Flexible Generation of Picosecond Laser Pulses in the Infrared and Green Spectral Range by Gain-Switching of Semiconductor Lasers
## Contents

1 Introduction 1

2 Gain-Switching of Distributed Feedback Lasers 5
  2.1 Distributed Feedback Lasers 5
    2.1.1 Fundamentals of Laser Diodes 5
    2.1.2 Bragg Gratings for Spectral Selectivity 8
    2.1.3 Device Layout and Processing 11
    2.1.4 Continuous-Wave Characteristics 13
  2.2 Gain Switching 16
    2.2.1 Basic Principle 16
    2.2.2 Gain-Switched Diode Lasers 17
    2.2.3 Other Pulse Generation Methods 18
  2.3 Modeling of Diode Laser Dynamics 20
    2.3.1 Dynamic Models of Distributed Feedback Lasers 20
    2.3.2 The k-p-Model of Gain in Semiconductors 26
  2.4 Gain-Switching of Distributed Feedback Laser Diodes 30
    2.4.1 A Rate-Equation Model of Mode Competition 31
    2.4.2 Device and Measurement Setup 35
    2.4.3 Mode Competition and Spectral Dynamics 36
    2.4.4 Optimization of DFB Lasers for Gain Switching 40

3 Optical Amplification of Picosecond Pulses 45
  3.1 Single-Pass Optical Amplification 45
    3.1.1 Introduction to Laser Amplifiers 45
    3.1.2 Gain Media at 1060 nm 48
  3.2 Optical Amplification of Picosecond Pulses 52
    3.2.1 Ytterbium-doped Fiber Amplifiers 52
    3.2.2 Semiconductor Tapered Amplifiers 54
    3.2.3 Comparison of Amplifier Technologies 58
Contents

3.3 Miniaturization ........................................ 60
  3.3.1 Hybrid Integrated MOPAs .............................. 60
  3.3.2 Monolithic Semiconductor MOPAs ................... 66

4 Generation of Green Picosecond Pulses .................. 71
  4.1 Introduction and Theoretical Background ............... 71
    4.1.1 Second Harmonic Generation with Plane Waves .... 71
    4.1.2 Nonlinear Optical Crystals and Phase Matching ... 74
    4.1.3 Second Harmonic Generation with Gaussian Beams .. 76
    4.1.4 Second Harmonic Generation with Non-Gaussian Beams 77
    4.1.5 Second Harmonic Generation with Multi-Mode Beams 78
  4.2 Second Harmonic Generation using Picosecond Pulses ... 80
    4.2.1 Differences to Continuous-Wave Operation ........ 80
    4.2.2 Experimental Setup .................................. 81
    4.2.3 Green Pulse Shape and Energy ...................... 83
    4.2.4 Dynamic Normalized Conversion Efficiency .......... 85
  4.3 Miniaturization .......................................... 87

5 Conclusion and Outlook .................................. 89
  5.1 Summary and Conclusion ................................. 89
  5.2 Future Directions ....................................... 92

List of Publications ......................................... 95

Bibliography ................................................... 97