UNIVERSITI PUTRA MALAYSIA

ANALYSIS AND FABRICATION OF FUSED FIBER OPTIC COUPLERS FOR COMMUNICATION SYSTEMS

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By

AHMAD ZAKI BIN HAJI SHAARI

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirement for the Degree of Master of Science

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UPM

DEDICATION

In the name of Allah, Most Gracious and Most Merciful

For the sake of seeking knowledge

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

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Chairman: **Associate Professor Mohd Adzir Mahdi, PhD**

Faculty: **Engineering**

Optical couplers such as fused optical fiber coupler are widely used in the network communication systems as either splitters or combiners. There are not much of theories available to describe the core and cladding interaction model inside fused coupler's region. In this study, suitable Models for analysis of core to cladding guidance interaction using BPM_CAD simulation are created. While core guidance occurs in between core ratios 1 to 0.65, cladding guidance does support propagation at certain core ratio lower than 0.65 with slightly different results between various Models. The Models are also able to generate low excess losses in both the simulated core guidance and cladding guidance.

Excess loss in real fused couplers depends on their elongations, which can be controlled through certain set-up parameters such as torch head positions and motor speed. The effects of changing hydrogen flowrate and

torch head positions do not have direct relationship with the insertion loss of WDM coupler, hence scientifically, the conclusion of fusion temperature effect on coupling cannot be made. Some design parameters are found out to confirm quite well with the parameters found from fabrication. This has been demonstrated through theoretical pulling signatures for various fused couplers.

Besides examining 1 x 2 fused couplers, the study on triangular shape arrangement of 1 x 3 monolithic star couplers do indicate that equal couplings in all output ports are possible if correct Intertwined Method of twisting fibers is used. The same technology used in fabricating fused coupler, is used to fabricate lattice filter, which has channel spacing 2.84 nm or 178 GHz. Generally, all the studies are carried out at most levels including theory, simulation and experiment. These findings or data are analyzed to show the relationship between them and they are also discussed in details in this thesis.

PERPUSTAKAAN SULTAN ABDUL SAMAD
UNIVERSITI PUTRA MALAYSIA

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

ANALISA DAN FABRIKASI PENGGANDING GENTIAN OPTIK TERLAKUR UNTUK SISTEM KOMUNIKASI

Oleh

AHMAD ZAKI BIN HAJI SHAARI

April 2006

Pengerusi: **Profesor Madya Mohd Adzir Mahdi, PhD**

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Pengganding optik, seperti pengganding gentian optik terlakur, telah digunakan secara meluas didalam sistem komunikasi rangkaian sebagai pembahagi atau penggabung. Tidak terdapat banyak kajian teori dilakukan mengenai model interaksi pergerakan terurus teras ke *cladding* didalam pengganding terlakur. Dalam kajian ini, model-model tertentu telah dicipta untuk analisa interaksi pergerakan terurus teras ke *cladding* dengan mengunakan perisian simulasi BPM_CAD. Didapati, pergerakan terurus *cladding* memang berlaku pada model tertentu jika nisbah diameter teras kurang dari 0.65 manakala pergerakan terurus teras berlaku pada nisbah diameter teras diantara 1 dan 0.65. Walaupun begitu, terdapat sedikit ketidaksamaan diantara model-model tersebut. Model-model juga berjaya menghasilkan lesapan lebihan yang kecil bagi kedua-dua simulasi pergerakan terurus teras dan *cladding.*

Lesapan lebihan didalam pengganding terlakur bergantung kepada panjang pengganding tersebut tetapi didapati kawalan keatas lesapan itu bergantung kepada parameter-parameter seting tertentu seperti posisi Kepala Penunu dan kelajuan motor. Kadar perubahan aliran hidrogen dan posisi Kepala Penunu tidak menunjukkan perhubungan langsung dengan lesapan sisip bagi pengganding terlakur *WDM.* Secara saintifiknya, kesimpulan bahawa suhu pelakuran mempengaruhi pengandingan tidak dapat dibuat. Parameter-parameter reka bentuk tertentu didapati ada perhubungan yang baik dengan parameter-parameter yang didapati dari fabrikasi. Ini telah ditunjukkan didalam graf teori *pulling signatures* bagi perbagai pengganding terlakur.

Selain kajian keatas pengganding terlakur 1 x 2, kajian juga dilakukan keatas pengganding terlakur 1 x 3 berbentuk susunan tigasegi yang boleh mengeluarkan kuasa penggandingan sama diantara ketiga-tiga arah keluaran *ports* jika Cara *Intertwined* yang betul diguna pakai bila melilitkan gentian-gentian optik berkenaan. Kajian keatas *Lattice Filter* juga dibuat dengan menggunakan teknologi yang sama untuk pembuatan pengganding terlakur tersebut. Didapati *Lattice Filter* berkenaan mempunyai ruangan saluran sebanyak 2.84 *nm.* Secara amnya, semua kajian yang dijalankan melibatkan teori, simulasi dan uji kaji. Kesemua penemuan atau data dianalisa untuk mencari perhubungan diantara kesemua parameter-parameter berkenaan dan dibincang secara menyeluruh didalam tesis ini.

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TABLE OF CONTENTS

		Page
DEDICATION		ii
ABSTRACT		iii
ABSTRAK		v
ACKNOWLEDGEMENTS		vii
APPROVAL		vii
DECLARATION		x
LIST OF TABLES		xiv
LIST OF FIGURES		xvi
LIST OF ABBREVIATIONS		xxii
LIST OF NOTATION		xxiv
CHAPTER		
1.	INTRODUCTION	1
	1.1 Brief History of Optical Couplers	1
	1.2 Optical Coupler Technology	2
	1.3 Fused Optical Fiber Coupler and Their Classifications	5
	1.3.1 Coupler and Splitter	5
	1.3.2 Wavelength Selective Coupler (WS)	6
	1.3.3 Monolithic Star or Tree Coupler	7
	1.3.4 Fused Circular-Tapered Coupler (FCT)	9
	1.4 Applications of Couplers	9
	1.4.1 WDM Technology	10
	1.4.2 Interleaver and De-interleaver	11
	1.4.3 Fiber to the Home	13
	1.5 Problem Statement	14
	1.6 Objectives	16
	1.7 Scope of Work	16
	1.8 Methodology	18
	1.9 Thesis Overview	23
2.	BASIC THEORY AND LITERATURE REVIEW	25
	2.1 Basic Concepts of Coupling	25
	2.1.1 Coupling Mode Theory (CMT)	25
	2.1.2 Beam Propagation Methods (BPM)	29
	2.2 Theoretical Design of Fused Coupler	33
	2.2.1 Propagation inside Tapered Region	34
	2.2.2 Taper Waist	36
	2.2.3 Improvement on Coupling Mode Theory	36
	2.2.4 LP Modes and Mode Transformation	41
	2.2.5 Adiabaticity	44
	2.2.6 Delineating Curves	45
	2.3 Concept of Lattice Filter	46

	2.4 Review	50
	2.4.1 Monolithic Star Coupler	53
3.	DESIGN AND FABRICATION	56
	3.1 Designing Couplers using BPM_CAD Simulation	56
	3.1.1 Designing Models	56
	3.1.2 Losses in Simulation	64
	3.2 Description of Equipment	66
	3.2.1 Coupler Workstation	66
	3.2.2 Coupler Workstation's Software	68
	3.2.3 Polarization Scrambler	69
	3.3 Fabrication Methods and Basic Parameters	71
	3.3.1 Basic Fabrication	71
	3.3.2 Fabrication Star Coupler	75
	3.3.3 Input and Output Parameters	78
4.	RESULTS AND DISCUSSION	89
	4.1 BPM_CAD Simulation Results	89
	4.1.1 Fiber Model	89
	4.1.2 Coupler Models	92
	4.1.3 A Review on Simulations	98
	4.2 Studies on 1 x 2 Fused Coupler	99
	4.2.1 Setting Torch Head Positions	100
	4.2.2 Excess Loss due to Different Torch Sizes	102
	4.2.3 Setting Motor Speed	103
	4.2.4 Coupling Ratio and Crosstalk	104
	4.2.5 Controlling and Minimizing Excess Losses	106
	4.2.6 Insertion Loss Investigation due to Different Hydrogen Flowrate	107
	4.2.7 Polarization Dependent Loss (PDL) at Small Difference in Hydrogen Flowrate	108
	4.2.8 Analysis on Design Parameters	109
	4.2.9 Pulling Signature for Standard Coupler	114
	4.2.10 Pulling Signature for WDM Coupler	116
	4.2.11 Pre-pull of Wideband Coupler	120
	4.3 Studies on Lattice Filter	123
	4.4 Studies on 1 x 3 Star Coupler	127
	4.4.1 Studies on Triangular Shape Arrangement	127
	4.4.2 Coupling between Launched and Non-launched Fibers	130
	4.4.3 Coupling between Non-launched Fibers	134
5.	CONCLUSIONS AND FURTHER WORK	135
	5.1 Conclusion	135
	5.2 Further Work	136

REFERENCES 139
APPENDICES 143
BIODATA OF THE AUTHOR 158

LIST OF TABLES

Table		Page
2.1	LP modes constituents	42
3.1	Ratio of cores for various models	62
3.2	Main specifications for Coupler Workstation	69
3.3	Set-up Parameters	79
3.4	Parameters shown by the FiberPro Software	79
4.1	Common set-up parameters for various types of couplers	99
4.2	Comparison between design and desired coupling ratios at various coupling length for 1550 nm wavelength	115
4.3	Comparison in between design and actual 1310/1550 WDM coupler	120
4.4	Design and performance parameters for 1 x 3 star coupler	133
B1	Definitions of parameters	144
B2.1	Input and output data for standard coupler	145
B2.2	Input and output data for standard coupler	146
B2.3	Input and output data for standard coupler	147
B3.1	Input and output data for 1310/1550 WDM coupler	148
B3.2	Input and output data for 1310/1550 WDM coupler	149
D1.1	Data for theoretical design (Z = 0 mm to 1.24 mm)	152
D1.2	Data for theoretical design (Z = 1.28 mm to 2.52 mm)	153
D1.3	Data for theoretical design (Z = 2.56 mm to 3.80 mm)	154

D1.4 Data for theoretical design (Z = 3.84 mm to 5.08 mm) 155

D1.5 Data for theoretical design (Z = 5.12 mm to 6.00 mm) 156

D2.1 Data for theoretical design (Z = 5.12 mm to 6.00 mm) of wavelength 1310 nm 157

LIST OF FIGURES

Figure		Page
1.1	Cross-section's view of FBT coupler [1] taken at an angle (photograph courtesy D.Mortimore, British Telecom Research Laboratories)	3
1.2	Cross-section of FCT coupler before tapering process [2]	3
1.3	A 3 dB standard coupler	5
1.4	A coupler with complete packaging (A); a coupler covered by heat shrinking tube (B); a coupler with exposed internal view (C)	6
1.5	980/1550 WDM coupler	7
1.6	(i) 1 x 16 tree coupler using 1 x 2 coupler; (ii) 1 x 16 tree coupler using 1 x 4 monolithic coupler	8
1.7	DWDM system [5]	11
1.8	A schematic of demultiplexer using de-interleaver [6]	12
1.9	One-stage lattice filter [8]	12
1.10	PON, simplified from [11]	14
1.11	Scope of Work	17
1.11a	Research Methodology	19
1.11b	Fabrication method of fused couplers	20
1.11c	Production step of fused couplers	22
2.1	The refractive index distribution of the coupled slab waveguides	26

2.2	Power coupled from two waveguides 1 and 2	28
2.3	A symmetrical taper region of an optical waveguide	30
2.4	A double cored slab waveguide structure with large core separation (6.5 μm) and highly confined fields. Wavelength is 1.55 μm	31
2.5	The same structure as in Figure 2.4 but with the separation of the guides reduced to 0.3 μm	32
2.6	The lowest order TE supermode for a dual core structure having the core refractive index difference = 0.04	33
2.7	Side view of FBT couplers (top view) showing neck region (V<1) and tapered region (V>1) and cross-section (bottom view) of neck region [31]	34
2.8	Power inside fused coupler showing cycles in which first peak for 1550 nm occurred when pull length = 16.1 mm or $KZ = \frac{\pi}{2}$	38
2.9	Normal fused coupler has (10) bandwidth shape while wideband coupler has more (11)(12) flattened shape [49]	41
2.10	Delineating curves of fibers for 800 nm and 1310 nm wavelengths [13]	46
2.11	Two-stage lattice filter	47
2.12	Single-stage and two-stage lattice filters showing free spectral range (FSR) of approximately 400 GHz	50
2.13	Structure of Passive Devices	51

2.14	Arrangements for star coupler; (i) linear array 3 x 3, (ii) equilateral 3 x 3, (iii) 4 x 4	53
2.15	Schematic diagram [34] of twisted 3 x 3 coupler, indicating direction of positive twist $+\theta$	54
2.16	Equal splitter's spectral response at wavelength 1300 nm [34] for linear array arrangement	54
3.1	Model structure for simulation	57
3.2	Schematic fused coupler representing various Regions	59
3.3	Flowchart showing chosen steps for design and simulation 2 x 2 fused couplers	61
3.4	Fiber Optic Coupler Manufacturing System	66
3.5	Coupler Workstation	67
3.6	Picture showing Torch's Head and Fiber Chucks	68
3.7	A polarization scrambler	69
3.8	A fiber in a planar coil	70
3.9	Schematic arrangement of equipment	72
3.10	Coupling cycle	74
3.11	Schematic arrangement of equipment for 1 x 3 couplers	76
3.12	Normal sitting arrangement of triangular shape of fibers	77
3.13	De-multiplexed wavelengths of WDM coupler	83
3.14	FiberPro Configuration Screen	85
3.15	FiberPro Manufacturing Screen	87
3.16	Pulling Signature showing output parameters in real time	88

4.1	V parameter versus core diameter for various wavelengths (Δ=0.00341)	90
4.2	Comparison of small and big core ratios for tapered fiber	91
4.3	Coupling characteristic for core ratio 1 to 0.43	92
4.4	Coupling characteristic for core ratio 0.65 to 0.43	93
4.5	Coupling characteristic for core ratio 0.56 to 0.43	94
4.6	Coupling characteristic for core ratio 0.56 to 0.43	95
4.7	Coupling characteristic for core ratio 0.65 to 0.43	97
4.8	Coupling characteristic for core ratio 0.75 to 0.56	98
4.9	Actual Pulling Signature showing jump in excess loss occurred at end of tapering process	101
4.10	Comparison of two different torch heads	102
4.11	The graph of distance versus runtime for equation $s = 111t - 91.41$	103
4.12	Set coupling ratio versus actual coupling ratio for 1550 nm wavelength	104
4.13	Achieved coupling ratios at various crosstalk level for 1310/1550 WDM coupler	105
4.14	Relationship in between excess loss and elongation	106
4.15	Insertion loss versus hydrogen flowrate	108
4.16	Polarization dependent loss at small change of hydrogen flowrate	109
4.17	Actual Pulling Signature showing various types of pull length	110

4.18 a) Fiber at time = 0 s, a section PQ of fused length Lo is heated. b) The structure of fiber taper representing cross-section view after tapering 111
4.19 Lengths increase as waist diameter ratio decreases 112
4.20 Manufacturing Screen for an actual 3 dB coupler 114
4.21 Theoretical pulling signature which represents standard coupler 115
4.22 Coupling coefficient increases as tapering process continues 116
4.23 Actual Pulling Signature showing both power for 1480 nm and 1610 nm wavelengths launched initially at both input ports simultaneously 117
4.24 Actual Pulling Signature showing both power for 1480 nm and 1550 nm wavelengths launched initially at both input ports simultaneously 118
4.25 Theoretical pulling signature showing de-multiplexing point 119
4.26 Comparison of coupling coefficient between identical (b=1) and non-identical fibers' diameters (b=0.82) 121
4.27 Theoretical pulling signature for wideband coupler 122
4.28 Power taken for various couplers with different diameters' ratios at first coupling cycle 123
4.29 A 1550 nm LED broadband input signal viewed from Optical Spectrum Analyzer 124

4.30 Interleaved output signal at first port showing odd wavelengths centred at 1548.5 nm 125

4.31 Interleaved output signal showing channel spacing = 2.84 nm or FSR = 178 GHz 126

4.32 Superimposed output signals showing both odd and even wavelengths overlapping each other 126

4.33 Arrows showing first rotation 127

4.34 Arrows showing second rotation 127

4.35 Two possible positions at fusion region for the intertwined twist method 128

4.36 Arrows showing the opposite rotation for second step of twist 128

4.37 Two possible worst positions for normal twisting 129

4.38 Possible position under 420° rotation for truly equilateral arrangement 130

4.39 Actual Pulling Signature for 1 x 3 star coupler with unequal splitting ratio 130

4.40 Actual Pulling Signature for 1 x 3 star coupler at wavelength of 1310 nm 132

4.41 Output power P_1 (red) and output power P_3 (blue) shows unequal powers between them for truly equilateral arrangement 134

5.1 Recommended modification for Coupler Workstation 137

C.1 Relationship between power and Volt 150

LIST OF ABBREVIATIONS

BPM	Beam Propagation Method
CAD	Computer Aided Design
CH	Photodetector
CMT	Coupled Mode Theory
CPU	Central Processing Unit
CR	Coupling Ratio
CW	Coupler Workstation
CWDM	Coarse Wavelength Division Multiplexing
DWDM	Dense Wavelength Division Multiplexing
EL	Excess Loss
FBT	Fused Biconical Taper
FTP	Flame Torch Position
FTTH	Fiber to the Home
IL	Insertion Loss
ITU	International Telecomunication Union
LM	Lower Modes
MFD	Mode Field Diameter
MZI	Mach Zehnder Inteferometer
OLT	Optical Line Terminal
ONU	Optical Network Unit
OSA	Optical Spectrum Analyzer
PDL	Polarization Dependent Loss

UPM

PL	Pull Length
PON	Passive Optical Network
SMF	Single Mode Fiber
WDM	Wavelength Division Multiplexing
WSF	Wavelength Selective Fused