ELEC 413 Project 1 Report

Alex Martin

Introduction

This project aims to design an interferometer featuring an optical multiplexer and demultiplexer. The multiplexer is intended to combine two lasers with a 25 GHz channel spacing into a single optical output, while the demultiplexer will separate two optical signals from a single waveguide into distinct waveguides. The system operates within a wavelength range of 1270 to 1330 nm. The interferometer circuit is designed using KLayout and simulated numerically using Lumerical MODE and Lumerical INTERCONNECT to assess its performance and functionality.

Modeling and Simulation

A silicon waveguide with SiO_2 cladding was simulated in Lumerical MODE using the following parameters: thickness of 220 nm and width of 350 nm. The waveguide was also simulated with a thickness of 220 nm and width of 335 nm to account for Applied Nanotools (ANT) process bias of -15 nm. The simulation results provided key metrics, including the effective index, group index, loss, and dispersion.

Table 1: Lumerical Mode Numerical Simulation Values for a 350nm Waveguide

Simulation Value	**350nm Waveguide**	**335nm Waveguide**
Effective Index	2.438621	2.382006
Group Index	4.4472	4.49101
Dispersion	1103.22 ps/nm/km	889.855 ps/nm/km
Loss	6.22025e-4 dB/cm	6.22497 e-4 dB/cm

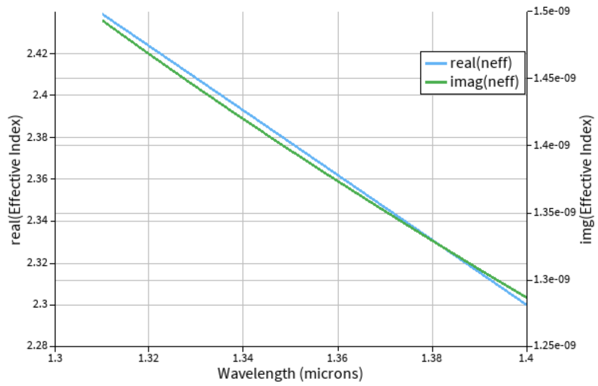

Figure 1a: 350nm Waveguide Lumerical MODE Effective Index

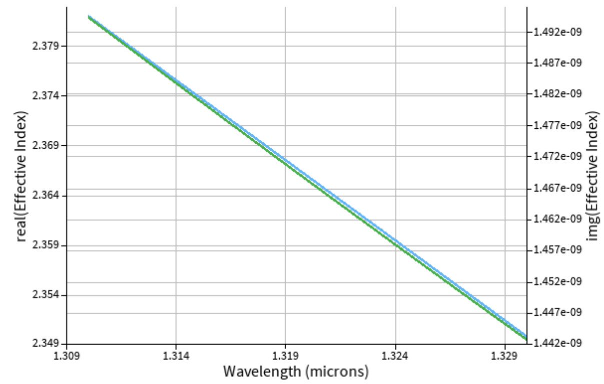

Figure 2a: 335nm Waveguide Lumerical MODE Effective Index

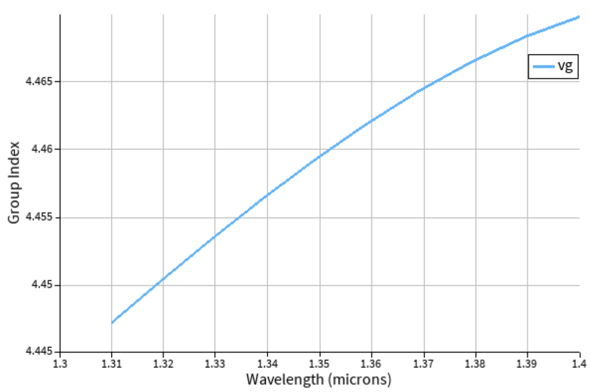

Figure 2a: 350nm Waveguide Lumerical MODE Group Index

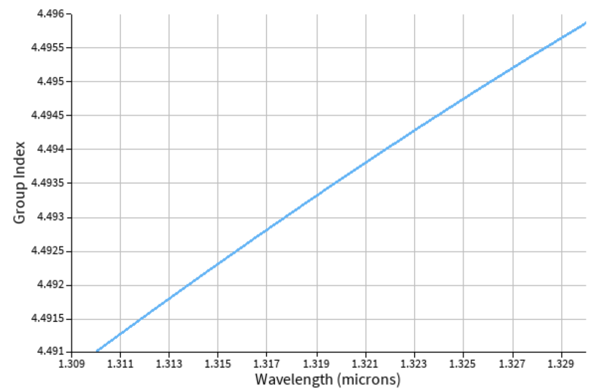

Figure 2b: 335nm Waveguide Lumerical MODE Group Index

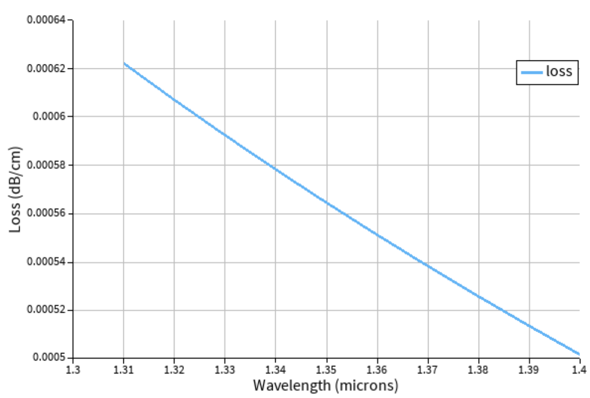

Figure 3a: 350nm Waveguide Lumerical MODE Loss Index

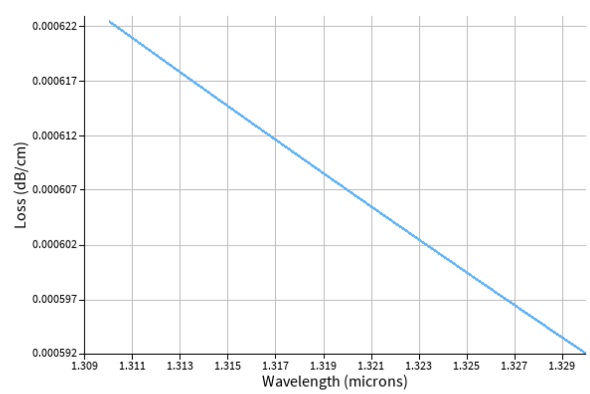

Figure 3b: 335nm Waveguide Lumerical MODE Loss Index

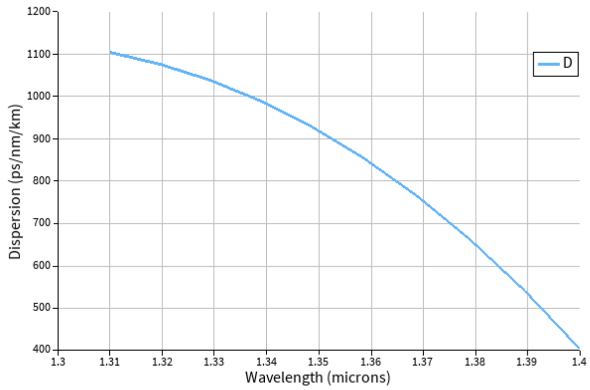

Figure 4a: 350nm Waveguide Lumerical MODE Dispersion Index

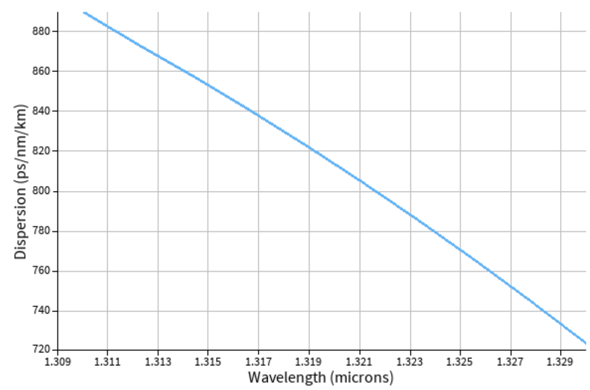

Figure 4b: 335nm Waveguide Lumerical MODE Dispersion Index

A wavelength sweep was conducted in Lumerical MODE, and curve fitting was applied to the effective index using the script prompt. The following equation and curve were determined:

$2.43862-1.5333\cdot(\lambda-1.31)-0.121782\cdot(\lambda-1.31)^2$

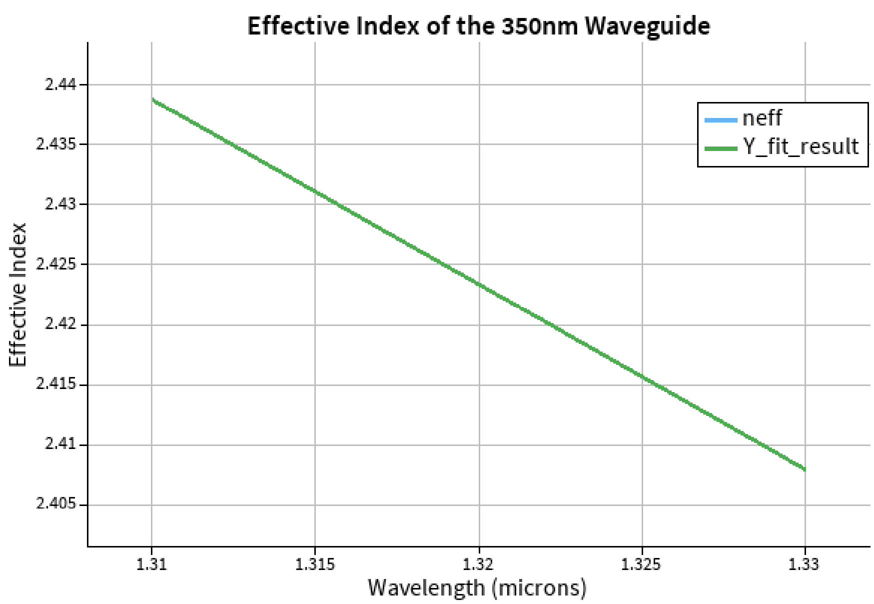

Figure 5: Lumerical MODE Effective Index Curve Fit

Layout

The circuit layout was created in KLayout using the SiEPIC compact model library components. The layout includes two different design concepts, the leftmost design will be referred to as design A and the rightmost design will be referred to as design B.

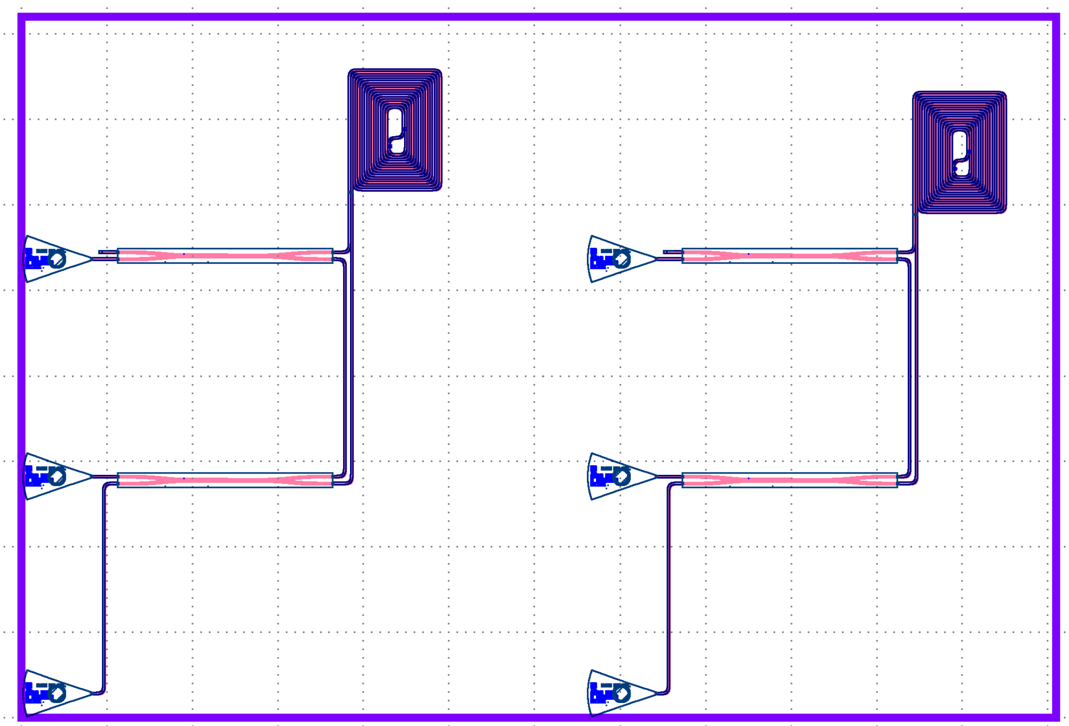

Figure 6: Circuit Layout - Left circuit: Design A, Right circuit: Design B

Using the following equation, ΔL was determined analytically to be ΔL = 2.69646 mm for the 350nm waveguide, and ΔL = 2.670156 mm for the 335nm waveguide.

$$FSR = \frac{c}{ng1,2 \cdot \Delta L}$$

Where FSR = 25 GHz, c = 299792458 m/s, ng1 = 4.4472, ng2 = 4.49101

These ΔL values were used to guide the layout of the circuits.

Design A consists of three 1310nm grating couplers, two 1310nm 50-50 ultra-broad band splitter, a 1310nm 8 loop spiral paperclip, and 1310nm waveguides. For design A ΔL =2.696471mm, this is 10.6834nm smaller than the ΔL determined analytically.

Design B takes into consideration the ANT process bias of -15nm. Design B uses the same components as Design A, however Design B ΔL=2.670151mm, this is 5.227nm smaller than the ΔL determined analytically.

Circuit Simulation

Circuit simulation was performed using Lumerical INTERCONNECT for design A. The mode 1 gain plot was examined to confirm 25GHz frequency spacing. $\Delta\lambda$ was determined analytically to be $\Delta\lambda$=143.1pm using the following formula:

$$\Delta\lambda = \frac{\lambda^2 \Delta f}{c}$$

Where λ = 1310nm, f = 25GHz, c = 299792458 m/s

From the mode 1 gain plot, points (1309.46,-10.0527) and (1309.59,-10.1084) were used to determine $\Delta\lambda$=130.0pm. This value differs from the value found analytically by 13.1pm.

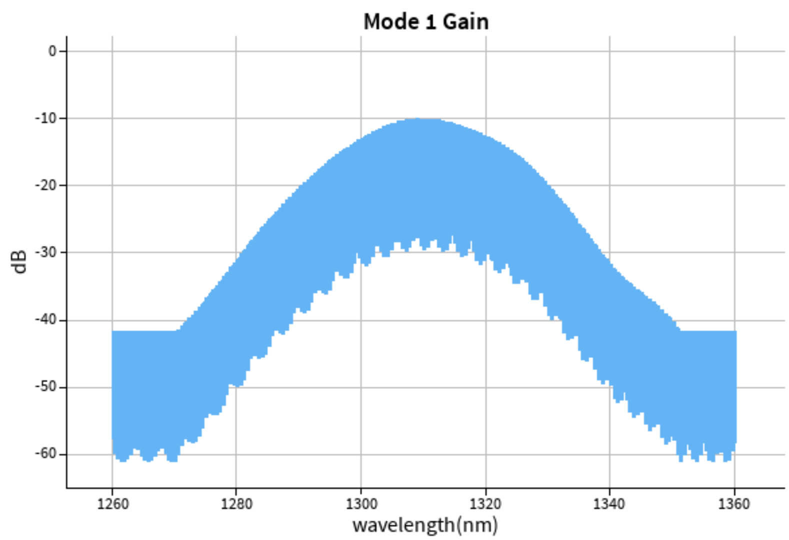

Figure 5: Lumerical INTERCONNECT Mode 1 Gain

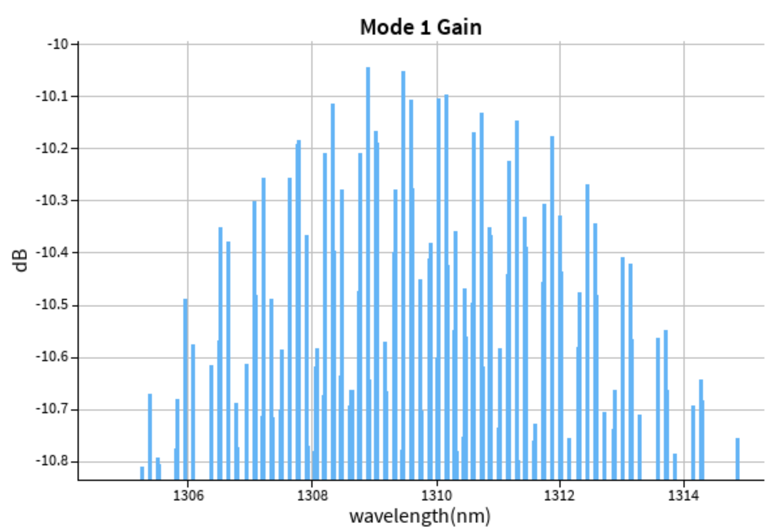

Figure 6: Lumerical INTERCONNECT Mode 1 Gain Closeup