ELEC 413 Project Report DRAFT

Will Grant

February 3, 2025

Abstract

TDB

Introduction

The Chip 1 Github Fork is:
https://github.com/wcgrant1/openEBL-2025-02.git
The design can be found at:
https://github.com/wcgrant1/openEBL-2025-02/blob/main
/submissions/ELEC413_wcgrant1_MZIv1.gds
The Chip 2 Fork is: https://github.com/wcgrant1/UBC-ELEC413-2025
Chip 2 design found at:
https://github.com/wcgrant1/UBC-ELEC413-2025/blob/main/submissions
/ELEC413_wcgrant1_MZIv2.gds

Part I: Modeling

(i): Lumerical Mode

This section pertains to the characterization/solution of the optical slab modes of a 220nm waveguide designed for operation at 1310nm. We consider a cannonical Si core (high index) and SiO2 cladding (low index) fabrication platform, and waveguides with rectangular geometry. Our waveguide parameters are motivated by 1310nm operating range, and we will select a 350nm width channel as is typical for this regime. The confinement of the mode in the core is determined by the indexes of refraction for light in the two mediums, and we aim for a TE waveguide which supports only the first TE mode, and possibly the first TM. We first use Lumerical Mode to generate the eigenmode solutions in the waveguide, and confirm that it only supports the first TE mode.

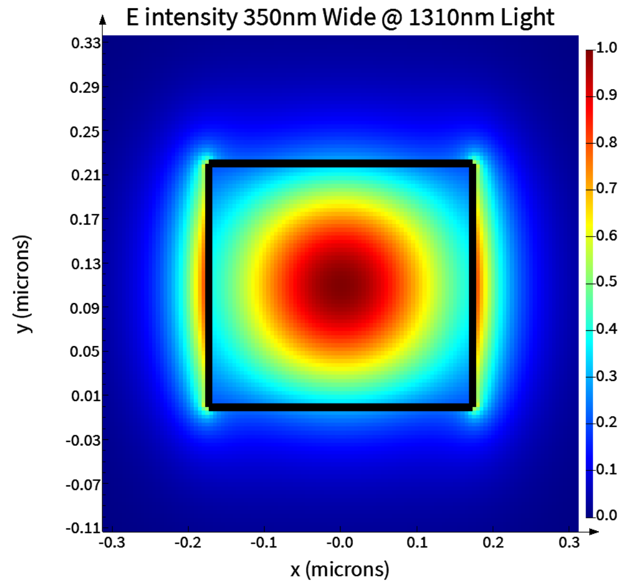

Figure 1.1: The first solved TE mode for a 220nm x 350nm waveguide.

This solution is achieved by applying finite-difference methods the problem geometry. The dimensions of the waveguide change the confinement of the modes, and in this case we can see that 350nm supports the first TE mode. The different confinement will cause the wave packet to "see" a different effective index, as more or less of the energy interacts with the low index cladding. This solution therefore governs a model of the dispersion.

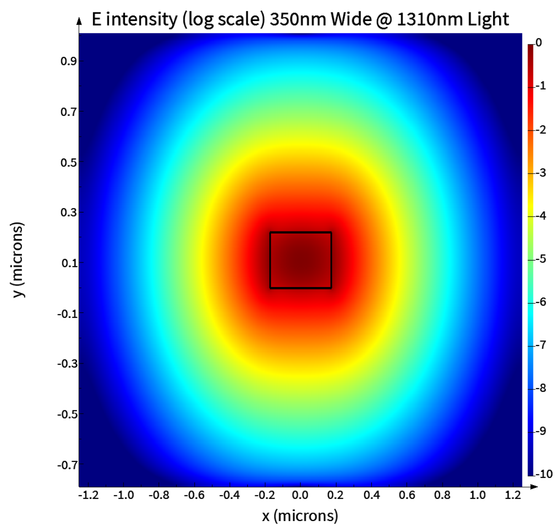

Figure 1.2: The first solved TE mode for a 220nm x 350nm waveguide in log scale. We can see that the fields are able to decay away before reaching the boundaries, which reduces the potential inaccuracies due to insufficient boundary conditions.

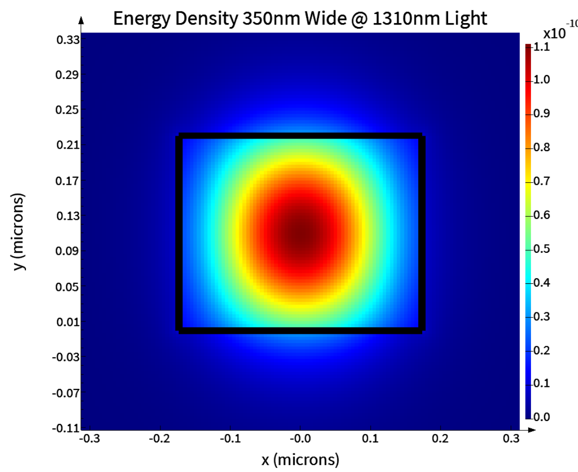

Figure 1.3: The first solved TE mode for a 220nm x 350nm waveguide. We can see that the solution has a low effective area, as the mode energy is well confined within the waveguide.

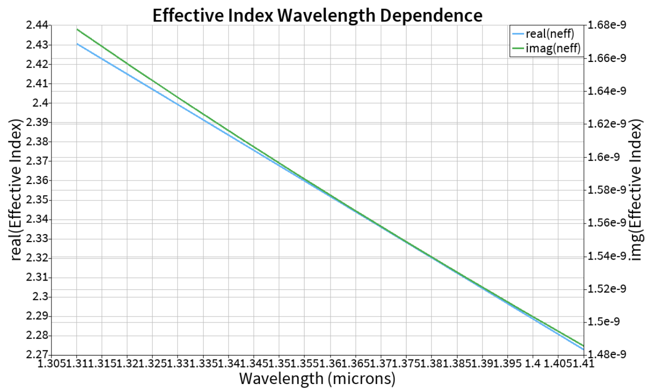

Figure 1.4: Effective index parameter sweep on first TE mode

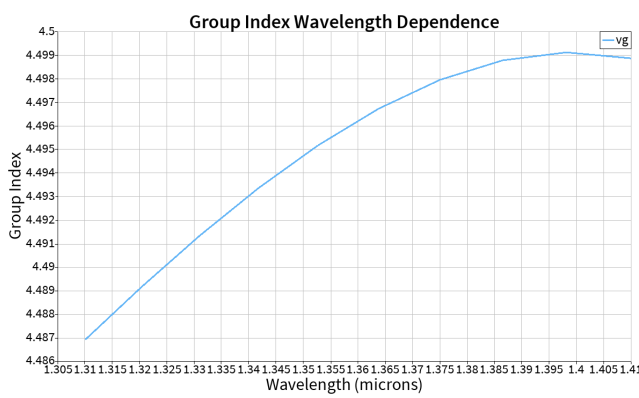

Figure 1.5: Group index parameter sweep on first TE mode

We can read off the curve that the group index for a 1310nm mode is 4.487, which determines the length ΔL for which the 25GHz FSR is achieved. In particular, the spacing is given by: $\Delta L = \frac{c}{(n_g)(FSR)}$ where c is the speed of light. This yields a ΔL of $2.673 \times 10^{-3} m = 2.673 mm$ which becomes our key design parameter, $\Delta L = L_2 - L_1$ will determine the spacing of the interferometer.

(ii): Theory Implementation on MATLAB

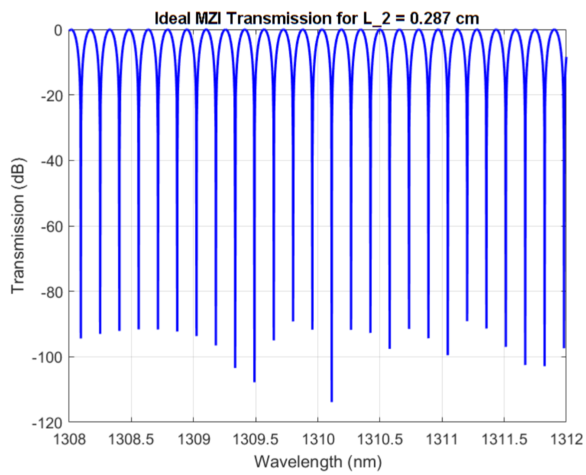

Figure 1.6: Using a polynomial expansion about 1310nm and fitting to the material dispersion curve, we can then compute the interference to get a first approximation for the FSR spectra. The dominant loss mechanism is sidewall scattering due to material imperfections, which has yet to included. The above pattern is generated under an idealization of plane waves with wavenumber k which carry a phase of form $e^{j\omega t}$

(iii): Interconnect Modeling

Here we simulate and verify our eigenmode solution:

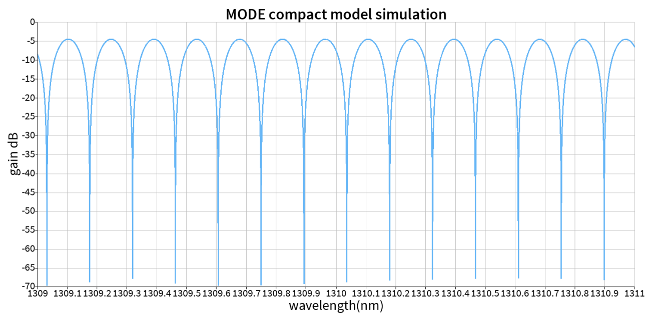

Figure 1.7: MODE model simulation

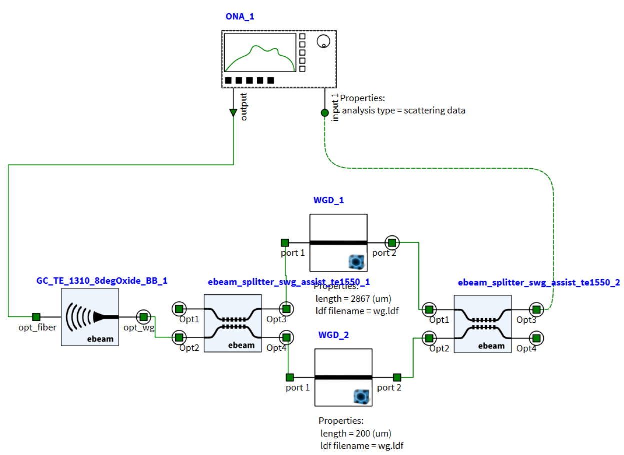

Figure 1.8: MODE Layout

Part II: Design and Verification

(i): KLayout Design

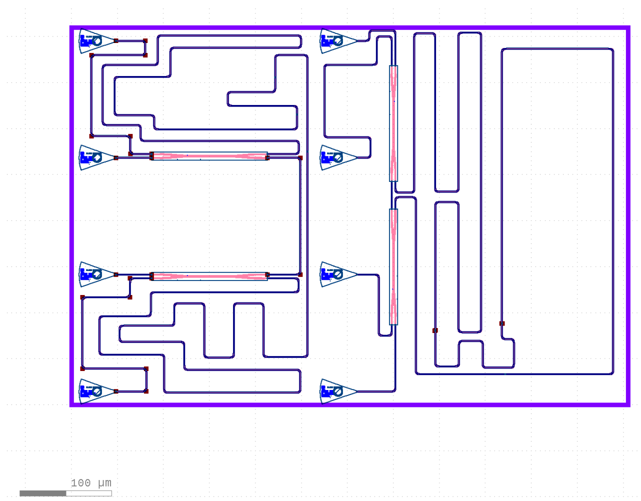

Figure 2.9: Above the fabrication layout is shown, which should correspond to the current Github rendition. There are two designs with different L_1 values, and relatively minor variances in $L_2 = \Delta L + L_1 \approx 1 - 10\mu m$ to have some tolerance to fabrication conditions and other loss factors such as temperature dependence, dispersion, and coupling to higher order modes. For these two designs $\Delta L = 2.665, 2.667mm$ (v1, v2 respectively for left and right).

(ii): Interconnect Verification

Importantly, we find the FSR to be $0.143nm$. Checking with the above relation, $\Delta\lambda = 0.143nm = \frac{\Delta v \lambda^2}{c} = \frac{(25GHz)(1310nm)^2}{2.998\times10^8 m/s}$ ✓

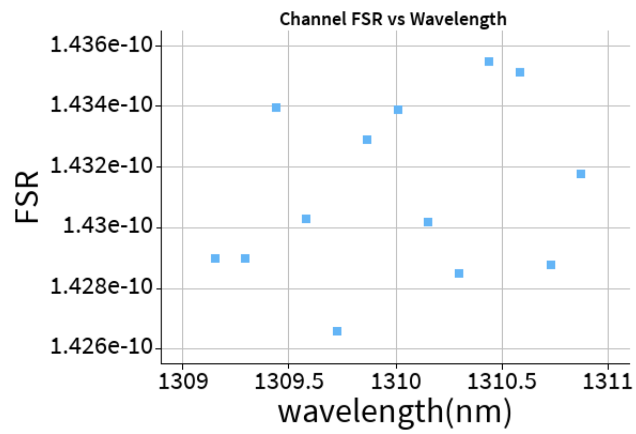

Figure 2.10: v1

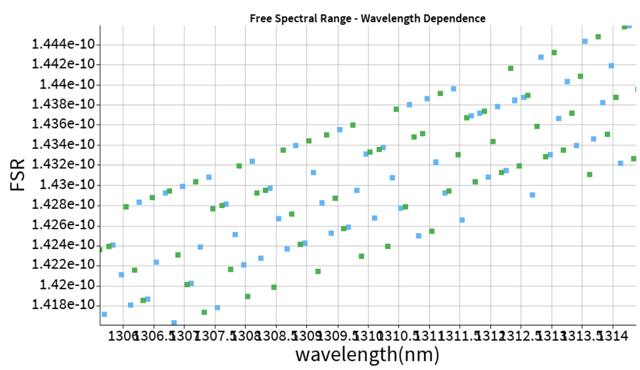

Figure 2.11: v2

Simulating our KLayout file directly in INTERCONNECT we can read out both channels, and see the expected interferometry which will facilitate mux/demux operations for signals in the 1310nm band with 25GHz spacing.

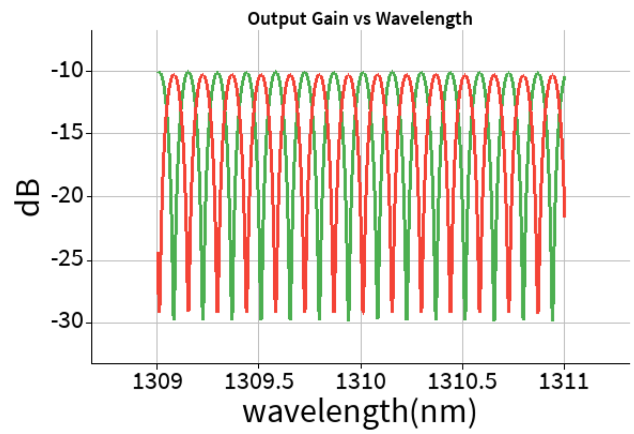

Figure 2.12: v1

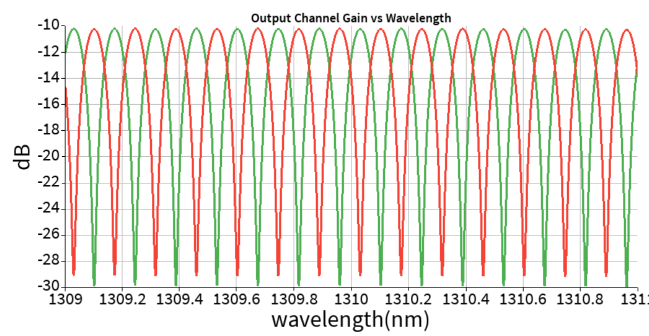

Figure 2.13: v2

Chip 2 Design and Adjustments

Performing the same eigenmode solution but with air cladding, we find a new group index of: $n_g = 4.896 \Rightarrow \Delta L = 2.449mm$

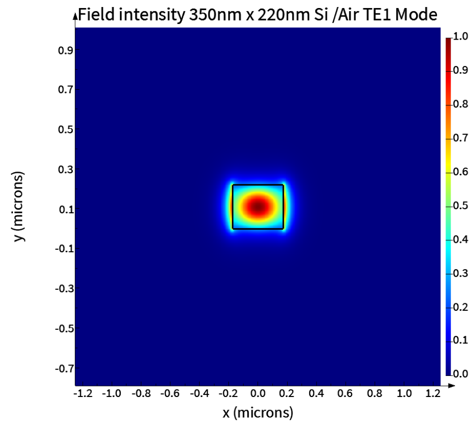

Figure 2.14: Eigenmode Solution Air Cladding

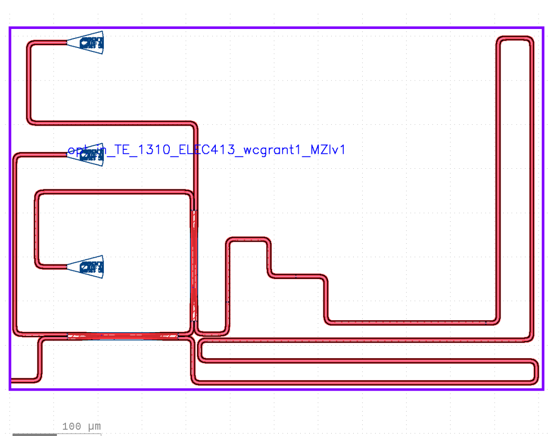

Figure 2.15: New KLayout

Conclusions

TBD

Citations

TBD

Appendix

TBD