Transform-Limited Ultrashort Pulse Generation by $\chi^{(2)}$-Lens Mode-Locking of Nd:LuYAG Laser with Inhomogeneously Broadened Gain Bandwidth

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In recent years, diode-pumped solid-state lasers based on Nd-doped crystals with disordered structure have attracted significant attention. The inhomogeneous broadened fluorescence spectrum of these crystals allows generation of pulses with sub-picosecond duration using traditionally narrow gain bandwidth transitions of the Nd^{3+} ions [1]. However, the main drawback is the lower thermal conductivity of disordered crystals in comparison with that of Nd:YAG, which limits the laser output power and efficiency. Nowadays, relatively good thermal and laser properties have been demonstrated using Nd-doped mixed aluminium garnets Nd:$Lu_xY_{3-x}Al_5O_{12}$ (Nd:LuYAG), Nd:$Gd_xY_{3-x}Al_5O_{12}$ (Nd:GdYAG) and Nd:$Gd_xLu_{3-x}Al_5O_{12}$ (Nd:GdLuAG) and continuous-wave laser operation with high efficiency and output power of several watts are achieved [2]. More recently, a Nd:$Lu_{1.5}Y_{1.5}Al_5O_{12}$ laser has been mode-locked using SESAM with output power of 850 mW and pulse duration of 6.6 ps [3]. However, the pulses have been chirped, i.e. the obtained pulse duration is not transform-limited.

In this work we report $\chi^{(2)}$-lens mode-locking of a diode-pumped Nd:$Lu_{1.5}Y_{1.5}Al_5O_{12}$ laser. Stable operation with 2.4 ps transform-limited pulses and output power of 290 mW at repetition rate of 120 MHz has been achieved.

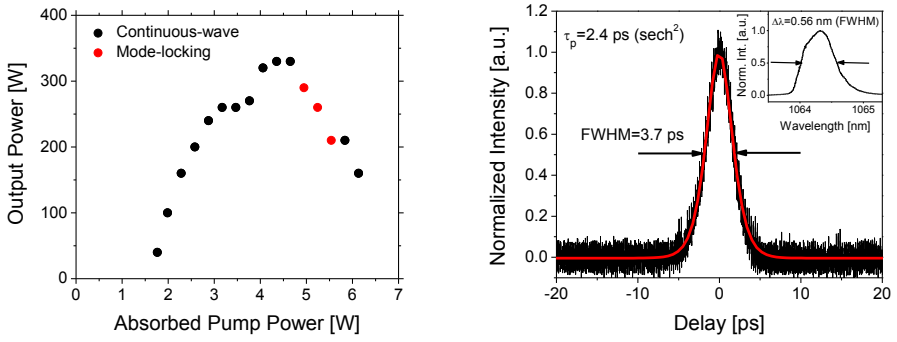

Fig. 1 (a) Input–output characteristics of the Nd:$Lu_{1.5}Y_{1.5}Al_5O_{12}$ laser, (b) autocorrelation curve (black), fit assuming $sech^2$ pulse shape (red) and optical spectrum (inset).

Mode-locking operation is observed at absorbed pump power in the range between 5 W and 5.5 W with maximum output power of 290 mW (Fig.1 (a)). In this range the slope efficiency turns into negative values, because of the non-optimal overlap between the pump waist area and the cavity waist area in the position of the active medium. The average power in mode-locking regime is close to the maximum achievable in continuous-wave operation. The measured pulse duration is 2.4 ps (FWHM), assuming $sech^2$-pulse shape (Fig. 1b). The optical spectrum has FWHM of 0.56 nm (Fig. 1b inset), corresponding to time-bandwidth product of 0.36, which is close to the Fourier transform limit for $sech^2$ pulse shape. The described laser performance is typical for $\chi^{(2)}$-lens mode-locking technique, for which the operation is governed by two processes: resonator intensity dependent losses due to intra-cavity $\chi^{(2)}$-lens formation and soliton-like pulse shaping due to negative intra-cavity self-phase modulation, introduced by phase mismatched SHG [4].

In conclusion, we demonstrate $\chi^{(2)}$-lens mode-locking of a diode-pumped Nd:$Lu_{1.5}Y_{1.5}Al_5O_{12}$ laser with inhomogeneously broadened gain bandwidth. Transform-limited pulses with duration of 2.4 ps are obtained with output power of 290 mW at repetition rate of 120 MHz.

References

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