1.3-µm Nd:YVO$_4$ laser mode locked by cascaded $\chi^{(2)}$ lens formation in periodically-poled stoichiometric lithium tantalate

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Passive mode-locking of Nd-lasers operating on the $^4F_{3/2} \rightarrow {}^4I_{13/2}$ transition near 1.3 µm is interesting for applications in telecommunications, fiber sensing, ranging, and data storage. Semiconductor saturable absorber mirrors (SESAMs) for this spectral range were initially developed on the basis of InGaAs quantum wells but they showed high insertion losses and the average output powers obtained in the picosecond regime were of the order of 100 mW [1]. An alternative mode-locking technique based on intracavity second-harmonic generation, called second-harmonic nonlinear mirror (SHNLM), in principle is free of spectral limitations but concerning its application to Nd-lasers operating on this transition we are aware only of realization of non-stationary mode-locking in a lamp pumped Nd:YAlO$_3$ laser [2].

Here we demonstrate steady-state passive mode-locking of a diode-pumped Nd:YVO$_4$ laser operating on the $^4F_{3/2} \rightarrow {}^4I_{13/2}$ transition at 1342 nm using negative cascaded $\chi^{(2)}$ lensing assisted by the SHNLM effect. This hybrid technique that we recently exploited for mode-locking of Nd-lasers on the $^4F_{3/2} \rightarrow {}^4I_{11/2}$ transition near 1.06 µm [3] relies on the pulse shortening effect due to the negative lens formation while the SHNLM contributes mainly to the self-starting and stability.

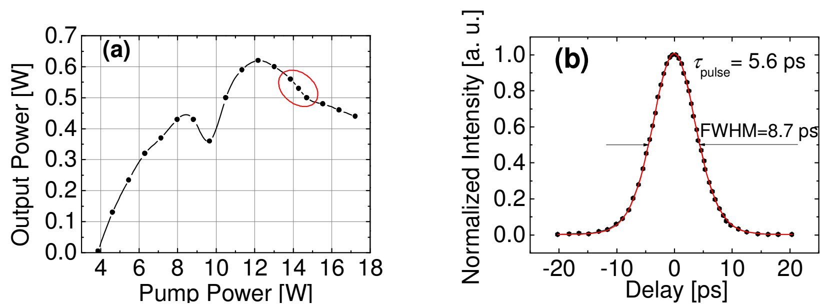

Fig. 1 (a) Input – output characteristics of the Nd:YVO$_4$ laser operating at 1342 nm with the mode-locking range indicated by the red oval and (b) autocorrelation trace (black line) and the corresponding fit (red line) assuming sech^2 shaped pulses.

The experiments were performed with a set-up and pump source similar to those described in [3]. The active element was a 9 mm long, 0.25 at. % doped Nd:YVO$_4$ crystal with an aperture of 2.5×2.5 mm^2. It was *a*-cut, 1.5°-wedged and antireflection (AR) coated. The nonlinear crystal was a 1-mm thick (along the z-axis) periodically poled Mg-doped stoichiometric lithium tantalate (PPMgSLT) with a poling period of 14.7 µm, a length of 10 mm and a width of 5 mm, AR-coated for both fundamental and second harmonic. It was mounted in an oven with high precision (0.1°C) temperature control. According to the design of the periodic structure phase-matched second harmonic generation at 671 nm occurs at a crystal temperature of 188°C. The dichroic mirror used as an output coupler is highly reflecting at the second harmonic with 5% transmission at the fundamental.

Self-starting and stable mode-locked operation was observed in the region between 13.7 and 14.8 W for the incident pump power where the average output power at 1342 nm was around 0.55 W, see Fig. 1a, at a pulse-repetition rate of 102 MHz. The pulse duration amounted to 5.6 ps (FWHM) estimated from the autocorrelation measurement shown in Fig. 1b.

Note that in the present work the average power in the mode-locked regime is very close to the maximum power achieved in the TEM$_{00}$ fundamental mode in the continuous-wave regime. Hence, up-scaling of these results in terms of average power depends on the up-scaling in the continuous-wave mode. Regarding the shortest pulse durations achievable with SESAM technology in the steady-state, the present results compare well with the 6.7 ps pulse duration and the 520 mW average power demonstrated recently with a GaInNAs SESAM in a Ti:sapphire laser pumped Nd:YLF laser operating at 1314 nm [4].

References

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