

Contents

Abstract	iii
Kurzfassung	vii
Introduction	1
1 Theoretical foundation for high power DFB lasers	7
1.1 Power conversion efficiency	8
1.1.1 Power conversion efficiency in DFB and FP lasers	8
1.1.2 Optical output power	9
1.1.3 Electrical power consumption	13
1.1.4 How to achieve a high peak power conversion efficiency	14
1.1.5 Continuous wave power and efficiency characteristics .	22
1.2 Distributed feedback in semiconductor lasers	28
1.2.1 The principle of distributed feedback	28
1.2.2 Coupled mode theory and coupling coefficients for second-order DFB gratings	35
1.2.3 Threshold condition for DFB lasers	43
1.2.4 Approximations and numerical solutions for DFB-BA lasers	44
1.2.5 Power and efficiency characteristics of DFB-BA lasers	58
1.2.6 Important aspects for the design of efficient high power DFB-BA lasers	63
2 DFB-BA laser review	67
3 Experimental and theoretical results from iteration I	75
3.1 Design of a low loss laser waveguide	76
3.2 Characterization of FP-BA reference lasers	84
3.2.1 Facet coating for FP-BA reference lasers	84
3.2.2 P-U-I characteristics of FP-BA lasers	85

3.2.3	Spectral properties of FP-BA lasers	87
3.2.4	Thermal properties of FP-BA lasers	89
3.2.5	Spatial emission properties of FP-BA lasers	93
3.3	Development of the DFB grating	96
3.3.1	Properties of the DFB grating	96
3.3.2	Manufacturing of the DFB grating	105
3.3.3	Coupling coefficient of the DFB grating	113
3.4	Characterization of DFB-BA lasers	121
3.4.1	Material parameters of DFB-BA wafers	121
3.4.2	Facet coating for DFB-BA lasers	124
3.4.3	Overview of DFB wafers	124
3.4.4	Power-voltage-current characteristics of DFB-BA lasers	127
3.4.5	Comparison of the power-voltage-current characteristics with FP-BA reference lasers	132
3.4.6	Spectral properties of DFB-BA lasers	136
3.4.7	Thermal properties of DFB-BA lasers	145
3.4.8	Spatial emission properties of DFB-BA lasers	151
3.4.9	Properties of higher-order vertical waveguide modes	161
3.4.10	Experimental determination of the coupling coefficient	168
3.4.11	Determination of the DFB locking range	175
3.4.12	Spectrally resolved lateral near fields and far fields	178
3.5	Comparison of experimental and theoretical results for threshold current and slope efficiency	191
3.6	Conclusions from iteration I	199
4	Experimental and theoretical results from iteration II	207
4.1	A concept for the further enhancement of the electro-optical properties of DFB-BA lasers	208
4.2	Development of a further optimized DFB grating	209
4.2.1	Changes of the properties of the DFB grating	209
4.2.2	Manufacturing of the DFB grating	213
4.2.3	Coupling coefficient of the DFB grating	220
4.3	Characterization of DFB-BA lasers	226
4.3.1	Overview of DFB wafers	226
4.3.2	Facet coating for DFB-BA lasers	227
4.3.3	Material parameters of DFB-BA wafers	229
4.3.4	Power-voltage-current characteristics of DFB-BA lasers	230

4.3.5	Comparison of the power-voltage-current characteristics with FP-BA reference lasers and DFB-BA lasers from iteration I	233
4.3.6	Spectral properties of DFB-BA lasers	241
4.3.7	Determination of the DFB locking range	256
4.3.8	Experimental determination of the coupling coefficient	258
4.3.9	Analysis of the reliability of DFB-BA lasers	264
4.4	Comparison of experimental and theoretical results for threshold current and slope efficiency	273
5	Evaluation of the electro-optical properties: Comparison to other publications	279
6	Summary	301
	Appendix	313
A	Fabrication and mounting	313
A.1	Wafer fabrication	313
A.2	Wafer processing	313
A.3	Facet coating	314
A.4	Mounting of single emitters	315
B	Measurement methods	317
B.1	Measurements under CW conditions	317
B.1.1	Measurement of power-voltage-current characteristics	317
B.1.2	Measurement of optical spectra	318
B.1.3	Measurement of vertical and lateral near fields and far fields	319
B.1.4	Spectrum measurements with fiber coupling	319
B.2	Measurements under short pulse conditions	320
B.2.1	Power-voltage-current characteristics and spectra of mounted single emitters	320
B.2.2	Power-voltage-current characteristics and spectra of unmounted single emitters on laser bars	321
B.3	Measurement of spectrally resolved lateral near fields and far fields	322

Bibliography	325
Publications, talks and patent	343
Abbreviations and Symbols	347