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First polymer-based reconfigurable add-drop multiplexer

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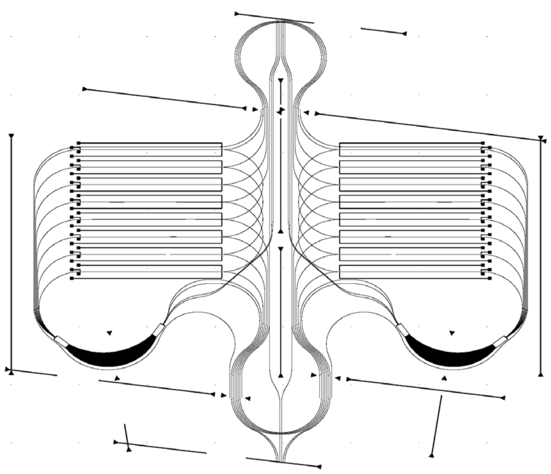
Abstract: An integrated OADM has been realised in a high index contrast polymer technology, exhibiting low switching power, polarisation insensitivity and low cross talk values. Two OADM's combined into one OXC fit on a single wafer.

I Introduction

Optical add-drop multiplexers (OADM) and optical cross-connects (OXC) play a key role in advanced WDM networks. Single-chip OADM's and OXCs based on one or more phasars and optical switches have been reported for technologies based on InP /1/, on silica /2/ and on polymer technology (a two-wafer device /3/). Based on a compact polymer technology /4/ we were able to design an integrated polymer 2x2 OXC consisting of two interconnected OADM's on a single wafer. In this paper we present experimental data of an individual pigtailed OADM and give an assessment of the OXC performance.

Fig.1: Layout of OXC consisting of two OADM's.



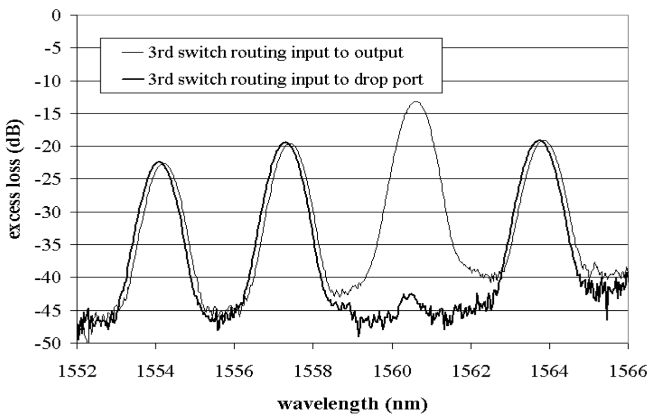
II Design

A layout /7/ of the OXC is shown in fig. 1. It consists of two interconnected four-channel OADM's. The 4 wavelengths are chosen around a central wavelength of 1555.75 nm (192.7 THz) according to the ITU standard, with 400 GHz (3.23nm) channel spacing.

Each OADM consists of a 16x6 mm^2 8x8 phasar connected with 4 add-drop switches in a fold-back configuration /3/, allowing all 4 wavelengths to be independently added to or dropped from the multiplexed channel. The add-drop switches consist of 2 cascaded 1x2 thermo-optical digital optical switches (DOS) /4/. No physical link exists between the add- and the drop gate. Minimum bend radius is 6 mm and waveguide crossing angles are not smaller than 30 degrees, corresponding to a measured maximum loss of 0.05 dB/90º and 0.1 dB per crossing respectively.

The OXC was processed and an OADM was diced from the wafer, making 8 equally spaced channels accessible at opposite chip edges: 4 channels for adding (dropping), 2 channels for multiplexed input (output) and 2 alignment channels for easy connection to an 8 fiber FAU.

Fig 2: OADM pass function



III Experimental results

The device has been pigtailed and polarization insensitivity was obtained by dicing a slot into the phasar and inserting a half wave compensating film. In this way the polarization sensitivity could be reduced from 2.21 nm to smaller than 0.03 nm. The channel spacing was 3.2 nm and the central wavelength was found to be at 1558.0 nm. Tuning to the desired central wavelength is obtained through the high thermo-optic coefficient by heating the phasar with approximately 20ºC /5/. Measured insertion loss from input to output is -26 dB

Measurements discussed below were performed on the non-pigtailed device with a spectrum analyzer and TE polarised light from an erbium-doped fiber ASE source. Excess loss values are relative to a 10-cm long reference channel. Switch power was less than 250 mW.

Pass function of the OADM: Fig. 2 shows the transmission spectrum from the input to the output when the 3rd switch is powered. Non-coherent cross talk between both switch states is less than –29 dB. (The other non-powered switches behave like cascaded passive Y-junctions. In a practical situation all switches are powered, resulting in about 6 dB higher output levels for signals routed to the output.)

Fig.3: OADM drop function

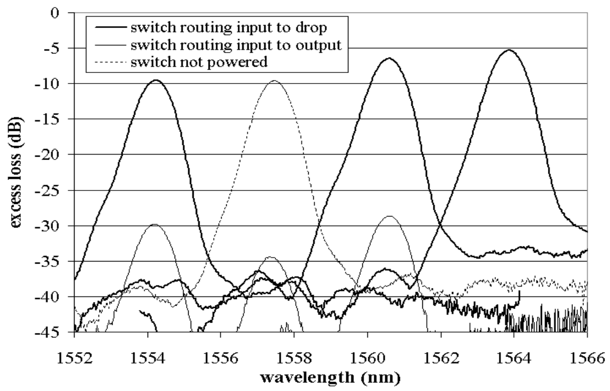
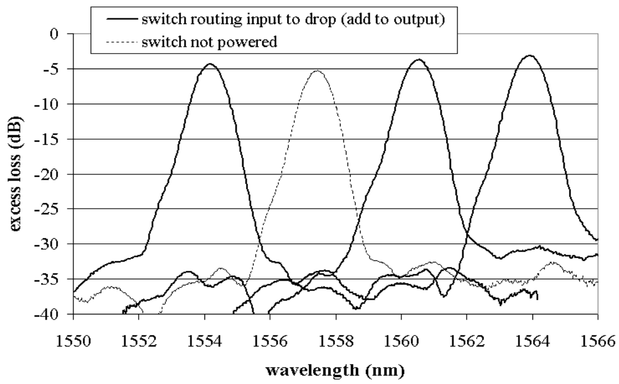


Fig.4: OADM add function



Drop and add function of the OADM: Figs. 3 and 4 show the transmission spectra from the input port to the 4 drop ports, and from the 4 add ports to the output port respectively. Cross talk between the drop ports is less than –27 dB. Cross talk between both switch states in a drop gate is below –20 dB. Cross talk between added channels is below -27 dB.

IV Predicted OXC performance

From the discussion above it is clear that for a given wavelength the cross talk at the output when dropping a wavelength is much smaller than the cross talk at the drop gate when routing the signal to the output. This is because in the former case the unwanted signal has to pass through 2 cascaded switches, whereas in the latter case it passes through only one switch.

In the OXC shown in figure 1 however, the cross paths are realised by interconnecting both OADMs through their add and drop gates. The result is that the add-drop switches of the OADMs are combined into 4 2x2 switches in which the optical paths always pass through two digital optical switches. The unwanted remaining power fraction at the drop gate of one OADM is thus further suppressed after passing the add gate of the other OADM. Moreover, this cross path is almost identical to the bar path of the OXC: both paths involve two passes through a phasar and a DOS, an almost equal amount of crossings and an almost equal optical path length. The only difference is that in the bar-state the light passes two times through the same OADM, whereas in the cross state it passes one time through two interconnected OADMs. In /6/ this cross connect architecture with two phasars and four 2x2 switches in a fold back configuration was found to be most favourable compared to other configurations with respect to cross talk. There is only one first order cross talk term, which in turn is completely determined by the cross talk in the 2x2 switch. From this analysis we can draw the conclusion that, taking into account an excess loss of about 2 dB caused by the extra waveguide connections, the pass function shown in figure 2, gives a good quantitative prediction for the cross and bar transmission spectra of the complete OXC.

V Conclusions

We have shown measurements of the first integrated polymer OADM. Cross talk in the multiplexed output between the two switch states (i.e. dropped vs. non-dropped) is as small as –29dB. This compares well to values found for OADM devices made in silica (-30 dB) /2/ and is much better than for OADM's based on InP /1/ (less than -20dB).

Power needed for switching is 4 times smaller than what is needed for silica devices because of the 10 times higher thermo-optical coefficient of the polymer. In addition all the switches are "digital" (and therewith insensitive to the polarization state), making individual tuning of the switches using complicated electronics unnecessary

From the OADM measurements OXC-crosstalk levels of –29 dB are predicted.

VI Acknowledgement

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