Passively mode-locked monolithic two-section gainguided tapered quantum-dot lasers: I. Ultrashort and stable pulse generation

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Passively mode-locked two-section quantum-dot monolithic semiconductor lasers are promising optical pulse sources for nonlinear medical imaging and communication applications. Their advantages are their compactness, ease of operation and high efficiency compared to solid state lasers. Quantum-dots (QD) incorporated as the active medium in a diode laser offer peculiar advantages like broad gain bandwidth and fast recovery time of the QD absorber being advantageous for mode-locking operation and generation of ultrashort pulses. Implemented as an index guided tapered structure high pulse peak power of 2.25W with a pulse width of 360 fs can be generated. [1] Recently, a fully gain guided two-section tapered laser has been demonstrated with a peak power of 3.6 W and a pulse width of 3.2 ps with good beam quality. [2]

We present sub-picosecond Fourier-limited pulse generation from a new gain guided tapered laser structure with a pulse width of 672 fs and a pulse peak power of 3.40 W. Being of essential importance a region of stable mode-locked operation is identified in dependence of the biasing conditions.

The active region of the laser structure consists of 10 InGaAs QD layers separated by GaAs barriers integrated in a GaAs waveguide. Gain guiding is achieved by ion implantation. The tapered section is 2.1 mm long, has a taper angle of 2°, the straight absorber section is 0.4 mm long and the absorber-to-gain length ratio amounts to 0.19. Front and rear facet have a high and an anti reflective coating, respectively. This device has a shorter cavity and a different absorber-to-gain length ratio compared to the device presented in [3]. The laser emits at a wavelength of 1260 nm and is operated by driving the gain section with a current source and the absorber section with a voltage source.

We report a shortest Fourier-limited pulse width of 672 fs with a peak power of 3.40 W and an average power of 41 mW at 6 V and 575 mA and a highest peak power of 4.65 W with a pulse width of 785 fs, a time-bandwidth-product of 0.45 and an average power of 66 mW at 6 V and 700 mA in stable mode-locked operation. Fig. 1 (left) shows the corresponding autocorrelation signals and Fig. 1 (middle) the corresponding RF spectra. The highest peak power amounts to 5.94 W at 6.5 V and 800 mA, however exhibits a pedestal in the radio-frequency (RF) signal (black) in Fig. 1 (middle), indicating certain, low degree of mode-locking instabilities. We quantify these by integrating the lower part of the RF spectrum from 20 MHz to a frequency equaling half of the repetition rate of 16 GHz. The resulting integrated RF power is shown in Fig. 1 (right) as a function of gain current and absorber voltage clearly exhibiting a flat minimum region which is marked by the white frame indicating stable mode-locking operation. This demonstrates stable mode-locking and ultrashort pulse generation.

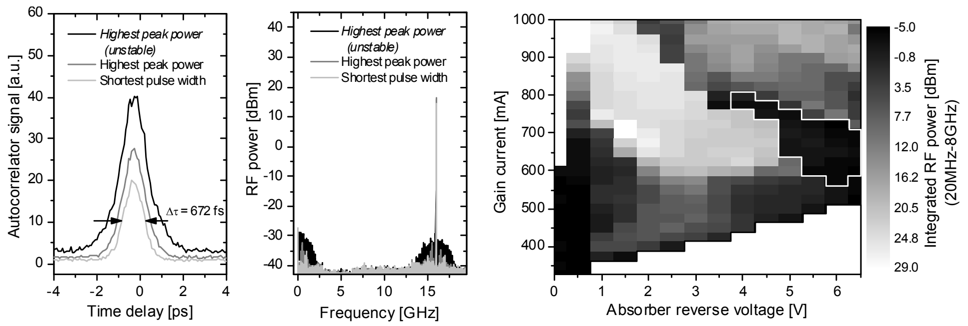

Fig. 1: Autocorrelator signal for three specified key operation conditions (left), RF signal for three specified key operation conditions (middle) and integrated RF power (20MHz – 8GHz) in dependence of gain current and absorber voltage, the white frame indicates the stable mode-locking regime (right)

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