C-band Performance of a Novel Tunable Integrated Filter for Dispersion Compensation

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Abstract—A novel dispersion compensating filter comprising higher order MMI couplers is fabricated in SOI platform. Characterization of the filter has shown that it can compensate residual dispersion for WDM channels over the entire C-band.

Index Terms—Dispersion Compensation, Multimode Interference Coupler, Silicon-on-Insulator

I. INTRODUCTION

In integrated optics, various basic and advance filtering operations have been realized. Mostly they involve 2-port couplers. Realization of future filter applications using 2-port couplers will lead to complex filter architectures. [1] and [2] have proposed filters for signal processing applications using higher order couplers but they have not been experimentally demonstrated. Filters involving higher order couplers will require smaller number of couplers and smaller waveguide lengths. This will result in compact filters with smaller loss.

Silicon photonics provides higher order Multimode Interference (MMI) couplers with low imbalance and small phase errors over the entire C-band [3]. Such higher order couplers are imperative for the realization of advance filtering applications. We have experimentally demonstrated a filter for fiber chromatic dispersion compensation using 4-port MMI couplers in silicon photonics. Chromatic dispersion is the major cause of Inter Symbol Interference (ISI) at high data rates in Standard Single Mode Fiber (SSMF). ISI can be eradicated by pre or post compensation of dispersion using dispersion compensating filter.

II. FILTER DESCRIPTION AND DESIGN

A generalized waveguide layout of an N stage filter for dispersion compensation using symmetric M-port MMI couplers is shown in Fig. 1. Each stage is composed of an M-port Mach-Zehnder Interferometer (MZI) as shown by the dotted section in Fig. 1. The first MMI coupler splits the input signal distorted by chromatic dispersion into M equal components. They are time delayed, recombined and split by each stage of the filter. The dispersion compensated signal is received at one of the output ports of the last MMI coupler. Remaining output ports of the last MMI couplers are used for monitoring purpose. By adjusting the phase of the time-delayed signals on the delay lines, the filter produces different linear group delay slopes for a certain fraction of the filter Free Spectral Range (FSR) making the filter tunable [4].

![Fig. 1. Waveguide layout of a generalized filter comprising M-port MMI couplers. A single stage is shown in the dotted section. Ports with arrows are for input and output. Other ports are either redundant or used for monitoring purpose.](image1)

![Fig. 2. Relation of attainable dispersion from a filter comprising M-port MMI couplers vs the filter order.](image2)

The maximum achievable dispersion from the filter depends on the order R of the filter. For a given group delay ripple and fraction of filter FSR with linear group delay slope, the attainable dispersion increases with an increase in the order R of the filter. In order to have a linear group delay for at least 40% of the filter FSR and a group delay ripple of less than ±3 ps, fig. 2 shows the relationship of the maximum achievable filter dispersion and the order R of the filter. The filter order...
Measurement results for only TE polarization are presented here because the fabricated device is not subjected to birefringence tuning. Fig. 3 is a measurement result, which shows the fraction of the filter FSR that has a linear group delay slope. The filter is tuned to compensate positive, no and negative residual dispersion as shown in fig. 3 (a), (b) and (c) respectively. In each FSR, the group delay is linear for at least 0.32 nm (40% of the filter FSR), which is sufficient to compensate residual dispersion for 40 Gbps WDM systems. The group delay ripple for the tuned filter stays below ±5 ps.

Fig. 4. (a) Measured transmission over a bandwidth of 35 nm (44 WDM channels) in the C-band, (b) Variation in filter dispersion for group delay ripple of less than ±5 ps with more than 40% of filter FSR with linear group delay.

To characterize the filter in C-band, measurement result in fig. 3 (c) is performed from 1530 nm to 1565 nm (44 WDM channels). Fig. 4 (a) shows the measured transmission for the filter. The variation in insertion loss is around 1.5 dB. Fig. 4 (b) shows the variation in filter dispersion for 44 WDM channels in the C-band. For a group delay ripple of less than ±5 ps with more than 40% of filter FSR with linear group delay, the maximum variation in filter dispersion is only 18 ps/nm.

IV. CONCLUSION

We have demonstrated the performance of a novel dispersion compensating filter over the entire C-band. 40% of the filter FSR has a linear group delay with less than ±5 ps of group delay ripple. The variation in dispersion for multiple WDM channels is only 18 ps/nm.

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REFERENCES