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Diode bar pumped, 0.5 mJ, sub-ns laser at 1.34 µm

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Compact lasers, emitting sub-ns, high energy and peak power pulses in wavelength near 1.3 µm spectral range are essential for wide variety of applications such as autonomous vehicle, remote sensing, frequency conversion and so on. Some of the recent and promising applications require both high pulse energy (~mJ) and peak power (~1 MW) at frequencies above 100 Hz. The diode-pumped short-cavity oscillators, working in passively Q-switching regime of operation, are now established as ultra-compact laser sources, capable to produce optical pulses with energy 1-1000 µJ and sub-ns duration with high beam quality [1, 2]. This is well developed mostly for Nd^{+3} doped active media emitting mainly at 1 µm transition $F_{3/2} \rightarrow {}^4I_{11/2}$ [1]. In addition, to achieve single transfer mode of operation at high excitation energy a fiber coupled diode with more than 100 W peak power was used for longitudinal pumping. However the transition ${}^4F_{3/2} \rightarrow {}^4I_{13/2}$ around 1.3 µm has substantially smaller emission cross which affects the formation of the leading edge of the Q-switched laser pulse and hence the obtaining of shorter pulse duration [4] and much higher pump energy is required. At present, diode laser bars with high fill factor can emit 200-300 W at pump wavelength in QCW operational mode, but the beam profile of a single diode laser bar is highly asymmetric to be used directly as a TEM_{00}-pump source.

In this work, we report a compact, laser diode bar pumped, single mode, passively Q-switched, Nd^{+3}:YAP based oscillator, providing TEM_{00} output at 1.34 µm, with 0.55 mJ, 730 ps pulses at 100 Hz repetition rate. A compact beam shaping scheme is developed for end pumping of 6 mm long Nd^{+3}:YAP crystal Fig. 1 (a).

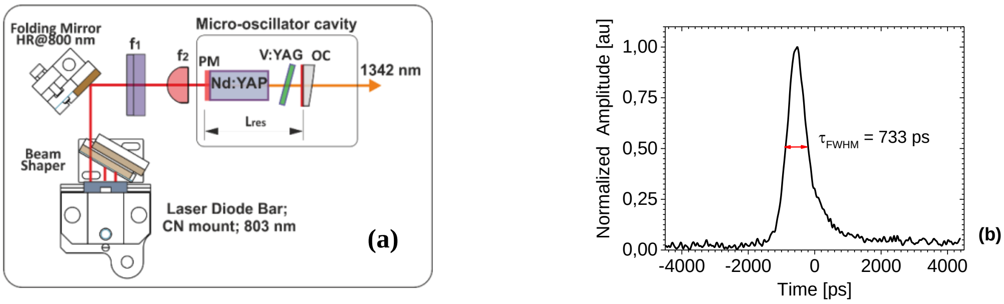

Fig. 1. Layout of the laser system **(a)** and oscilloscope trace of the Q-switched pulse **(b).**

For pump source we use a TEC cooled, quasi-CW laser diode bar, emitting pulses on 803 nm (at 18°C) with maximal duty cycle of 4%. In order to obtain a compact design, the radiation from the diode bar was passed through a specially designed beam shaper, which partially symmetries the excitation laser beam in the x - y directions, perpendicular to the laser cavity axis. It is a modification of the idea proposed in [5,6]. The resulting beam is focused by two cylindrical lenses to a nearly circular pump area (~ 400 µm, $1/e^2$ width) in the active medium (ϕ4x6 mm, b-cut Nd^{+3}:YAP). The exact position of the lens with the shorter focal length f_2, along z-axis is adjusted by optimizing the minimum value of the laser threshold. The positioning of the lens f_1 has been done in a way that provides a single TM_{00} mode of operation of the laser oscillator.

The laser operation has been modeled numerically using three coupled differential equations for the passively Q-switched laser oscillator [3], in order to obtain laser pulses with maximum output energy and as shorter as possible pulse duration. Based on the theoretical analysis, we constructed a 12 mm long, plane-parallel laser resonator with 50% output coupler. For passive Q-switching, we use a V^{+3}:YAG saturable absorber with initial absorption T_0 = 52% for 1342 nm. Maximum output energy of 0.55 mJ at 1342 nm is obtained in Q-switching for 19 mJ absorbed pump energy. The pump pulse duration is 170 µs at 100 Hz repetition rate. At these resonator parameters, the measured Q-pulse duration is 733 ps (deconvoluted with system response function) with corresponding peak power of 0.75 MW (Fig 1 (b)). The output beam is near diffraction limited (M^2_x = 1.2) with 2.5 mrad divergence and linear polarization (polarization extinction ratio 1:200).

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