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DESIGN AND CHARACTERISATION OF BRILLOUIN-ERBIUM FIBER LASER SYSTEMS

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ABSTRACT

This dissertation presents the design and characterisation of Brillouin-Erbium Fiber Laser (BEFL) systems. A BEFL system utilises the Erbium gain provided by the erbium doped fiber (EDF) and the Brillouin gain provided by the single-mode optical fiber (SMOF) to produce dense laser signals with spacing signals of about 10GHz. In designing the BEFL system an Erbium doped fiber laser (EDFL) was characterised and as a result a high power EDFL with delivers a maximum power of 24mW and tunable from 1520 to 1565nm was constructed and used as the Brillouin pump. The BEFL system was characterised on several parameters such as the BEFL threshold, output power, slope efficiency, tuning range, power fluctuation and its side-mode suppression ratio (SMSR). The optimum EDF length for the system was found to be 11.3m, which provides the highest output power. The lowest BEFL threshold was 17.4mW and a maximum power of 8.87mW was obtained at 124mW of pump power and 20% reflectivity. It was found that a launch power (LP) of about 3mW was sufficient to create an efficient BEFL system. This system has a tuning range of 8.7nm over the 1550nm EDF gain bandwidth at 20% reflectivity and a maximum of 34nm was obtained in a 80% reflectivity system. A output power fluctuation of 0.14dB was achievable for the system. The Brillouin signal has an average SMSR and 3dB spectral width value of 36.4dB and 0.05dB respectively. The multi-wavelength BEFL (MWBEFL) system that was designed could generate multiple Stokes signal and up to the 13^{th} order Stokes signal has been obtained from this optimized system. The MWBEFL threshold value ranges from 33.5mW to 42.7mW for the 1^{st} to the 7^{th} order Stokes signal respectively. A maximum tuning range of 5nm was

obtained in this system for the 10m EDF length. The lasing gain and gain dynamics was found to effect the performance of this MWBEFL system in whole.

ABSTRAK

Disertasi ini adalah hasil penyelidikan di dalam rekabentuk dan pencirian sistem laser gentian optik Brillouin-Erbium (BEFL). Sistem BEFL ini menggunakan gandaan erbium yang dibekalkan oleh gentian optik mod tunggal untuk menjana gelombang-gelombang laser yang padat dengan jarak antara gelombang sebanyak 10GHz. Di dalam merekabentuk sistem BEFL, satu sistem laser gentian optik erbium (EDF) telah diciri untuk memberi kuasa keluaran setinggi 24mW serta boleh-laras dari 1520-1560nm dan digunakan sebagai pam Brillouin. Sistem BEFL ini telah diciri untuk beberapa parameter seperti titik-mula BEFL, kuasa keluaran, cerun kecekapan, julat boleh laras, kestabilan kuasa dan nisbah mampatan mod tepi (SMSR). Panjang optima EDF bagi sistem ini didapati 11.3m yang menghasilkan kuasa keluaran yang tertinggi. Titik-mula BEFL yang terendah ialah 17.4mW dan kuasa maksimum sebanyak 8.87mW telah diperolehi dengan kuasa pump sebanyak 124mW dan pantulan sebanyak 20%. Telah didapati kuasa lancar sebanyak 3mW sudah memadai untuk menghasilkan satu sistem BEFL yang berkesan. Sistem ini mempunyai julat boleh-laras sebanyak 8.7nm sepanjang lebar jalur gandaan erbium pada pantulan 20%. Julat boleh-laras maksimum sebanyak 34nm telah diperolehi dengan pantulan 80%. Kestabilan kuasa keluaran sebanyak 0.14dB didapati dari sistem ini. Gelombang Brillouin mempunyai purata SMSR dan lebar jalur 3dB dengan nilai 36.4dB dan 0.05dB masing- masing. Sistem multi-gelombang BEFL (MWBEFL) yang direkabentuk boleh menjana pelbagai gelombang Stokes dan gelombang Stokes sehingga peringkat ke-13 telah berjaya diperolehi dari sistem yang telah dioptimumkan. Nilai titik-mula MWBEFL mempunyai julat kuasa pam dari 33.5mW hingga 42.7mW bagi

peringkat pertama hingga ke peringkat ke-7 masing-masing. Nilai maximum julat boleh-ubah sehingga 5nm telah diperolehi dari sistem dengan panjang EDF bernilai 10m. Gandaan laser serta perubahaan gandaan telah didapati menggangu prestasi sistem MWBEFL ini secara keseluruhannya.

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CONTENTS

ABSTRACT		i
ABSTRAK		ii
ACKNOWLEDGMENT		iii
CHAPTER 1	**INTRODUCTION : FIBER NONLINEARITIES**	**1**
1.1	**Non-linear Effects in Optical Fibers**	1
1.2	**Stimulated Brillouin Scattering (SBS)**	3
1.2.1	Brillouin Frequency Shift	5
1.2.2	Brillouin Gain	7
1.2.3	SBS Threshold	10
1.2.4	Reported Experiments on SBS	11
1.2.5	Importance of SBS in Optical Fibers	17
1.3	**Four Wave Mixing (FWM)**	18
1.4	**Stimulated Raman Scattering (SRS)**	21
1.5	**Self-Phase Modulation (SPM)**	22
1.6	**Cross-Phase Modulation (XPM)**	23
References		24
CHAPTER 2	**ERBIUM DOPED RING FIBER LASER**	**27**
2.1	**Fiber Based Optical Components**	27

2.1.1	Isolator	28
2.1.2	Bi-directional Coupler (Splitters)	28
2.1.3	Wavelength Selective Coupler (WSC)	28
2.1.4	Gain Medium – Rare-earth Doped Fiber (DF)	28
2.1.5	Pump Source - Pigtailed Laser Diode (LD)	30
2.2	**General Characteristics of a ring EDFL**	31
2.2.1	Slope Efficiency (SE)	32
2.2.2	Laser Threshold and Output Power	32
2.2.3	Free-Spectral Range (FSR) and Linewidth (FWHM)	33
2.2.4	Finesse	35
2.2.5	Side-Mode Suppression Ratio (SMSR)	35
2.3	**Cavity Designs**	37
2.3.1	Fabry-Perot Cavity	38
2.3.2	Ring Cavity	38
2.4	**Characterization of Erbium Doped Ring Fiber Laser**	39
2.5	**Experiments, Results and Discussion**	40
2.5.1	Effects of EDF length	41
2.5.2	Effects of Pump Power (LD Power)	43
2.5.3	Effects of Reflectivity, R	44
2.5.4	Effects of Pump Power and Wavelength Fluctuation	46
2.5.5	Effects of Back Reflection (BR)	48
2.5.6	Tuning Range	49
2.6	**Implications to the BEFL System**	50

References 51

CHAPTER 3 BRILLOUIN-ERBIUM FIBER LASER (BEFL) **52**

3.1 Introduction 52

3.1.1 Experimental Setup 54

3.1.2 Operating Principle 56

3.2 Experiments, Results and Discussion 58

3.2.1 Optimization of EDF length 58

3.2.2 BEFL Threshold 59

3.2.3 Output Power and Slope Efficiency (SE) 62

3.2.4 Tuning Range 69

3.2.5 Effect of Single-Mode Optical Fiber (SMOF) Length 75

3.2.6 Output Signal Power Fluctuation 76

3.2.7 Side-Mode Suppression Ratio (SMSR) 78

References 81

CHAPTER 4 MULTI-WAVELENGTH BEFL (MWBEFL) **82**

4.1 Introduction 82

4.1.1 Experimental Setup 83

4.1.2 Operating Principle 85

4.1.3 Multiple Generation Process 87

4.1.4 Lasing Gain and Gain Dynamics 88

4.2 Experiments, Results and Discussion 92

4.2.1 MWBEFL Threshold 92

4.2.2 Output Power 94

4.2.3 Tuning Range 95

4.2.4 Side-Mode Suppression Ratio (SMSR) 97

4.2.5 Maximum Number of Stokes Signal 98

4.3 Implications Towards Optical Communications 102

References 104

CHAPTER 5 CONCLUSION **105**

APPENDICES : OUTPUT OF THIS DISSERTATION **108**

Appendix A Papers Published 109

Appendix B Exhibited Prototype Model 112