

Contents

1	Introduction and Background	1
2	Optical field model	9
2.1	The traveling-wave equations	9
2.2	Balance of radiative energy	12
2.3	Effective longitudinal-lateral projected equations	13
2.4	Retrieval of real device characteristics	16
2.5	Summary	18
3	Carrier transport model	19
3.1	Basic drift-diffusion model	20
3.2	Reduction to effective diffusion equation and models for the injection current	23
3.2.1	Carrier transport in the active region	24
3.2.2	Models for the injection current density	26
3.3	Summary	29
4	Heat model	31
4.1	Basic equations	32
4.2	Approximate equations for the heat source density	34
4.2.1	Treatment of spontaneous emission	34
4.2.2	Impact of vanishing thermoelectric effects on the heat generation	34
4.2.3	Heat sources for the longitudinal-lateral approximate equations	37
4.3	Energy conservation	40
4.4	Treatment of pulsed operation (no-heat-flow approximation)	42
4.4.1	Experimental validation	45
4.5	Treatment of continuous-wave operation	46
4.6	Summary	49
5	Power saturation under short pulse operation	51
5.1	Spatial hole burning, current spreading, two-photon absorption and gain compression	52
5.2	Impact of spatio-temporal power variations	55
5.3	Estimation of additional effects not included in the model	56
5.4	Conclusions	58
6	Factors influencing the lateral field profile	61
6.1	Modulation instability induced by Kerr nonlinearities	62
6.1.1	Bespalov Talanov modulation instability	62

6.1.2	Instabilities induced by the optical material Kerr effect	63
6.1.3	Instabilities induced by spatial hole burning	65
6.1.4	Conclusions	68
6.2	Multi-mode lasing	69
6.3	Nonthermal effects	73
6.3.1	Nonthermal far-field blooming	74
6.3.2	Differential index (α_H -factor)	76
6.3.3	Lateral carrier distribution in the active region	79
6.3.4	Conclusions	82
6.4	Thermal waveguiding effects	83
6.4.1	Short-pulse operation	83
6.4.2	Continuous-wave operation	87
6.4.3	Conclusions	92
7	Improvement of the lateral brightness	93
7.1	Index guiding trenches and implantation	94
7.1.1	Comparison with measurements	95
7.1.2	Conclusions	99
7.2	Contact structuring	100
7.2.1	Coherently coupled laser arrays	101
7.2.2	Talbot lasers	104
7.2.3	Chessboard lasers	106
7.2.4	Conclusions	113
8	Summary and outlook	115
	Appendix	119
A	Simulation parameters	119
B	Nonlinear susceptibility	127
C	The Fermi integral $F_{1/2}$	131
D	Numerical schemes	133
D.1	Traveling wave and carrier rate equations	133
D.1.1	Split step Fourier method for solution of traveling wave equations	134
D.1.2	Finite difference scheme for solution of carrier rate equations . .	136
D.1.3	Parallelization	138
D.2	Current spreading and heat transport solvers	138
D.2.1	Current spreading solver	138
D.2.2	Heat transport solver	140
	Bibliography	141