Chi$^{(2)}$-lens Mode Locking of a 1.34 μm Nd:$GdVO_4$ Laser In-band Pumped by a 880 nm Laser Diode

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Efficient and high power mode locking operation of lasers operating around 1.3 μm, is interesting for applications in semiconductor industry, telecommunications and medicine. Passive mode-locking of Nd-lasers operating on the $^4F_{3/2} \rightarrow {}^4I_{13/2}$ transition is problematic for semiconductor saturable absorber mirrors (SESAMs) not only because of difficulties in their fabrication process but also in relation to the achievable parameters and damage resistivity [1]. Moreover each SESAM is designed and fabricated to operate only at specific wavelength. Recently an alternative passive mode-locking technique based on second-order nonlinearity inside the Nd-laser cavity, which utilizes $\chi^{(2)}$-lens formation in a second-harmonic generation (SHG) crystal, was successfully used for generation of pulses with a duration of few picoseconds at 1.06 μm [2] as well as at 1.34 μm [3]. Although passive mode-locking operation around 1.3 μm is in principle similar to the same regime near 1 μm, when Nd-vanadate lasers are pumped by 808 nm laser diodes, the scaling of the output power is quite limited due to the lower emission cross-section and higher thermal load, compared with the case of 1 μm emission. These major drawbacks restrict also the achievable laser efficiency. On the other hand, direct in-band pumping around 880 nm enables minimization of the thermal load by reducing the quantum defect by ~14%, while the absorption cross section remains high enough for efficient CW and mode locked operation.

In this work we investigate an alternative mode-locking approach based on intra-cavity SHG in periodically poled stoichiometric lithium tantalate (PPMgSLT) in a Nd:$GdVO_4$ laser in-band pumped with a 880 nm laser diode. We demonstrate stable, steady state mode-locking at 1.34 μm achieving average output power of > 2 W for a absorbed pump power of 17.7 W at 123 MHz repetition rate, and pulse duration as short as 9.2 ps. The obtained slope efficiency is 15.4 %.

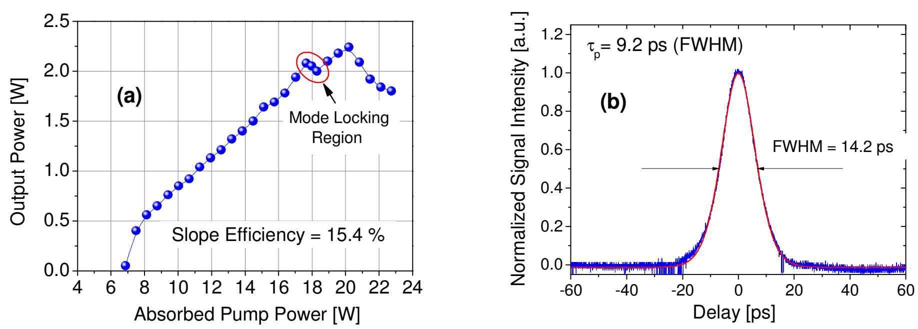

Fig. 1 (a) Input–output characteristics of the Nd:$GdVO_4$ laser, (b) autocorrelation trace (blue) and fit assuming sech^2 pulse shape (red).

The Nd:$GdVO_4$ laser was longitudinally pumped by the unpolarized radiation of a 880 nm laser diode bar coupled into a 400 μm optical fiber (NA=0.22). The output beam from the optical fiber was focused by a 1:1 reimaging unit and delivered onto the Nd:$GdVO_4$ crystal with a spot radius of ~200 μm. The active element absorbed more than 70% of the incident pump power.

Mode-locked operation was studied with an output coupler having high reflection at the second harmonic and transmission of 10% at the fundamental wavelength. Figure 1(a) shows the measured average output power versus absorbed pump power. Figure 1(b) shows the measured autocorrelation trace which leads to an estimation of 9.2 ps for the pulse duration (FWHM).

In conclusion, we have demonstrated the first realization of stable steady state operation of a 1.34 μm mode-locked Nd:$GdVO_4$ laser using $\chi^{(2)}$-negative lens formation in PPMgSLT intra-cavity SHG crystal and direct in-band pumping with a 880 nm laser diode. The maximum average output power of the order of 2 W is limited by the achievable output power in stable TEM_{00} mode in the CW regime.

References

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