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TuD1 Multimode interference couplers

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Experimental results are presented on a new type of planar (Multimode Interference) coupler. Two-mode interference (TMI) couplers (Fig. 1a) were reported already in 1977 as an alternative to weak synchronous couplers,[1] they are shorter and less sensitive to variations in the fabrication process, and thus have a potential for application without trimming or tuning facility. Further, they exhibit less polarization dependence.

Residual spread in TMI-coupler performance is caused by the Y-junctions at both sides of the coupler. Due to the finite resolution of the lithographic process the gaps between the two Y-junction branches are partially filled in a poorly controllable manner (the shaded regions in Fig. 1a). We reduced this problem by applying strongly bent access waveguides, in which the mode profile is shifted towards the outer edge. In order to maintain a good field match at the junction with the TMI-section the access waveguides are shifted into the opposite direction over the same distance (Fig. 1b), thus creating a gap. If this gap is wider then the resolution of the lithographic process it will no longer be filled, thus eliminating a source of irreproducibility.

Coupling between the Y-junction branches is further reduced by applying a wider (multimode) coupler section (while keeping the access-waveguides monomode, Fig. 1c), which allows for a larger access waveguide separation. Both simulation and experiments indicate that coupler performance improves with increasing coupler-section width, despite of the occurrence of higher-order modes. This phenomenon is due to the self-imaging properties of multi-mode waveguides, as suggested by Bryngdahl[2] and described in more detail by Ulrich.[3]

The coupler transfer was analyzed by computing the mode-conversion at the (discontinuous) junctions at both sides of the MultiMode Interference (MMI) section with the overlap-integral method. Couplers were atom-beam milled with argon in a sputter-deposited $SiO_2/Al_2O_3/SiO_2$ ridge-type waveguide system on silicon substrate, as described by Smit *et al.*[4]

Figures 2 and 3 show the predicted and measured transmission of two series of couplers operating at 633 and 1520 nm, as a function of the MMI-section length. The results demonstrate that MMI power dividers (3-dB hybrids) have been fabricated with short lengths (< 500 μm) and low insertion loss (in the order of 0.5 dB), both at short and long wavelengths. Simulations indicate that even better results can be obtained with stronger multimoded MMI-sections. Experiments on such couplers are presently underway. Results will be presented at the meeting.

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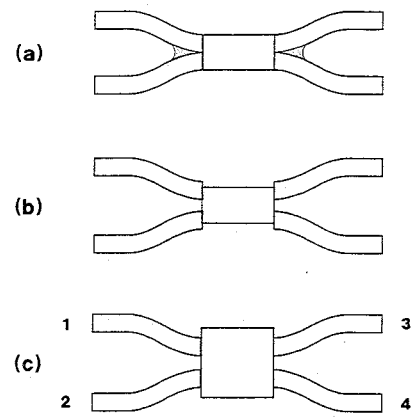

Fig. 1. Basic geometry of (a) a TMI-coupler, (b) a modified TMI-coupler, and (c) an MMI-coupler.

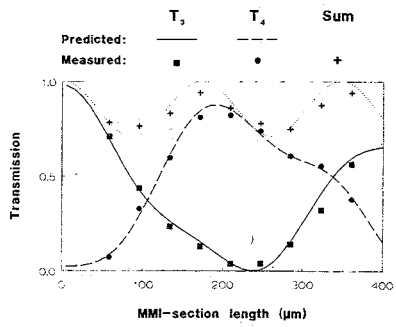

Fig. 2. Predicted and measured power transfer coefficients to ports 3 and 4 (see Fig. 1) on excitation of port 1, for a 7 μm wide MMI-coupler with a 1.6 μm Y-branch separation, operating at 633 nm wavelength. Measurement accuracy ±0.5 dB.

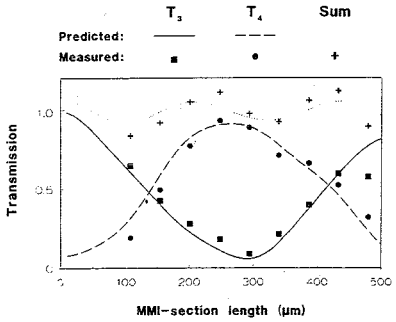

Fig. 3. The same as Fig. 3, but for a 12 μm wide MMI-coupler with 1.6 μm Y-branch separation, operating at 1520 nm wavelength. Measurement accuracy ±1 dB (predicted values are slightly optimistic due to ignoring modal overlap between ports).