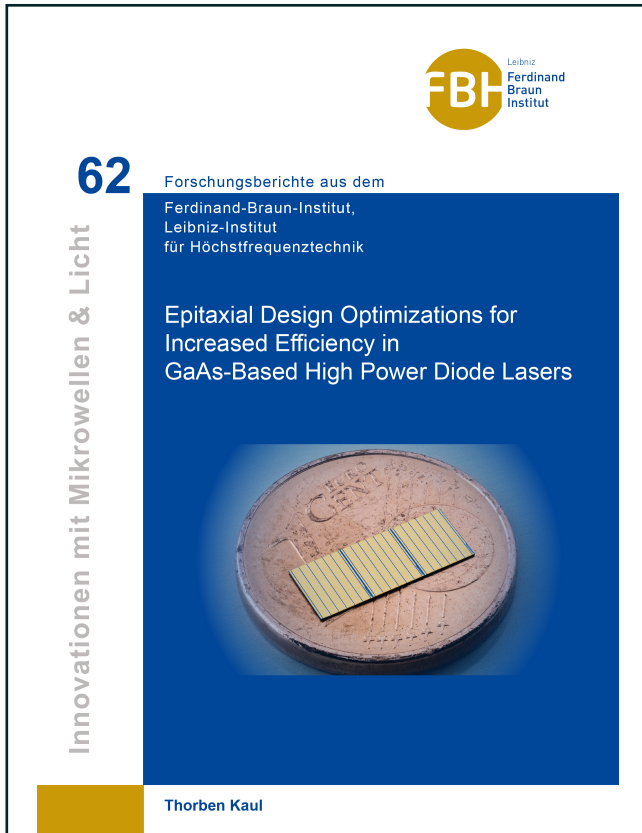




Thorben Kaul (Autor)

Epitaxial Design Optimizations for Increased Efficiency in GaAs-Based High Power Diode Lasers



<https://cuvillier.de/de/shop/publications/8415>

Copyright:

Cuvillier Verlag, Inhaberin Annette Jentsch-Cuvillier, Nonnenstieg 8, 37075 Göttingen, Germany

Telefon: +49 (0)551 54724-0, E-Mail: info@cuvillier.de, Website: <https://cuvillier.de>

Contents

List of Publications	1
Abstract	3
Kurzfassung	5
1 Introduction	7
1.1 Structure and method of this work	9
2 Fundamentals	11
2.1 Laser technology and market context	11
2.1.1 Laser systems for material processing	12
2.1.2 Thin-disk lasers	14
2.1.3 Diode laser types and their applications	15
2.2 Fabrication technology	18
2.2.1 Epitaxy	19
2.2.2 Wafer process	20
2.2.3 Facet passivation and coating	22
2.2.4 Mounting	23
2.3 Mathematical framework of semiconductor lasers	25
2.3.1 Rate equations and gain-clamping	25
2.3.2 Optical loss	28
2.3.3 Thermal resistance	29
2.3.4 UI simulation	30
2.3.5 PI simulation	31
2.3.6 Power conversion efficiency	32
2.3.7 Helmholtz equation	32
2.3.8 Longitudinal steady state rate equations	34
2.4 Parameters for characterization of broad area diode lasers	36
2.4.1 Experimental access to internal parameters	37
2.5 Simulation tools	38
2.6 Device configurations and measurement setups	40

3	Literature Review, Prior State of the Art and Target Specifications	43
3.1	Power and efficiency limiting effects - an overview	43
3.2	Target specifications	47
3.3	Prior state of the art high power diode lasers and laser bars	48
4	Novel Epitaxial Layer-Stack Design for Increased Efficiency	52
4.1	General epitaxial design considerations	52
4.2	Prior state of the art epitaxial design concepts and their limits	55
4.2.1	ASLOC: Asymmetric large optical cavity design	56
4.2.2	EDAS: Extreme double asymmetric design	58
4.3	ETAS: The novel extreme triple asymmetric design concept	59
5	Diagnosis and Analysis of Power Limiting Mechanisms	62
5.1	Devices designed and used for diagnosis	62
5.2	Quantifying thermal- and bias-driven contributions to rollover	65
5.3	Bias-driven power limitations	67
5.3.1	Two-photon-absorption and gain compression	68
5.3.2	Longitudinal spatial hole burning	70
5.3.3	Summary	72
5.4	Thermal-driven power limitations	72
5.4.1	Degradation of material gain	73
5.4.2	Degradation of absorption cross sections and optical loss	75
5.4.3	Degradation of internal efficiency: A root-cause analysis of thermal power saturation	79
6	Performance of Diode Lasers Using Optimized Vertical Designs	87
6.1	Impact of optical confinement on T_0 and T_1	89
6.2	Measurement results of diode laser bars	90
6.3	Short-term perspective for further improved performance	91
7	Conclusion and Outlook	94
7.1	The role of optical loss in thermal power saturation	94
7.2	The role of internal differential quantum efficiency in thermal power saturation	95
7.3	Performance of optimized devices using the novel ETAS design	96
7.4	Outlook	97
8	Acknowledgements	99
A	Appendix	101

B List of Abbreviations	104
Bibliography	105