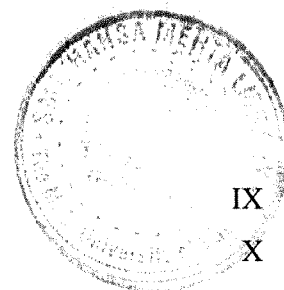


INDEX



❖	Abstract	IX
❖	Acknowledgement	X
1.	Introduction	1
1.1	Applications of Laser Diode	1
1.2	Brief History of Laser Diode	3
1.3	Background and Prerequisites	4
1.3.1	General Laser Theory	4
1.3.2	Diversities of Laser Systems	8
1.3.3	Lasing in Semiconductor	9
1.3.3.1	Gain Medium	10
1.3.3.2	Population Inversion	11
1.3.3.3	Resonator Cavity	13
1.3.3.4	Condition for Lasing	13
1.3.4	Operation of Laser Diode	15
1.4	Laser Diode Structures	17
1.4.1	Homojunction Laser Structure	17
1.4.2	Double-Heterojunction Laser structure	18
1.4.3	QW Laser Diodes	19
1.4.4	Separate Confinement Heterostructure (SCH)	22
1.5	Thesis Overview	23
1.6	Organization of Thesis	26
➤	References	28
2.	Growth of Laser Diode Structure using MOVPE	30
2.1	Introduction	30
2.2	Epitaxial Growth of Semiconductor Materials	31
2.3	Epitaxial Growth Techniques	35
2.3.1	Liquid Phase Epitaxy	35
2.3.2	Molecular Beam Epitaxy	36
2.3.3	Vapor Phase Epitaxy	37

2.3.3.1	Metal-Organic Vapor Phase Epitaxy	37
2.4	Growth of III-V Semiconductors using MOVPE	40
2.4.1	Chemical Reactions and Precursors	40
2.4.2	Growth Mechanism	41
2.4.3	Growth Regimes	42
2.4.4	Growth Rate	42
2.4.5	Doping of Semiconductors	44
2.4.5.1	Donors	44
2.4.5.2	Acceptors	45
2.5	Characterization Techniques	45
2.5.1	High-Resolution X-Ray Diffractometry	45
2.5.2	Photoluminescence Spectroscopy	48
2.5.3	Electrochemical Capacitance Voltage Profiling	50
2.6	Growth and Optimization of Laser Structure	52
2.6.1	Materials for High-Power Laser Diodes	53
2.6.1.1	The InGaP/InAlGaP Material System	55
2.6.1.2	The ZnCdSe Material System	57
2.6.1.3	The AlInGaN Material System	57
2.6.2	Experimental	58
2.6.3	Optimization of Different Layers	59
2.6.3.1	InAlP Cladding layer	59
2.6.3.2	InAlGaP Waveguide layer	62
2.6.3.3	InGaP QW Active Layer	65
2.6.4	Growth of a Complete Laser Structure	66
➤	References	68
3.	Device Processing for Laser Diodes	70
3.1	Various Laser Diode Geometries	70
3.1.1	Broad-Area Laser Diodes	70
3.1.2	Stripe Geometry Laser Diodes	71
3.1.2.1	Gain-Guided Stripe Geometry Laser Diodes	71
3.1.2.2	Index-Guided Stripe Geometry Laser Diode	73
3.2	Laser Diode Bars	74

3.3	Fabrication of Laser Diode Bar with Mesa-Stripe Geometry	75
3.4	Optimization of Various Steps in Laser Diode Processing	76
3.4.1	Organic Cleaning	76
3.4.2	Photolithography	77
3.4.2.1	Photoresist Coating	77
3.4.2.2	Chlorobenzene Soak	80
3.4.2.3	Alignment	80
3.4.2.4	Exposure	81
3.4.2.5	Development	81
3.4.3	Top Metal Contact Deposition	81
3.4.4	Lift-off Process	82
3.4.5	Rapid Thermal Annealing of Top Contact	83
3.4.6	Etching	84
3.4.7	Lapping & Polishing	85
3.4.8	Bottom Metal Contact Deposition	85
3.4.9	RTA of Bottom Contact	86
3.4.10	Scribing	86
3.5	Detailed Process Layout	86
3.6	Testing of Laser Diode Bars	87
➤	References	89
4.	Optimization of Facet-Coating for Laser Diode	90
4.1	Degradation of Laser Diodes	90
4.1.1	COMD Mechanisms	91
4.2	Facet Passivation for Laser Diode	93
4.3	Optical Thin Films for Laser Diode Facets	96
4.3.1	Anti-Reflection Coating	96
4.3.2	High-Reflection Coating	98
4.3.3	Materials for AR-HR Coatings	99
4.4	Thin Film Deposition Technique	100
4.4.1	Physical Vapor Deposition	101
4.4.1.1	Electron Beam Evaporation Technique	102
4.5	Optimization of Coating Conditions for Laser Diode	103

4.6	Experimental	105
4.7	Reflectivity Simulation	106
4.8	Optical Thin Film Characterizations	108
4.8.1	Ex-situ Reflectivity Measurements	108
4.8.2	In-situ Reflectivity Measurements	112
4.8.2.1	Experimental Setup	112
4.8.2.2	Results and Discussion	114
4.8.2.3	Upgradation of In-situ Reflectivity Measurement	116
4.9	Optimization of AR-HR Coatings for Different Wavelengths	120
4.9.1	650 nm	120
4.9.2	820 nm	121
4.9.3	850 nm	123
4.9.4	890 nm	124
4.9.5	950 nm	125
4.9.6	1200 nm	126
4.10	Conclusion	131
➤	References	132
5.	Laser Diode Characterization: Setup and Automation	135
5.1	Overview of Laser Diode Characterizations	135
5.1.1	L-I Characteristics	136
5.1.1.1	Threshold Current	136
5.1.1.2	Slope Efficiency	138
5.1.1.3	External Differential Quantum Efficiency	138
5.1.1.4	Kinks	139
5.1.2	I-V Characteristics	139
5.1.3	Spectral Response Measurement	140
5.2	Instruments for Laser Diode Characterization	141
5.2.1	Current Driver	141
5.2.2	Integrating Sphere	142
5.2.3	Photodetector	144
5.2.4	Lock-in Amplifier	144
5.2.5	Temperature Controller	146

5.2.6	Monochromator	146
5.3	Automation of Characterization Facility	146
5.4	Virtual Instrumentation	147
5.4.1	Data Acquisition System	147
5.4.1.1	The Personal Computer	148
5.4.1.2	Transducers	148
5.4.1.3	Signal Conditioning	148
5.4.1.4	DAQ hardware	149
5.4.1.5	Software	151
5.4.2	Communication Protocols	152
5.4.2.1	Serial Communication	152
5.4.2.2	Parallel Port Communication	153
5.4.2.3	GPIB	153
5.4.3	Programming	154
5.5	Experimental Setups and VI Implementations	156
5.5.1	L-I-V Characteristics and Spectral Response Measurement	156
5.5.2	Characteristic Temperature Measurement	163
5.5.3	Thermal Impedance Measurement	164
5.5.4	Lifetime and Degradation Rate Measurement	168
➤	References	172
6.	Packaging and Testing of High-Power Laser diode Assembly	174
6.1	Die-Bonding	175
6.1.1	Adhesive Bonding	175
6.1.2	Soldering	176
6.1.2.1	Eutectic Bonding	176
6.1.2.2	Soft Soldering	177
6.1.3	Solders Used for Die-bonding	178
6.1.3.1	Silver (Ag) Epoxy	178
6.1.3.2	Lead-Tin (Pb-Sn) Paste	178
6.1.3.3	Indium (In) Preform	179
6.1.3.4	Gold-Tin (Au-Sn) Preform	179