Out-of-plane fiber coupler for coupling to high-index-contrast waveguides

Dirk Taillaert, Wim Bogaerts, Roel Baets

Ghent University - IMEC, Department of Information Technology, Sint-Pietersnieuwstraat 41, 9000 Gent, BELGIUM

http://www.intec.rug.ac.be/opto

mailto:dirk.taillaert@intec.rug.ac.be

UNIVERSITEIT GENT

PHOTONnetwork

imec

INTEC

Picco

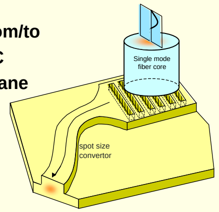
Introduction

The problem

- the interface between a photonic crystal waveguide and the outside world is a serious problem
- huge mismatch between waveguide mode and fiber mode : 26dB coupling loss
- a spot-size converter is needed :
  - lateral (in-plane) : easy
  - *vertical (out-plane) : not so easy*

Our approach

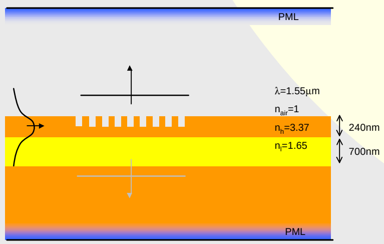
- use a grating to couple light from/to a fiber perpendicular to the PIC
- use a spot-size convertor in plane
- 1.55μm wavelength range
- TE-polarisation
- wafer scale, no need to cleave the devices for testing



Theoretical results

Basics

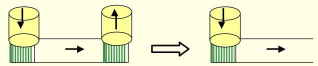
- in a coupler grating (grating period = λ/n), the first order diffraction can be used to couple out-of-plane
- short grating (approx. 10 μm long)
- high refractive index contrast : oxide cladding
- use rigorous electromagnetic modelling (2D) to optimize the grating parameters
- method : mode expansion with PML
- calculate coupling from waveguide to fiber
- optimize grating parameters
- computational model :

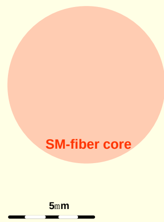


Experimental results

Measurements

- measure transmission from fiber to waveguide to fiber
- waveguide = SOI (205nm Si / 400nm SiO_2)
- correction for substrate losses
- extract coupling efficiency from fiber to waveguide (coupling efficiency from fiber to waveguide is the same as coupling from waveguide to fiber)
- good alignment sensitivity
- don't need to cleave/polish SOI



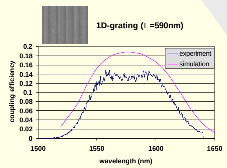


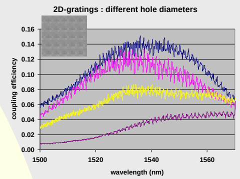
1D grating

- 15% efficiency (8.5dB coupling loss)
- wavelength range > 50nm
- good agreement theory- experiment

2D grating

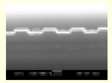
- change DUV exposure dose -> change hole size
- optimum hole diameter = 380nm





Fabricated structures

- 1D grating in a ridge waveguide
- e-beam litho (Glasgow Univ. + COM)
- DUV-litho (IMEC Leuven)
- cross-section after etch:



- shallow etch (50nm)
- etch depth is critical

Simulation results

simple coupler grating : 20% coupling efficiency

coupler grating with parallelogramic teeth : 40%

coupler grating + reflector grating : 40%

structures with bottom reflector (2-pair DBR)

simple coupler grating : 40% efficiency to fiber

coupler grating + reflector grating : 75%

We have also made more complicated structures in GaAs/Alox with a higher theoretical efficiency. Unfortunately these are very sensitive to fabrication tolerances and the highest efficiency measured was 20%

Acknowledgements

This work is supported in part by the European Union in the context of the IST project PICCO. This work is also supported in part by the Belgian IAP-V-18 project (PHOTON network)

We gratefully acknowledge

The PICCO project (www.intec.rug.ac.be/picco) and its partners, in particular St.-Andrews and Glasgow University and DTU/COM research center

Also thanks to Peter Bienstman for the CAMFR simulation tool (camfr.sourceforge.net)