Passive mode locking of a diode-pumped weakly hybrid Nd:silicate glass and Nd:YVO_4 laser

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Abstract: We studied the first experiment result of the passive mode-locking of a diode-pumped weakly hybrid Nd:silicate glass and Nd:YVO_4 laser. We observed that Nd:YVO_4 can help improve mode locking performance of the Nd:silicate glass laser in both the stability and pulse duration.

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The hybrid laser scheme is a way to utilize the useful properties of different laser media to control and improve the laser performance. It has been shown that a small gain from a Nd:YLF medium can control and stabilize the actively mode-locked spectrum of Nd:phosphate glass and generate coherent and short laser pulses [1]. In the cw operation, we demonstrated that the small gain from Nd:YVO_4 can effectively control the Nd:phosphate glass lasing spectrum even when two lasing line centers were 10 nm apart [2]. In this paper we study the influence of small gain of Nd:YVO_4 laser upon the passively mode-locked Nd:silicate glass laser performance.

The schematic of the hybrid laser cavity is shown in Fig. 1. A Nd:silicate glass plate (LG-680 3wt% doping) was placed in between two concave mirrors, M1 and M2. The Nd:glass was pumped by two single-stripe diode

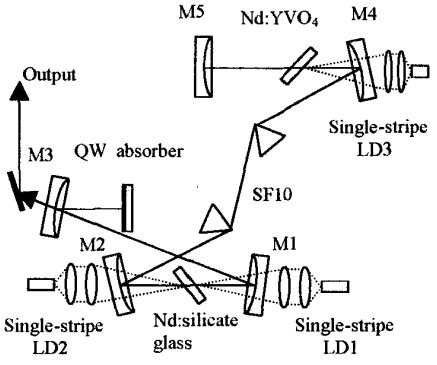

Fig. 1. Schematic diagram of a diode-pumped, passively mode-locked weakly hybrid Nd:silicate glass and Nd:YVO_4 laser.

lasers LD1 and LD2 in the pulsed mode operation. A Nd:YVO_4 plate (Skytec 2 wt% doping) was placed at one end between mirrors, M4 and M5. The mirror M3 with radius of curvature 5 cm focused the laser beam onto a quantum-well saturable absorber. A pair of SF10 prisms, separated from apex-to-apex approximately 50 cm, introduced a negative round-trip group velocity dispersion (GVD).

The Nd:silicate glass is a strong inhomogeneously broadened laser medium with a fluorescence linewidth about 28 nm and is centered at 1060 nm. Nd:YVO_4 is homogeneously broadened medium with a narrow linewidth about 1 nm and is centered at 1064 nm. The laser cavity produced a net intracavity round-trip GVD of -2058 fs^2. The experiment was carried out by weakly pumping at Nd:silicate glass from 2.55-3.08 times above the threshold, $r_{silicate}$ = 2.55-3.08. The mode-locked Nd:silicate laser operated at 1061 nm, and the intracavity pulse energy was 4.85 nJ-8.36 nJ. The average output power was measured from 0.55 mW to 0.95 mW and nearly unchanged as the pumping of Nd:YVO_4 was applied. For the mode-locked Nd:silicate glass laser alone, the pulse duration was reduced from 850 fs to 600 fs as the average output power was increased, and the time-bandwidth products were in range of 0.33-0.35, as shown in Fig. 2. On the other hand, the mode-locked hybrid Nd:silicate glass and Nd:YVO4 laser generated shorter pulse durations, in the range of 850-500 fs. When the average pump output was greater than 0.7 mW, the

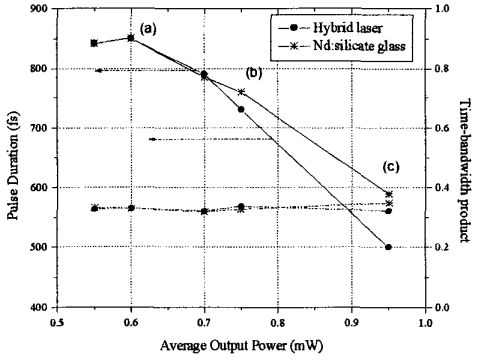

Fig. 2. Pulse duration of the passively mode-locked hybrid Nd:silicate glass and Nd:YVO_4 laser. The net round-trip GVD was fixed at -2058 fs^2.

pulse duration of the hybrid laser became shorter than the Nd:silicate glass alone. The shorter pulse duration is an evidence of a broader and flatter hybrid gain profile due to cross saturated gains of the two hybrid media. At (b) in Fig. 2., the output power was 0.75 mW. After pumping the Nd:YVO_4 laser with $r_{yvo}/r_{silicate} \approx 2.14 \times 10^{-2}$, the pulses decreased from 760 fs to 730 fs. While the output power was 0.95 mW, at (c) in Fig. 2, the pulse duration was significantly decreased from 590 fs to 500 fs after pumping the Nd:YVO_4 laser with $r_{yvo}/r_{silicate} \approx 2.74 \times 10^{-2}$. The larger pump ratio $r_{yvo}/r_{silicate}$ provides a larger hybrid gain extension and shorter pulses. Beside the improvement of the pulse duration, the mode-locked stability was enhanced because the spectral broadening by the self phase modulation was easier and stronger.

With a smaller negative GVD, stronger soliton force, around -1400 fs^2, the hybrid laser produced a larger improvement of the mode locking performance, as shown in Fig. 3. The stronger solition force allowed utilization of a larger gain bandwidth. Therefore, with a small average output power 0.65 mW the pulse duration was significantly reduced from 780 fs to 520 fs.

In summary, we investigated a passive mode locking of a diode-pumped weakly hybrid Nd:silicate and Nd:YVO_4 laser. With a proper small gain from the Nd:YVO_4 medium, the improvement of the hybrid laser performance is enhanced with a smaller negative GVD and stronger pump power. The hybrid Nd:silicate glass and Nd:YVO_4 laser generates a shorter pulse duration and better mode locking stability than the Nd:silicate glass laser alone.

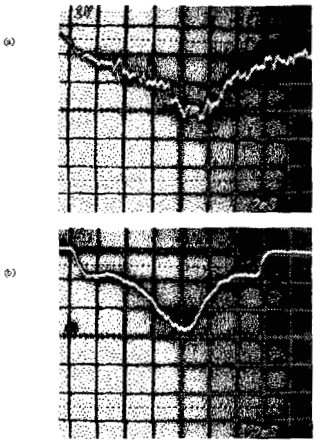

Fig. 3. The autocorrelator trace for the mode-locked (a) Nd:silicate glass laser alone and (b) hybrid Nd:silicate glass and Nd:YVO_4 laser when the net round-trip GVD was -1,400 fs^2, and output power was 0.65 mW.

References:

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