BEHAVIORAL AND FUNCTIONAL ANALYSIS OF SOI WAVELENGTH SELECTIVE ELEMENT FOR WDM APPLICATIONS

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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This report is submitted in partial fulfilment of the requirements for the degree of Bachelor of Electronic Engineering with Honours

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I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Bachelor of Electronic Engineering with Honours.

Signature	:	……
Supervisor Name	:	Dr. Hazura binti Haroon
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DEDICATION

Every grind and asserted tasks requires aspiration as well as supervision and advices from the superior especially those who are near-at-hand. My unpretentious accomplishment I dedicate to my affectionate father and mother, who's love, reassurance and prays of day and night make me able to get such achievement and recognition, along with long haul and appreciated lecturers.

ABSTRACT

Wavelength Division Multiplexing (WDM) is a technology in the fibre-optic communication field that uses different wavelengths of laser light to multiplex a number of optical carrier signals onto a single optical fibre. By dividing the wavelength accordingly, it can be applied to analyse its behavioural and functional characteristics. For this project, it is specifically focused on the silicon-on-insulator (SOI) type as the silicon material properties enable a wide range of electronic and photonic integrated circuits. Basically, this project is going to be using a commercially available software called CST Studio Suite to design a single-mode silicon-on-insulator wavelength selective element and thus observing the effect of varying the structural parameters towards the power at the drop port and through port which are the output ports.

ABSTRAK

Multiplexing Division of Wavelength (WDM) adalah teknologi dalam bidang komunikasi optik gentian yang menggunakan panjang gelombang cahaya laser yang berlainan untuk membilang beberapa isyarat pembawa optik ke serat optik tunggal. Dengan membahagikan panjang gelombang dengan sewajarnya, ia boleh digunakan untuk menganalisis ciri-ciri tingkah laku dan fungsinya. Untuk projek ini, ia khusus memberi tumpuan kepada jenis 'silicon-on-insulator' (SOI) kerana ciri-ciri bahan silikon membolehkan pelbagai litar bersepadu elektronik dan fotonik. Pada asasnya, projek ini akan menggunakan perisian yang boleh didapati secara komersial yang dikenali sebagai CST Studio Suite untuk mereka bentuk elemen terpilih panjang gelombang silicon-di atas-penebat dan dengan itu memerhatikan kesannya dengan mengubah parameter struktural ke arah kuasa di pelabuhan 'drop' dan melalui pelabuhan yang merupakan pelabuhan hasil keluar.

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I am also thankful to everyone who supported me, for that I have completed this project effectively and moreover on time. They gave me many helpful comments which helped me a lot in preparing this project.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF SYMBOLS AND ABBREVIATIONS

A	:	Associating length
APF	:	All Pass Filter
BOX	:	Buried Oxide
CROW	:	Coupled Resonator Optical Waveguide
d	:	Diameter
ebl	:	Electron Beam Litography
FYP	:	Final Year Project
g	:	Gap between microring and waveguide
h	:	Microring and waveguide height
HIC	:	Hogh Index Contrast
LNA	:	Local Network Area
MEMS	:	Micro Electro Mechanical
MRR	:	Microring Resonator
NOR	:	Not OR gate
OADM	:	Optical Add Drop Multiplexer
P_{Drop}	:	Drop port power
$P_{Through}$	:	Through port power
r	:	Radius of microring

SCISSORs	:	Side Coupled Integrated Spaced Sequence of Resonators
Si	:	Silicon
SOI	:	Silicon On Insulator
UTeM	:	Universiti Teknikal Malaysia Melaka
w	:	Microring and waveguide width
WDM	:	Wavelength Division Multiplexing

CHAPTER 1

INTRODUCTION

1.1 Thesis Background

This project is specifically focused on the silicon-on-insulator (SOI) type as the silicon material properties enable a wide range of electronic and photonic integrated circuits. Basically, this project is dome by using CST software to design the wavelength selective element in order to being applied in the WDM applications as an optical switch.

1.2 Thesis Objectives

The major target of this project is to find out the behavioral and functional of the SOI wavelength selective element for WDM application. In concise, the objectives of this project are listed below in 1.3.1, 1.3.2, and 1.3.3 respectively.

1.2.1 To model a single mode silicon-on-insulator (SOI) wavelength selective element using CST software

This will first be made based on the previous study and then be varied according to the range of each structural parameters of the SOI wavelength selective elements.

1.2.2 To study the effect of parameter geometry variations on the behavioral and functional of the SOI wavelength selective element performance

The parameters used in this design are the radius of the microring (r), the gap size between microring and waveguide (g), the microring and waveguide width (w) and the microring and waveguide thickness (h).

1.2.3 To prove the optimal model based on previous study for the SOI wavelength selective element for WDM applications

This will be conducted by comparing the power/average power at the output ports which are the drop port and the through port with the output power produced by the optimal structure of the SOI wavelength selective element from previous study.

1.3 Thesis Scope

The scope of this project is based on the wavelength selective element which applied on the wavelength division multiplexing (WDM) applications. The focus of this study will be only towards the single-mode configuration which silicon-on-insulator (SOI) will be employed as the platform for the device construction. The project direction is to analyze the effect of parameter variations towards the optimal optical filter design based on the wavelength for the single-mode wavelength selective element.

1.4 Problem Statement

Data communication is very important in this new era especially for the purpose of downloading files, online gaming, live streaming and not forgetting the purpose of connecting with people through social networks. Per say the connection or transmission is slow, everything that is in line is going to be having a problem; so for that, fiber optic technology is the answer in which the wavelength selective element is the new technology to replace the current regular optical fiber in microchip packet size. As for that, the study on the effect of parameter geometry variations on the wavelength filter needs to be conducted in order to find the optimum design of the SOI wavelength selective element for the Wavelength Division Multiplexing (WDM) applications. Since each microring is characterized and highly dependent on the design of the parameter, it needs to be carefully studied in order to detect its effect towards the SOI wavelength selective element's output power based on the single-mode wavelength range.

1.5 Thesis Significance

This study has its perks and commercialization potentials in either the electronic world or the photonic world. As towards the electronic world, it can be used for optical delay lines and optical logic gates. Optical delay lines can be possible candidates for realization of more complicated nano-waveguide based structures which can backup slow light operation while optical logic gates are the most important based-structure for photonic logic gates as NOR logic gate and ultra-fast all-optical AND logic gate. Last but not least towards the photonic world, this study can be applied in the bio sensor field as for chemical analysis environmental monitoring, drug discovery and disease diagnostics can be done.

1.6 Thesis Layout

The thesis of this project is divided into a few chapters. It consist of 5 chapters which were Introduction, Background Study, Methodology, Results and Discussion and lastly Conclusion.

First and foremost, chapter one is the introduction of this project. This chapter will briefly explain about the overview of this project. It will also be covering the objectives, scopes, problem statement and significance of this project.

Next chapter will be the background study of this project which means it mainly contain the project's literature reviews or researches based on this particular project's title. Most of the resources used during the accomplishment of thesis and project were from the internet, journals and books. While the facts, figures and information found are used as references, they were also being used to find the best approach to succeed in this project.

Chapter three will be explaining about how this project is conducted. The steps taken during the process of experiment will be discuss thoroughly in this chapter. Reader will get more understandings on the flow of this project from here.

The results and discussion will then be recorded in chapter four. This chapter will cover all the simulations by the software used. Discussion of the results from the simulations will be made by comparing them with all the studies and analysis that has been made in the past. Based on the outcomes, a few assembles of graphs, figures and tables will be commenced and discussed briefly.

Last but not least, chapter five will be the conclusion of this project. The agenda of this project which include the project findings, accomplishment and conclusion will be recorded in this chapter. Basically it will summarize meticulously about what this project is all about.

By amassing all the five chapters discussed above, a legit and decent thesis of the degree's Final Year Project (FYP) will be produced. This thesis is wholly made based on UTeM's fixed full final year project report guidelines.

CHAPTER 2

BACKGROUND STUDY

2.1 Introduction

This chapter mainly contain all the researches and reviews on the WDM applications and advantages, SOI fabrication technology, applications and other related theories. Plus, further information on CST Studio Suite which the software used during this project completion were also written in this chapter.