

Contents

1	Introduction and background	1
2	Wave propagation in optical waveguides	7
2.1	Maxwell's and wave equations	7
2.2	Waveguide modes	8
2.2.1	Eigenmode classification and orthogonality	10
2.2.2	Effective index method	12
2.3	Local modes and modal decomposition	14
2.4	Integrated waveguide components	16
2.4.1	Losses and adiabatic criterion	16
2.4.2	S-Bends and outcouple bends	17
2.4.3	Waveguide taper	19
2.4.4	Waveguide coupler	21
3	Simulation models	23
3.1	Traveling-wave model based laser simulation	23
3.1.1	Optical model	23
3.1.2	Carrier transport model	25
3.1.3	Thermal model	26
3.1.4	Modal analysis of BALaser results	27
3.2	Eigenmode expansion method	28
3.3	Beam propagation method	30
4	MMI-coupler-based dual-wavelength lasers	33
4.1	Introduction	33
4.2	Device design	36
4.2.1	Design approach	36
4.2.2	Transverse waveguide and device fabrication	37
4.2.3	Lateral-longitudinal waveguide and contact layout	39
4.3	Integrated waveguide component optimization	40
4.3.1	Waveguide taper and S-bends	40
4.3.2	Waveguide coupler	43
4.4	Experimental device characterization	46
4.4.1	Power-current characteristics	46
4.4.2	Optical spectra	48
4.4.3	Near- and far-field profiles	49
4.5	Complementary results and discussion	51

4.6	Chapter summary	55
5	High-brightness tapered ridge-waveguide lasers	57
5.1	Introduction	57
5.2	Device design	60
5.2.1	Transverse waveguide and device fabrication	60
5.2.2	Lateral-longitudinal waveguide and contact layout	61
5.3	Straight ridge-waveguide laser	62
5.3.1	Power-current characteristics	62
5.3.2	Near- and far-field profiles	64
5.4	Tapered ridge-waveguide laser	66
5.4.1	Power-current characteristics	66
5.4.2	Near- and far-field profiles	67
5.4.3	Modal waveguide analysis	68
5.4.4	Beam propagation analysis	70
5.5	Design optimization	72
5.6	Chapter summary	73
6	Efficient high-power tapered broad-area lasers	75
6.1	Introduction	75
6.2	Device design	78
6.3	Electro-optical characteristics	79
6.4	Intra-cavity intensity, carrier density and temp. dist.	81
6.4.1	Lateral-longitudinal distributions	81
6.4.2	Inhomogeneity measures	83
6.4.3	Longitudinal-lateral inhomogeneities	84
6.5	Local gain, modal analysis and beam quality	87
6.5.1	Longitudinally resolved local gain	87
6.5.2	Modal waveguide analysis	88
6.5.3	Beam quality	90
6.6	Chapter summary	91
7	Summary and conclusion	93
	Appendix	97
	A: Simulation parameters	97
	B: Finite-difference method 1D modesolver	105
	C: Conformal mapping of bent waveguides	108
	D: Simulation of low index contrast waveguide bends	111
	Bibliography	122
	List of abbreviations	141
	List of publications	143
	Acknowledgment	145