The Design of a Bragg Resonator Cavity to Maximize Quality Factor

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Abstract—This report outlines a process taken to design an optical resonator through a Fabry-Perot cavity with symmetrical phase shifted Bragg gratings. The design object is to maximize quality factor around the O-band(1310[nm]) while having a free spectral range (FSR) of less than 0.2[nm].

I. Introduction

Through the use of various simulation tools and analytical methods, the objective of this report is to design, simulate, and fabricate an optical resonator through various means and processes. This design uses a Fabry-Perot cavity with two symmetric phase-shifted Bragg gratings to meet its design requirements. We will use Lumerical MODE to model an optical waveguide with a width of 335[nm] and a height of 220[nm] to obtain intermediate simulation parameters. A Finite-difference time-domain method will be used to model a unit cell of a Bragg grating. Both simulation results would be used to solve the transfer matrix model of our design, used to model the final resonator cavity of our design. These parameters are then used to construct layouts of our resonator, through manual layout in KLayout using SiEPIC-EBeam Process Design Kit (PDK) and through python scripting using the SiEPICfab-ZEP PDK. This specific report will vary the number of gratings as a design parameter and subject of study.

II. Theory

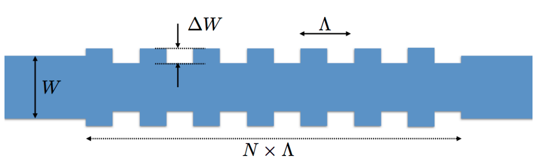

Fig. 1. Bragg Grating diagram from Ch. 4, Figure 4.42 of Silicon Photonics Design[1]

To describe a Bragg cavity, we need to set certain set of intermediate parameters and simulations. We first need find the effective index of a 335[nm] strip waveguide.

III. Waveguide Modelling and simulation

A. Lumerical MODE

We used Lumerical model to numerically solve for the effective index polynomial fit coefficients, which were:

$$2.37969 - 1.67511(\lambda_b - 1.310) - 0.111309(\lambda_b - 1.310)^2$$

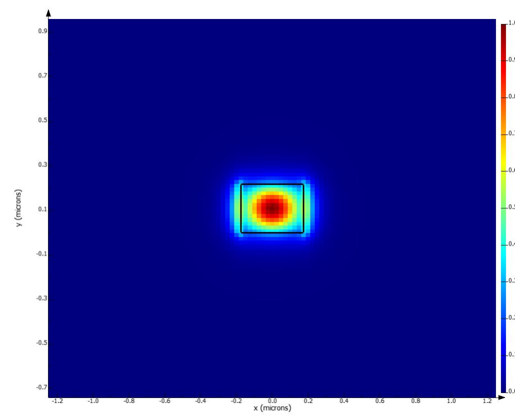

Fig. 2. First Quasi-TE mode of the waveguide (1310nm)

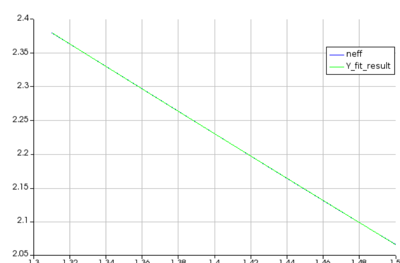

Fig. 3. Effective Index over wavelength (1310-1500 nm)

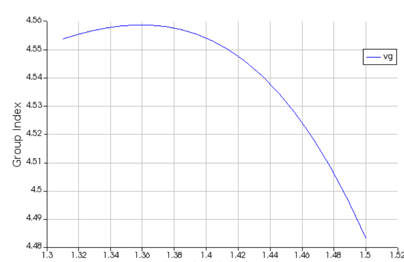

Fig. 4. Group Index over wavelength (1310-1500 nm)

B. Lumerical FDTD

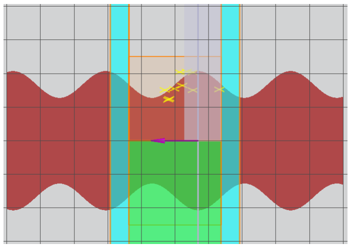

Fig. 5. View of unit-cell of Bragg grating

The simulation gave us the following intermediate design parameters:

1) $\kappa = 204230$

C. Transfer Matrix Method (Lumerical Interconnect)

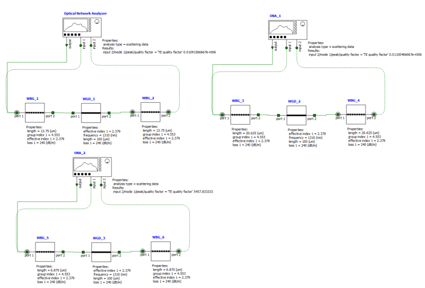

Fig. 6. View of unit-cell of Bragg grating

3 designs were made via varying different number of gratings per cavity. These were the transfer function graphs of reflection and transmission simulated via Lumerical interconnect.

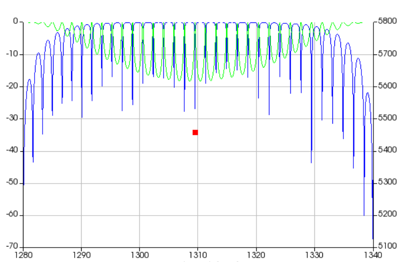

Fig. 7. Interconnect simulation of cavity at 25 gratings

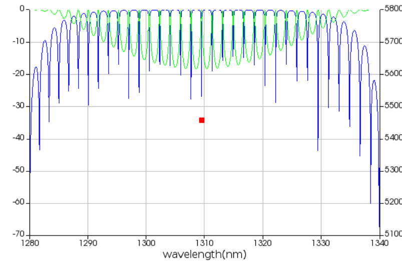

Fig. 8. Interconnect simulation of cavity at 50 gratings

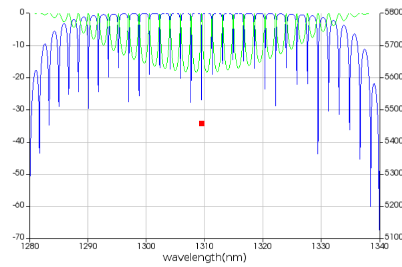

Fig. 9. Interconnect simulation of cavity at 75 gratings

D. Design constraints and parameters

Our bragg resonator cavity will have the following fixed design parameters:

Parameter	Value	units
wavelength	1310	nm
Δ W	0.08	um

IV. Fabrication

A. Layout

Project 1:

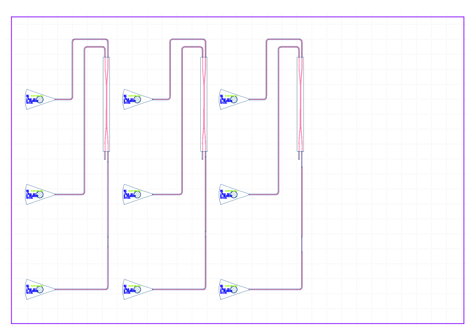

Fig. 10. Layout of project 1

Design paramters:

Parameter	Value	units
polarization	TE	
waveguide width	335	nm
waveguide height	220	nm
wavelength	1310	nm
Number of gratings	50 (increments of 25)	
Bragg Geometry	Sinusoidal	
Bragg period	275	nm
cavity length (L)	100	um
Δ W	0.08	um

Project 2:

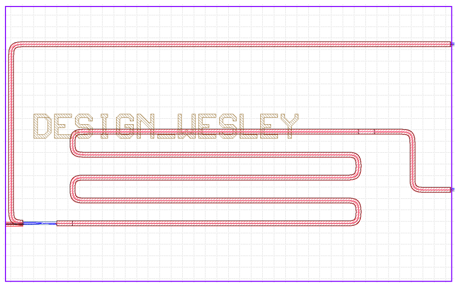

Fig. 11. Layout of project 2

Design paramters:

Number of gratings	50	
Bragg Geometry	Sinusoidal	
Bragg period	275	nm
corrugation width	275	nm
Δ W	0.08	um

V. Experiment data

- To be completed later

VI. Analysis

- To be completed later

VII. Conclusion

- To be completed later

VIII. References

[1] L. Chrostowski, M. E. Hochberg and Cambridge University Press, Silicon Photonics Design. 2015. DOI: 10.1017/CBO9781316084168.

IX. Appendix