Compact polymer components for an integrated add-drop multiplexer

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Abstract — A phasar and a digital thermo optic switch have been designed and processed in a high index contrast polymer technology. Both devices are small enough to fabricate two integrated add-drop multiplexers on one 4 inch wafer.

I. INTRODUCTION

In the framework of the Dutch collaboration program IOP Electro-Optics/Polymers, supported by the Ministry of Economic Affairs, an add-drop WDM node has been realized. The node is composed of fiber-connected digital thermo-optic add-drop switches and a polarization insensitive 8x8 phasar [1]. All components were manufactured in the commercial low index contrast polymer technology of JDS FITEL .

The present work is directed towards the realization of a polymer based add-drop WDM multiplexer on a single chip. This means the up to now employed standard technology had to be altered in order to arrive at low-loss bends with a small radius.

II BUILDING BLOCKS IN COMPACT TECHNOLOGY

II.1 Small radius bends

Using standard low contrast technology bend losses below 0.1 dB/90° are only possible with bend radii larger than 30 mm. Smaller bend radii can be achieved by increasing the index contrast between waveguide core and cladding. We increased the index contrast to 0.010 ± 0.001. By doing so, we were able to reduce the minimum allowable bend radius by a factor of 6. At the same time core dimensions were optimized for good coupling efficiency to a standard 9/125 fiber, while preserving monomodality in the EDFA window.

Calculated coupling loss to a standard single mode fiber is 0.5 dB. Measured insertion loss for a 55 mm straight channel was –5.5 dB. Figure 1 shows calculated and measured bend loss values. For bends with a radius larger than 5 mm no measureable losses compared to a straight channel could be observed.

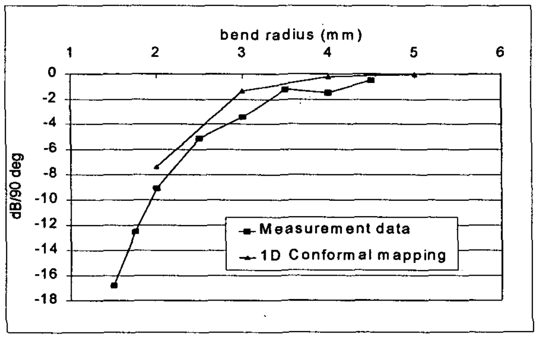

Figure 1: *Calculated [2] and measured TE bend loss in high index contrast polymer waveguides. The measured bend loss shown represents the excess loss relative to a straight waveguide of equal length.*

II.2 Phasar

An 8x8 symmetric phasar with a minium bend radius of 7.5 mm was designed [3] for the compact polymer technology. Its dimensions are only 16 x 6 mm, compared to 66 x 11 mm for the low contrast polymer phasar. It will be incorporated into an all-optical integrated 4-wavelength add-drop multiplexer (OADM) with fold-back architecture. We have chosen the fold back architecture over a loop back architecture, because the the latter has proven to be unsuitable for all-optical amplified closed ring networks [4]. The 4 wavelengths are chosen around a centre wavelength of 1555.75 nm (192.7 THz) according to the ITU standard, with. 400 GHz (3.23nm) channel spacing. The central wavelength used for the phasar design was 1557.37 nm, i.e. the third wavelength channel. In this way, a 4 wavelength signal offered at the third entrance from below will be demultiplexed into the 4 upper most output channels (see fig. 2). Equally, 4 wavelengths presented at channels B5 to B8 will be multiplexed into channel 2A.

Measurement results are presented in figure 2b. TM polarised light was presented at input 6A. Because of the symmetry of the phasar, the wavelength corresponding to the third peak from the left is the phasar

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central wavelength. Its value, 1558.25 nm, is shifted 0.88 nm from its design value. Central wavelength excess loss relative to a straight channel with a length equal to the length of the phasar including its acces channels is –0.85 dB. The cross talk at output channels B1 to B4 at the peak wavelength is –29 dB and better than –20 dB at FWHM. Uniformity is 2.3 dB. Measured channel spacing is 3.23 nm.

For the TE measurements the same cross talk values are found. However, when compared to the TM measurement, a shift in the central wavelength of 3 nm was observed. It is due to stress-induced birefringence and will be eliminated by inserting a half wave compensating film in the device, as has been demonstrated successfully for the standard polymer technology-phasars [1].

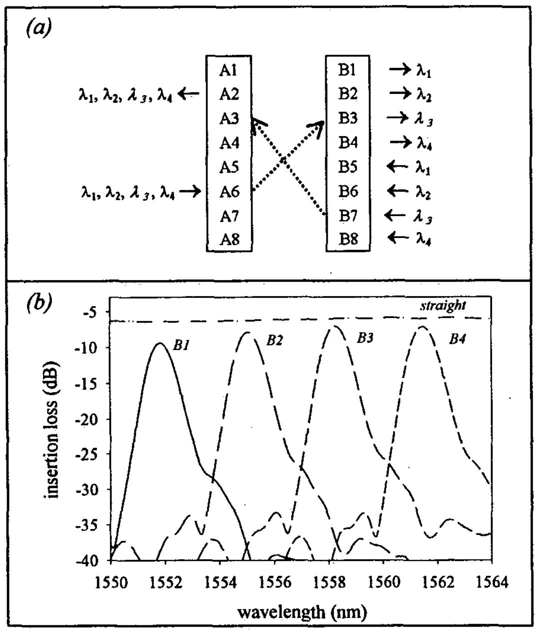

Figure 2: *a) Fold-back operation of a 8x8 phasar with central wavelength equal to λ_3. b) TM spectral response for multiplexed signal offered at input channel A6*

II.3 Digital optical switch

A 1x2 digital thermo-optic switch (DOS) has been designed [2] for the compact polymer technology. It has a minimum opening angle of 0.05 degrees. This is smaller than for a low contrast technology DOS. The smaller angle has to compensate for the diminishing magnitude of the mode conversion factor [5] caused by the higher index contrast.

A cascaded 1x2 add-drop switch consisting of two of these switches has been processed. Measurement results are shown in figure 3. Excess loss compared to a straight waveguide is less than -1.0 dB. The power needed to switch light from *IN* to *DROP* with -20 dB

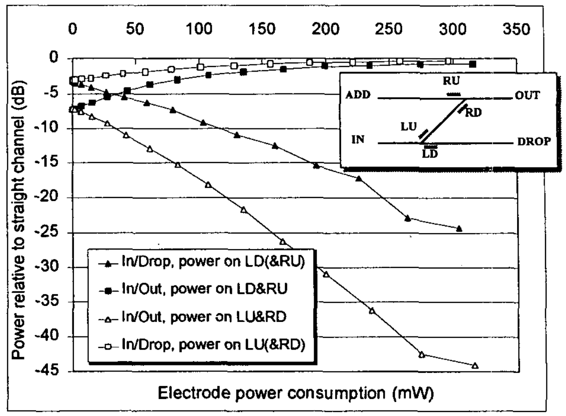

Figure 3: *Switching curves of an add-drop switch composed of two cascaded digital thermo-optic switches.*

isolation relative to *OUT* is 125 mW. Switching from *IN* to *OUT* with -20 dB isolation relative to *DROP* requires 250 mW of heating power.

III CONCLUSIONS

Waveguides with small radii can be realized in polymer by using a high index contrast technology with good fiber chip coupling and without giving up monomodality. Feasibility of digital thermo optic switches and phased arrays in the new technology has been demonstrated, enabling future single chip integration of multiple polymer optical components in an add-drop or cross-connect node.

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