Steady-state Operation of Pulsed Pumped Self Mode Locked Nd:YVO_4 Laser using Electro-optical Feedback Control

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Generation of a train of picosecond pulses with high-reproducibility is interesting for a wide range of applications in medicine, spectroscopy, material science, OPO and FEL development. The passively mode-locked (ML) CW pumped lasers are the most robust approach for obtaining steady state operation but their pulse energy is quite limited (1-10nJ). Pulse pumping has significant advantages in terms of energy scaling and cost reduction. The major drawback in such lasers is the fluctuation of both pulse energy and duration, coming from the statistical nature of the intra-cavity light formation and lack of quasi steady-state pulse formation within the pump pulse[1]. Although the electro-optical negative feedback control (NFC) has been used to improve the performance of pulsed diode pumped systems [2,3] the operation is limited to the low repetition frequency (<100Hz). Moreover the repetition frequency limitation also depends on the thermal resistance of the high-voltage photocurrent element used in the NFC. Here we report mode-locked operation of a pulsed pumped Nd:YVO_4 laser using NFC emitting picosecond pulses enveloped in 60 µs pulses at 400 Hz repetition rate with ~1 mJ macro-pulse energy, and excellent beam quality (M^2 < 1,2). The quasi-steady operation and self mode-locking of the laser is obtained, by introducing the NFC in the laser resonator

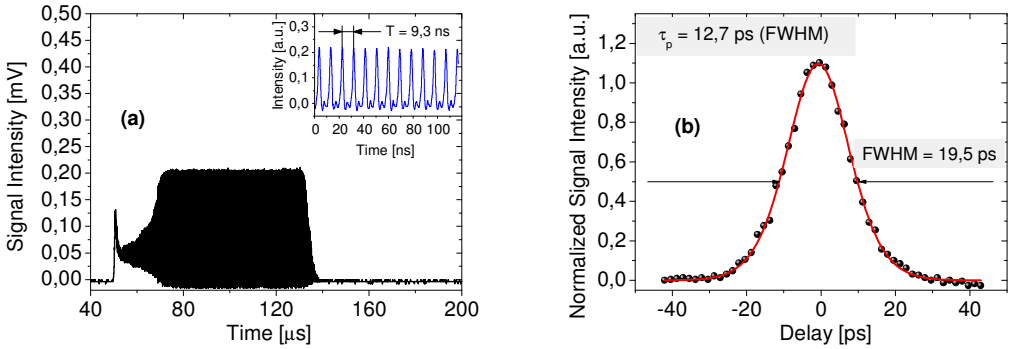

Fig. 1 (a) Oscilloscope trace of the envelop and the single ps pulses (inset) and (b) autocorrelation function

The 808-nm pump laser diode was operated in QCW mode by a pulsed current driver, delivering rectangular, 80 A, 140 µs pulse. When the delay in the NFC loop was adjusted to be equal to the cavity roundtrip, the self mode-locking has been observed with pulse duration of ~90 ps assuming $sech^2$ pulse shape. Additional pulse shortening was possible by introducing passive, nonlinear feedback based on an intra-cavity second harmonic generation crystal and dichroic mirror separated at the proper distance. Measurement of the pulse duration shows shortening ratio of ~7 i.e. 12,7-ps FWHM, (fig. 1b), assuming $Sech^2$ pulse. The amplitude of the pulses after the first ~20 µs is constant within 1% (fig. 1a), indicating that a quasi-stationary regime has been achieved. The output power is 0.4 W at repetition rate of 400 Hz, corresponding to 1 mJ energy in each envelope. The repetition rate of the picosecond pulses, determined by the length of the cavity is ~108 MHz, with energy of a single picosecond pulse ~150 nJ, more than one order of magnitude higher than the one typically obtainable in CW-pumped mode-locked lasers.

In conclusion, by introducing electro-optical NFC, self mode-locking of a pulse pumped Nd:YVO_4 laser has been achieved. Additional pulse shortening by factor of 7 has been obtained by introducing passive nonlinear feedback inside the laser cavity.

References

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