CHAPTER 6: CONCLUSION

6.1 Introduction

In this project, some researches concern silica-on-silicon components for optical communication where forming on uniform symmetric directional coupler and planar Bragg grating were conducted. The aim of this project is to utilize the uniform symmetric directional coupler and planar Bragg grating as an essential building block for waveguide amplifiers. This project mainly concentrates on design, simulation of the uniform symmetric directional coupler and planar Bragg grating as a part of the multiplexer and de-multiplexer for application in waveguide amplifier. Experimental characterization of the proposed devices is beyond the scope of this work and would be reported elsewhere.

6.2 Conclusions

In chapter 3, the performance of 980/1550 nm pump/signal multiplexer in relation to the length of central coupling region and edge-to-edge spacing was analyzed using 3D FD-BPM. The optimum length for the central coupling region and edge-to-edge spacing are 6200 μm and 7.75 μm, respectively. These waveguide parameters were to allow for larger fabrication tolerance. The drawback of this design is the inability to produce 100% transmission for 980 nm pump wavelength which suffers less than 0.5 dB loss. This is thought to be caused by the design being optimized for 1550 nm. However, 0.5 dB loss is an acceptable value for pump signal wavelength. The 100%

transmission for pump wavelength is achievable if longer device dimensions are adopted.

The effect of length of central coupling region, *L* and edge-to-edge spacing, *d* to 800/1310nm pump/signal multiplexer was investigated and analyzed in the second part of chapter 3. The optimum length of the central coupling region, *L* and edge-to-edge spacing, *d* are found to be 3317.5 μm and 4.5 μm, respectively. Similar to the 980/1550nm multiplexer, the simulation showed the transmission of 800 nm suffers less than 0.5 dB loss. These MUXs will form essential building blocks for waveguide amplifier modules.

Chapter 4 concerns silica-on-silicon hybrid pump/signal multiplexer for application in broadband amplifiers. Similarly, the uniform symmetric directional coupler plays a significant role in forming the hybrid pump/signal multiplexer. The characteristic of three different wavelength combinations of pump/signal multiplexers or de-multiplexers: 980/1550 nm coupler, 800/1310 nm coupler and 1310/1550 nm coupler were investigated separately. From the work done, we found that the optimum length of the central coupling region, *L* and edge-to-edge spacing, *d* for 980/1550 nm coupler, first 1310/1550 nm coupler and 800/1310 nm coupler are 6200 μm and 7.8 μm, 5450 μm and 3.8 μm, and 3317.5 μm and 4.5 μm, respectively. For the second 1310/1550 nm coupler, the optimal length of coupling region is 5200 μm corresponding to the edge-to-edge spacing of 3.8 μm. Subsequently, four uniform symmetric directional couplers are joined together. Even though from the simulation results there is less than 1% residual power being transmitted to output 3, but it is observed that the insertion loss found for the transmission of 1310 nm and 1550 nm signal wavelengths are 0.24 dB and 0.87 dB, respectively. The loss can be compensated by applying lateral offset. The insertion loss has improved to 0.23 dB and 0.33 dB for the transmission of

1310 nm and 1550 nm signal wavelengths, respectively. It is found that the fabrication tolerance is high for this design. However, this design has not been fabricated, so the conclusions still remain to be confirmed experimentally.

Chapter 5 describes an optical chip which is composed of uniform symmetric directional coupler and planar Bragg grating as elements of multiplexer for application in waveguide broadband amplifier. For the case of planar Bragg grating, there is >99.9% reflectivity for the wavelength range from 1.26-1.62 μm. The grating length for each wavelength having >99.9% reflectivity is between 355 nm and 474 nm. Two cascaded Bragg gratings were constructed which having broadband spectral from 1.260-1.462 μm and 1.4621-1.6200 μm, respectively. The spectral FWHM of the first cascaded Bragg grating is 208nm whereas the second cascade Bragg grating is164nm. Meanwhile, for the case of the uniform symmetric directional coupler, the optimal edge-to-edge spacing, *d* and length of central coupling region, *L* of (i) 800/1350 nm and (ii) 980/1550 nm are 3 μm and (i) 3280 μm; (ii) 1850 μm, respectively. It is found that the proposed uniform symmetric directional coupler is a wavelength sensitive device. Thus, the wavelengths transmitted from the cascaded Bragg grating suffered losses during the transmission from input to output of the directional coupler.

6.3 Future Works

In the following section, some possible recommendations for future works are presented. It is necessary to make a comparison of numerical and experimental results for each design. It is because of numerical analysis cannot stand alone and must be accompanied by experiments. Other multiplexer architectures such as multimode interference coupler and Mach-Zender interferometer can be investigated in order to overcome the less than

100% coupling for pump wavelength. For the existing design (uniform symmetric directional coupler), the solution is extent the dimension of multiplexer. However, this is against the purpose of this work. It is found that the fabrication tolerance is high in terms of refractive index for the hybrid pump/signal multiplexer design in Chapter 4. Nevertheless, this has to be confirmed experimentally. Wavelength flattened output multiplexer designs should be developed for the optical chip in Chapter 5 in order to overcome losses during transmission in the coupler. Architectures like point symmetric Mach-Zender interferometer would probably be able to achieve wavelength flattened outputs. Besides, to get higher accuracy, 3D modeling should be carried out for the design in chapter 5 including planar bragg grating and uniform symmetric directional coupler.

LIST OF PUBLICATIONS

Conferences

[1] A.W.P. Law, W.Y. Chong, F.R.M. Adikan, H. Ahmad, “Modeling of 980/1550nm PLC WDM directional coupler,” Proceedings of IEEE 2008 6th National Conference on Telecommunication Technologies and IEEE 2008 2nd Malaysia Conference on Photonics, 26-27 August 2008, Putrajaya, Malaysia, 6-11 (2008).

[2] A.W.P. Law, W.Y. Chong, F.R.M. Adikan, H. Ahmad, “Design and Modeling of Silica-On-Silicon Planar Wavelength Selective Coupler for Application in Broadband Amplifier,” 4th Mathematics and Physical Science Graduate Congress, 17-19 December 2008, Faculty of Science, National University of Singapore.