETCT, pp711-716, May 2000.

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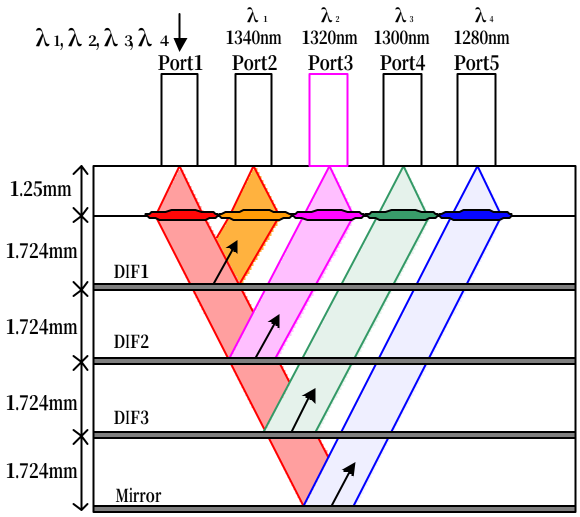
4. Code V is a registered trademark of Optical Research Associates.



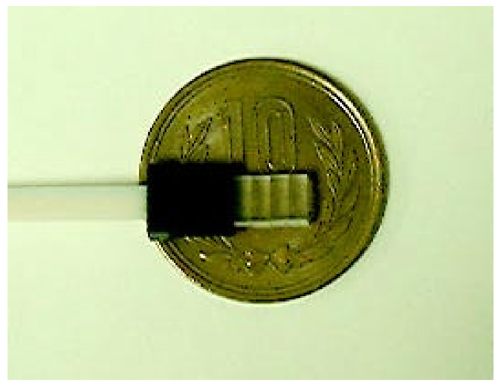


Figure1. Proposed WWDM multi/demultiplexer. Figure2. Assembled WWDM multi/demultiplexer

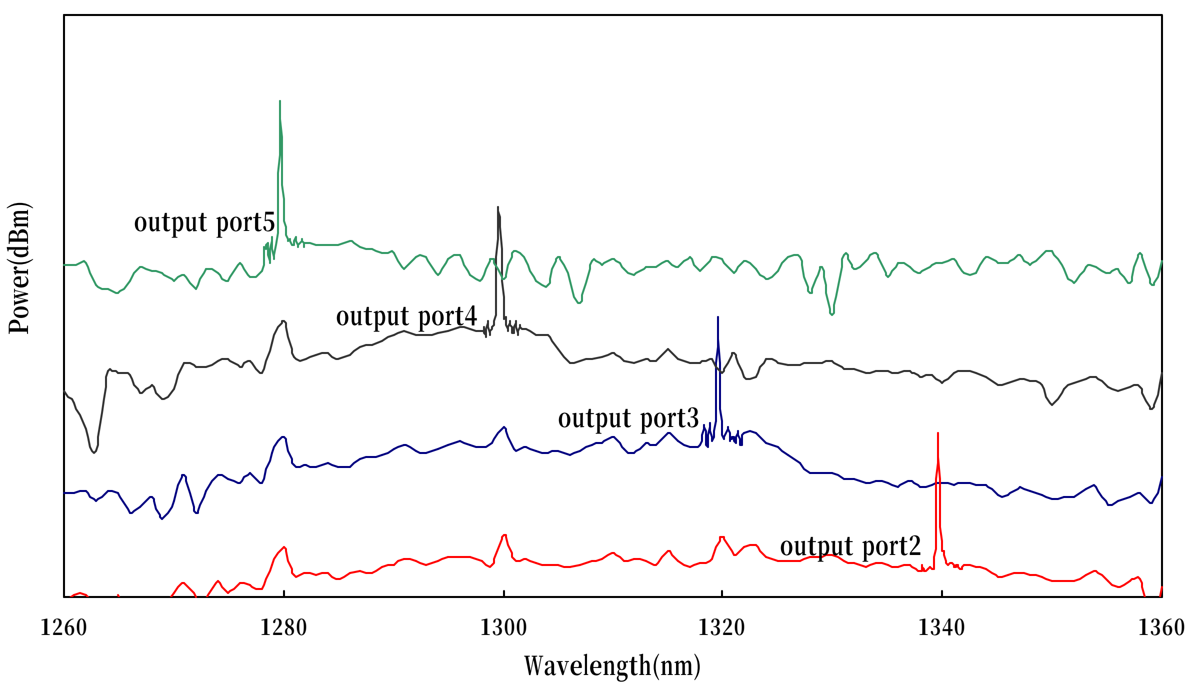


Figure3. The wavelength spectrum of the output ports.