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Theoretical studies of the generation of picoseconds pulses with two-section blue-violet semiconductor lasers

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Abstract

We report the results of theoretical investigations of the generation of sub-10 ps pulses by a blue-violet InGaN two-section laser. The principle of pulse generation is active Q-switching. We study numerically the influence of the length of the switching section and the emission wavelength on the steady-state and dynamic behaviour. We investigate also the impact of the gain-compression factor on peak power, pulse energy and pulse width and compare the numerical results with semi-analytic expressions.

Keywords: picoseconds pulses, blue-violet semiconductor lasers, pulse energy, bifurcations analysis

(Some figures may appear in colour only in the online journal)

1. Introduction

Picoseconds optical pulses which find applications in distance measurements, free-space communications, material processing and spectroscopy can be easily generated with diode lasers for two reasons. First, the gain can be modulated simply by turning the injection current on and off. Second, a part of the cavity can be readily utilized as an electrically controllable saturable absorber by proper contacting. However, diode lasers compete with other lasers such as solid state and fibre lasers regarding pulse energy and peak power. Therefore, during the last years experimental and theoretical efforts have been undertaken by several groups to improve the performance of pulsed diode lasers in the red and near-infrared spectral region [1–5].

For a long time the violet-blue-green spectral region was accessible with diode lasers only by nonlinear frequency conversion [6]. For example, by using gain-switched, wavelength stabilized infrared lasers and subsequent second harmonic generation green picoseconds pulses were generated [7]. With the invention of GaN based diode lasers the situation had changed partially and several experimental studies on violet-blue laser diodes were published. In [8] optical pulses with a peak power of 55 W, an optical pulse energy of 820 pJ, and a pulse duration of 15 ps were obtained with gain-switched fundamental-lateral mode lasers. In [9] the generation of picoseconds optical pulses with a peak power of 8 W by mode locking was reported. The pulses were amplified by a flared semiconductor optical amplifier to a peak power of about 300 W (pulse width 1.9 ps, pulse energy of 586 pJ). These results reveal the potential of blue-violet lasers to generate picosecond optical pulses with high pulse energy and peak power.

The dynamics, in particular the self-pulsating behaviour, of InGaN lasers was investigated in [10, 11] for different types of saturable absorbers in the cavity. A good agreement between measurements and simulations based on rate equation models was found. Later, the properties of saturable absorbers realized by a reverse-biased section along the cavity axis were experimentally investigated in more detail in [12, 13]. Different types of self-pulsations (undamped relaxation oscillations and self-Q-switching) were observed. By reducing the duration of the electric excitation pulse single

