# Analysis of Etch Depth for Polarization-free Directional Couplers

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*We analyze etch depth as a design parameter to realize integrated polarization independent directional couplers. The coupling coefficients of TE and TM polarizations are investigated by manipulating the etch depth in coupler section.*
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## 1. Introduction

Directional couplers (DCs) are one of the basic building blocks in photonic integrated circuits, which are mainly used as power couplers between two waveguides in proximity. In general, DCs are polarization depending. Etch depth and waveguide separation between closely spaced waveguides plays a critical role on device performance depending on polarization, especially for high index contrast structures [1]. In this work, we show that, by properly controlling etch depth, it is possible to realize DCs that perform similarly for TE and TM polarizations. In particular, we study the effects of etch depth on the coupling coefficients of differently polarized fields in Indium-Phosphide Membrane on Silicon (IMOS) structures [2], to investigate the way of realizing polarization independent DC.

## 2. The studied structure

The schematic of DC is shown in Fig. 1(a). The deep etched InP waveguides (*w=400*, *h=300 nm*) connect the coupler section to the Input, Through and Coupled ports.

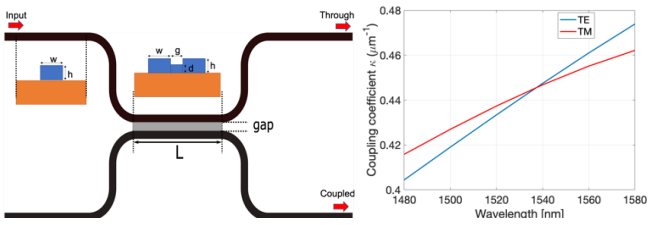


Fig. 1 Schematic of DC with the insets of cross-sections of waveguide and coupling region (a) and simulation results of coupling coefficients for TE and TM polarizations with g =100 nm and d = 90 nm (b).

The coupling section has a gap where we supposed to have partially etched waveguides with (d) representing the etch dept, which is investigated as a design parameter. The coupling coefficients of the TE and TM modes with $d = 90\,nm$ and $g = 100\,nm$ shown in Fig. 1(b) are calculated through super-modes of cross section of the coupler region. The parameters chosen for the simulations are estimated via post-processing of the measured data of DCs with $L = 10\,\mu m$ and $g = 100\,nm$, fabricated in IMOS technology. The theoretical model used to calculate normalized coupled powers is fully described in [1].

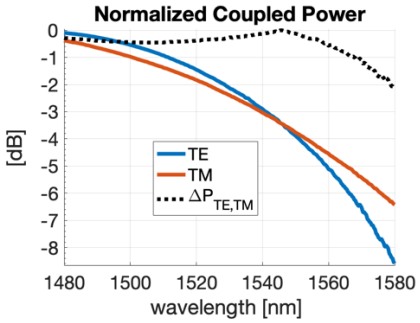


Fig. 2 Measured normalized coupled power of TE (Blue) and TM (Red) polarizations and the coupled power difference between TE and TM polarizations (Dotted).

As shown in Fig. 2, the difference of the measured output powers between TE and TM polarizations $\Delta P$ remains at a low value of 0.45 dB between $1480 - 1560\,nm$ of wavelength span.

## References

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2. van der Tol, J. J. G. M., Jiao, Y., van Engelen, J. P et al. *IEEE Journal of Quantum Electronics*, **56**, 1-7 (2020).