Directional Coupler–based Polarization Beam Splitter using dissimilar waveguides in InP Membrane on Silicon (IMOS)

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1. Introduction
   • InP Membrane On Silicon (IMOS)
   • Polarization Beam Splitters (PBS)
   • Slot waveguides

2. Coupled Mode Theory (CMT)

3. PBS structure

4. Simulation Results

5. Conclusions
InP Membrane On Silicon (IMOS)

- New photonic integration platform
- Photonic Membrane technology
- InP Membrane: Optical layer
- Silicon: Electronics below
- High index contrast → high confinement
- Light generation
Polarization Manipulation

- Polarization can add functionalities to PICs
- Effective manipulation of polarization states
- Various PBS’s
  - Mach Zehnder
  - Directional Coupler
  - Mode evolution device
Slot waveguides

- Geometrical birefringence
- EM boundary conditions:
  - TE mode is strongly confined in the slot region (low index)
  - TM mode changes very slightly
- Normal waveguide fabrication
Coupled Mode Theory (CMT)

- Power is evanescently coupled from one waveguide to the other
- Two system modes: even and odd
- Power is completely coupled at
  \[ L_c = \frac{\pi}{\beta_e - \beta_o} \]
Coupled Mode Theory (CMT)

- If $\beta_{core_1} - \beta_{core_2} \neq 0$ total power transfer cannot be achieved

- One of the two polarization states should be completely transferred
Effective indices

- TM is roughly the same, TE substantially differs
- For TM $\rightarrow$ Complete power transfer is possible
- For TE $\rightarrow$ Complete power transfer is not possible
PBS Structure

- **TE** → even number of crossings
- **TM** → odd number of crossings
- S-bend contributions are taken into account

Top View

- S-bend Length
- Coupling Region

Coupling region cross section

- Waveguide width
- Gap
- Slot width
- Ridge width
- Membrane Thickness
Performance – FDTD Simulation

Extinction ratio: 18 – 25 dB for the whole C-band

<table>
<thead>
<tr>
<th>$L_c$ [μm]</th>
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<tbody>
<tr>
<td>TE</td>
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<tr>
<td>TM</td>
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Cross, TM →

Input →

Bar, TE →

14 μm
Fabrication Error Tolerance

- Fabrication error: deviation from design widths
- Extinction ratio >10dB for a width deviation up to 30nm
- Acceptable for IMOS platform
Conclusions

• A 14 μm long PBS for membrane technology is proposed and simulated

• The PBS exhibits high extinction ratio for the whole C–band

• Fabrication comparable to normal waveguides

• The device has acceptable fabrication tolerances

• It can be used for polarization diverse applications