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Towards ultra fast pulse generation by gain-switching of diode pumped surface emitting semiconductor lasers

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Gain-switching is the most straightforward approach for picosecond pulse generation with semiconductor lasers. Instead of integrating any variable losses in the laser cavity, pulsed operation is achieved by modulation of the electrical or optical pump power and hence the gain. In addition to that, a general property of gain-switched semiconductor lasers is a reduction of output pulse length compared to the pump pulse due to fast pulse build-up after pumping several times above threshold [1]. Here, we will give some very first insights on our research on cascaded gain-switching of a vertical-cavity surface-emitting laser (VCSEL) optically pumped by gain-switched laser diodes. This approach will be advantageous for building a compact and robust single-frequency picosecond oscillator with kHz repetition rates.

The focus in this paper is on the development of the optically pumped VCSEL structure for picosecond pulse generation around 1030 nm. The structure design was based on the resonant periodic gain (RPG) approach [2], where double quantum well (QW) gain sections are placed at the anti-nodes of the standing wave pattern of the internal electric field. Each gain section is based on a 7 nm $In_{0.246}Ga_{0.754}As$/GaAs double quantum well structure with strain compensation and $\lambda/2$ thickness in total.

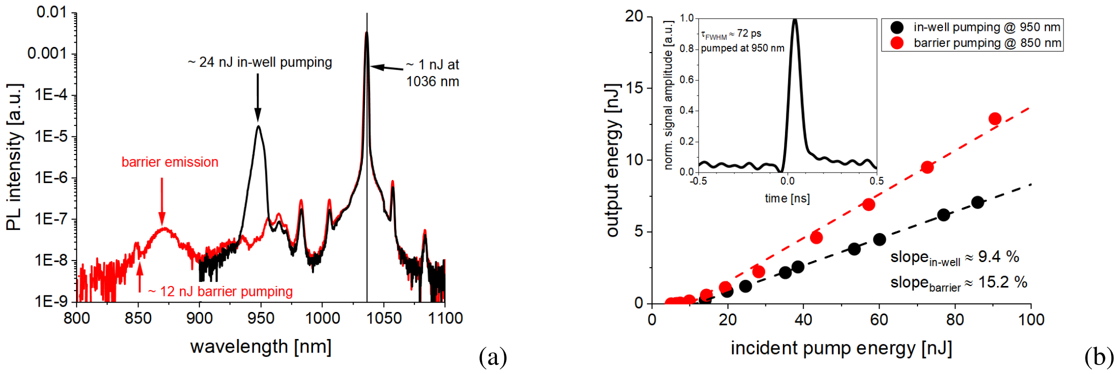

Fig. 1. (a) Time integrated photoluminescence (PL) spectra for barrier and in-well pumping of optically gain-switched VCSEL laser. (b) Slope for barrier and in-well pumping. Trace of currently shortest pulse of 72 ps FWHM (inset).

For fundamental investigations of the output parameters and their dependencies on both the pump wavelength and the pump fluence, we used a self-built wavelength tuneable pulsed laser system [3]. Excitation of discrete QW states (in-well pumping) as well as of electrons in the GaAs barriers (barrier pumping) was investigated. The goal is to replace this system with an optimized gain-switched broad area emitter in a later step. The results in Fig. 1 are from a sample with 25 stacked double-QW gain sections surrounded by a bottom DBR consisting of 25 pairs of AlAs/GaAs $\lambda/4$-layers and a top-DBR, as the output coupling mirror, consisting of 15 pairs of $AlAs/Al_{0.2}Ga_{0.8}As$ $\lambda/4$-layers with reflectivities of 99.98 % and 97.5 %, respectively, for 1030 nm. For in-well pumping at 950 nm and 86 ps pump pulse duration, output pulses at 1036 nm with energy around 1 nJ and duration of 72 ps FWHM, measured with a fast photodetector and oscilloscope, were demonstrated. Further optimization of the RPG structure and the cavity design should allow for even shorter output pulses.

References

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