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EDX Course Design Report (2026/01)

Markus_RS

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1 Introduction

My goals for this course are to understand the photonics design workflow and learn about the tools. I will use tidy3d for EM simulations and Lumerical Interconnect for circuit simulations.

I decided to design several optical circuits components using strip waveguides with a width of 500 nm and a height of 220 nm for TE polarization at a wavelength around 1550 nm.

- MZIs with Y splitters with three different imbalance lengths [50,100,150]um to extract the group index of the waveguide.
- Optical THRU consisting of two grating couplers connected by a straight waveguide.

An MZI circuit in Interconnect is shown in figure 1 and its gain spectrum is shown in figure 2. The effective group index can be calculated from the FSR as discussed in section 3.2 and agrees very well with the simulation. The optical THRU is straight forward and not shown here.

2 Theory

3 Modelling and Simulation

3.1 Waveguide Compact Model

For the waveguide compact model the tidy3D mode solver was used for analyzing the first three modes. Figure 3 visualizes the fundamental TE mode of the waveguide. Using the mode solver, the effective index as a function of wavelength was extracted and is displayed in figure 4.

The effective index for the fundamental mode was then fitted with a second order polynomial to create a compact model for circuit simulation in Interconnect.

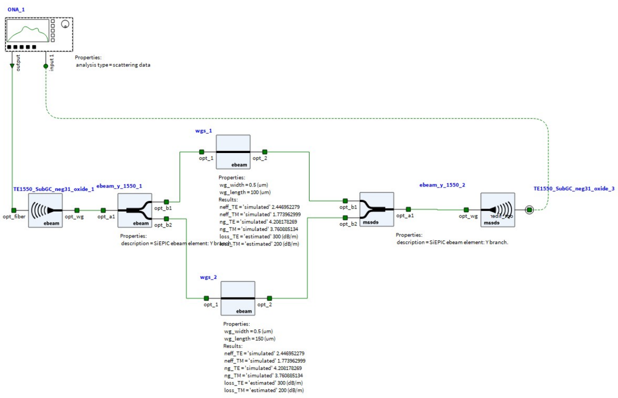

Fig. 1 MZI circuit in Lumerical Interconnect with ΔL=50um.

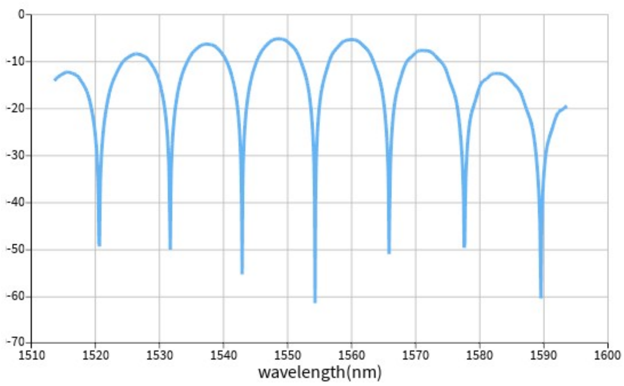

Fig. 2 MZI gain spectrum from Lumerical Interconnect for ΔL=50um.

Markus_RS
Affiliation not available

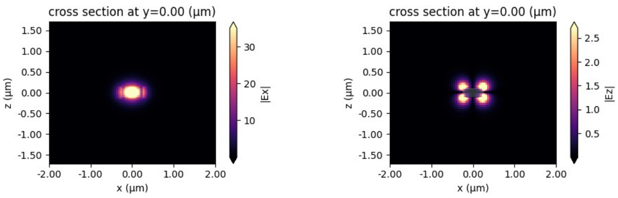

Fig. 3 Fundamental TE mode E field in the waveguide.

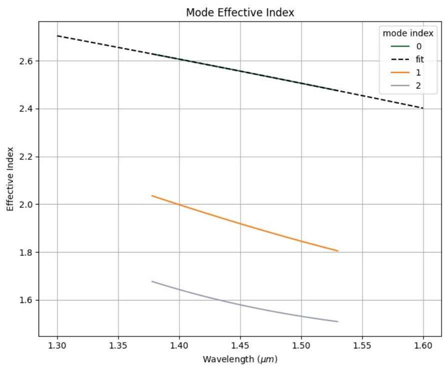

Fig. 4 Effective index vs. wavelength for the first three modes. The dashed lines represents the compact model.

The equation that was fitted is

$$n_{eff}(\lambda) = a_0 + a_1(\lambda - \lambda_0) + a_2(\lambda - \lambda_0)^2 \,, \tag{1}$$

where the following values have been obtained:

- $a_0 = 2.56$
- $a_1 = -1.01[1/m]$
- $a_2 = -0.16[1/m^2]$

This corresponds to the following compact model parameters for Interconnect:

- $n_{eff} = 2.56$
- $n_g = 4.017$
- $D = 1.587e - 15[s/m2]$

3.2 MZI Compact Model

The equation for the MZI transmission is given by:

$$\frac{I_{out}}{I_{in}} = \frac{1}{2}(1 + cos(\beta \varDelta L)) \tag{2}$$

where

$$\beta = \frac{2\pi n_{eff}}{\lambda} \tag{3}$$

The FSR of the structure is

$$FSR = \frac{\lambda^2}{n_g \varDelta L} \,. \tag{4}$$

The group index can be extracted from the FSR by rearranging the equation:

$$n_g = \frac{\lambda^2}{FSR \varDelta L} \,. \tag{5}$$

4 Fabrication

TBD

5 Conclusion

The conclusion goes here.

6 Acknowledgements

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References

1. Chrostowski L, Hochberg M (2015) Silicon Photonics Design. Cambridge University Press (CUP)

2. Bojko RJ, Li J, He L, et al. (2011) Electron beam lithography writing strategies for low loss high confinement silicon optical waveguides. Journal of Vacuum Science & Technology B: Microelectronics and Nanometer Structures 29:06F309. `https://doi.org/10.1116/1.3653266`

3. Chrostowski L, Hochberg M Testing and packaging. In: Silicon Photonics Design. Cambridge University Press (CUP), pp 381–405

4. Wang Y, Wang X, Flueckiger J, et al. (2014) Focusing sub-wavelength grating couplers with low back reflections for rapid prototyping of silicon photonic circuits. Opt Express 22:20652. `https://doi.org/10.1364/oe.22.020652`