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LD-pumped passively Q-switched Nd : YVO_4 infrared and green lasers

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Abstract

A laser diode directly end-pumped, passively Q-switched Nd : YVO_4/Cr : YAG laser is presented in this paper. With 600 mW incident pump laser, Q-switched 1064 nm laser with an average power of 138 mW, pulse width of 19.8 ns, repetition rate of 170.1 kHz and peak power of 40.96 W is obtained. When a KTP crystal was inserted into the cavity, Q-switched 532 nm laser with an average power of 56 mW, pulse width of 28.4 ns, repetition rate of 118.2 kHz and peak power of 16.7 W is obtained at last.

Keywords: LD-pumped; Nd : YVO_4 laser; Passive Q-switch

1. Introduction

In recent years, great attention has been paid to high peak power all-solid-state blue–green laser for some applications, such as spectroscopy, display, optical data storage, undersea communications and so on. The intracavity frequency doubling of a cw laser-diode-pumped Q-switched Nd-doped solid-state laser is one of the most efficient ways to generate these wavelengths. Furthermore, laser-diode-pumped all-solid-state laser device has high efficiency, small volume and compact structure, very convenient for application.

Recently, Cr : YAG used as passive Q-switch has received much attention [1]. Cr : YAG, which demonstrates saturable absorption property at the wavelength range of 0.9–1.2 μm, has the advantages of large absorption cross section, moderate excited-state lifetime, high doped-ion concentration, good thermal conductivity, high damage threshold, low saturation intensity, no degradation with time, durability, stable physical and chemical properties. So it is considered to be an ideal saturable absorber as passive Q-switch for Nd-doped lasers to obtain high peak power and high repetition rate pulse.

Lamp and LD pumped Q-switched lasers with Cr : YAG have been successfully demonstrated for Nd : YAG, Nd : YLF and Nd : S-FAP [2–4]. But there are few reports on passively Q-switched Nd : YVO_4/Cr : YAG infrared laser [5]. As to intracavity frequency doubling of a cw laser-diode-pumped Cr : YAG Q-switched Nd : YAG, Nd : YVO_4 or Nd : YLF solid-state laser, none has been reported yet as far as we know [6,7].

In this paper, by using a cw laser diode as pump source, Cr : YAG as passive Q-switch, with 600 mW incident pump laser, Q-switched infrared laser with an average power of 138 mW, pulse width of 19.8 ns, repetition rate of 170.1 kHz and peak power of 40.96 W was obtained. When a KTP crystal was inserted into the cavity, Q-switched green laser with an average power of 56 mW, pulse width of 28.4 ns, repetition rate of 118.2 kHz and peak power of 16.7 W was obtained at last.

2. Passively Q-switched infrared laser

Fig. 1 shows the experimental setup of Q-switched 1064 nm laser. By using a cw laser diode to directly pump Nd : YVO_4 crystal, continuous 1064 nm laser emission could be obtained easily. Then, Cr : YAG was placed next to Nd : YVO_4, so that Q-switched laser would be achieved.

LD is a continuous GaAlAs quantum-well laser diode with a maximum power of 1 W, emission cross section of $100 \times 1\ \mu m^2$ and divergent angle of $7.8 \times 28.6\ deg^2$. By TEC, LD's emitting wavelength is tuned to Nd : YVO_4's

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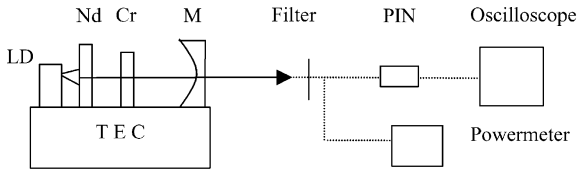

LD—laser diode Nd—Nd:YVO_4 Cr—Cr:YAG
M—output mirror TEC—thermoelectric cooler

Fig. 1. Setup of passively Q-switched 1064 nm laser.

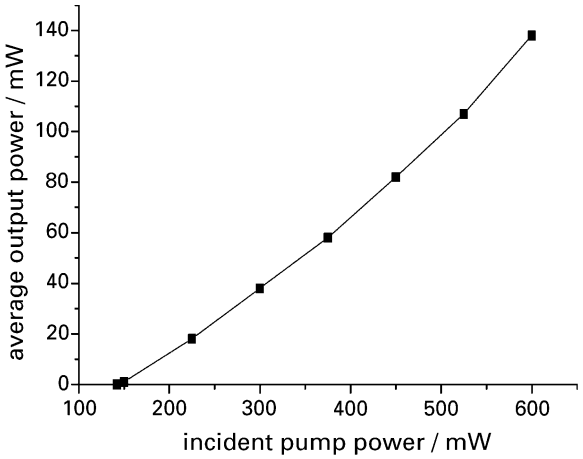

Fig. 2. Average output power of Q-switched 1064 nm laser as a function of incident pump power.

absorption peak to make Nd : YVO_4 fully utilize the pump light.

In the setup, because LD's emission cross section is very small, no optical coupling system is used, namely, pump light is directly injected into Nd : YVO_4 next closely to it. The "bell shaping effect" of Cr : YAG [1], which restrains high-order modes from oscillating, can ensure only TEM_{00} mode operation.

The left facet of Nd : YVO_4 (1.15 mm thick, 3 at% doped) is coated with 808 nmAR(anti-reflection) and 1064 nmHR(high-reflection) as a reflective mirror of the resonator, and right facet with 1064 nmAR. Both sides of Cr : YAG ($7\times7\times1.4$ mm^3, $T_0=87\%$ for small signal) are coated with 1064 nmAR. The transmission of output mirror (M, $\rho=50$ mm) at 1064 nm is about 8%. The resonator's length is about 9 mm.

By a powermeter (LabMaster Ultima, model P540), a PIN (model GT-106) and a digital storage oscilloscope (LeCroy, model 9361C, 300 MHz bandwidth) are used to measure the average power, peak power, pulse width and period of Q-switched infrared laser.

Fig. 2 shows the average output power of Q-switched 1064 nm laser as a function of incident pump power. The threshold is about 142 mW. When the incident pump laser is 600 mW, the Q-switched infrared laser with an average power of 138 mW, pulse width of 19.8 ns, repetition rate of 170.1 kHz and peak power of 40.96 W is obtained, optical to optical conversion efficiency is up to 23%.

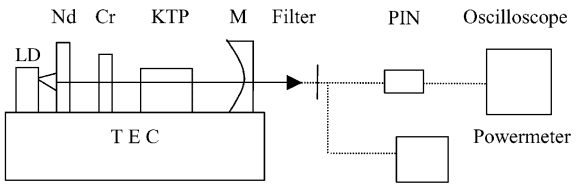

Fig. 3. Setup of passively Q-switched 532 nm laser.

3. Passively Q-switched green laser

When a piece of KTP was placed in Fig. 1 closely next to Cr : YAG, Q-switched 532 nm laser would be achieved. The experimental setup is shown in Fig. 3, in which, both sides of KTP ($2\times2\times9$ mm^3, type-II phase matching) are coated with 1064/532 nmAR, and M is a green light output mirror, coated with 1064 nmHR/532 nmAR. Here, resonator's length is about 15 mm.

Measurements show that the threshold of Q-switched green laser is about 240 mW. When the incident pump laser is 600 mW, the Q-switched green laser with an average power of 56 mW, pulse width of 28.4 ns, repetition rate of 118.2 kHz and peak power of 16.7 W is obtained, optical to optical conversion efficiency is more than 9.3%.

Fig. 4 has shown the output average power, peak power, repetition rate and pulse width of Q-switched green laser as a function of incident pump power. It shows that the average power and peak power greatly increase, while repetition rate and pulse width increase then decrease, while pump power is increasing.

4. Conclusions

By using a cw laser diode as pump source, Cr : YAG as passive Q-switch, passively Q-switched Nd : YVO_4 infrared and green lasers have been successfully demonstrated in this paper. With 600 mW incident pump laser, Q-switched 1064 nm laser with an average power of 138 mW, pulse width of 19.8 ns, repetition rate of 170.1 kHz and peak power of 40.96 W was obtained. When a KTP crystal was inserted into the cavity, Q-switched 532 nm laser with an average power of 56 mW, pulse width of 28.4 ns, repetition rate of 118.2 kHz and peak power of 16.7 W was obtained at last.

In addition, both average and peak powers of the Q-switched infrared and green Nd : YVO_4 laser increase sharply as the pump power increases. Now, we are preparing to use a 2 W laser diode and a "V-shaped" folded cavity to achieve better Q-switched performance.

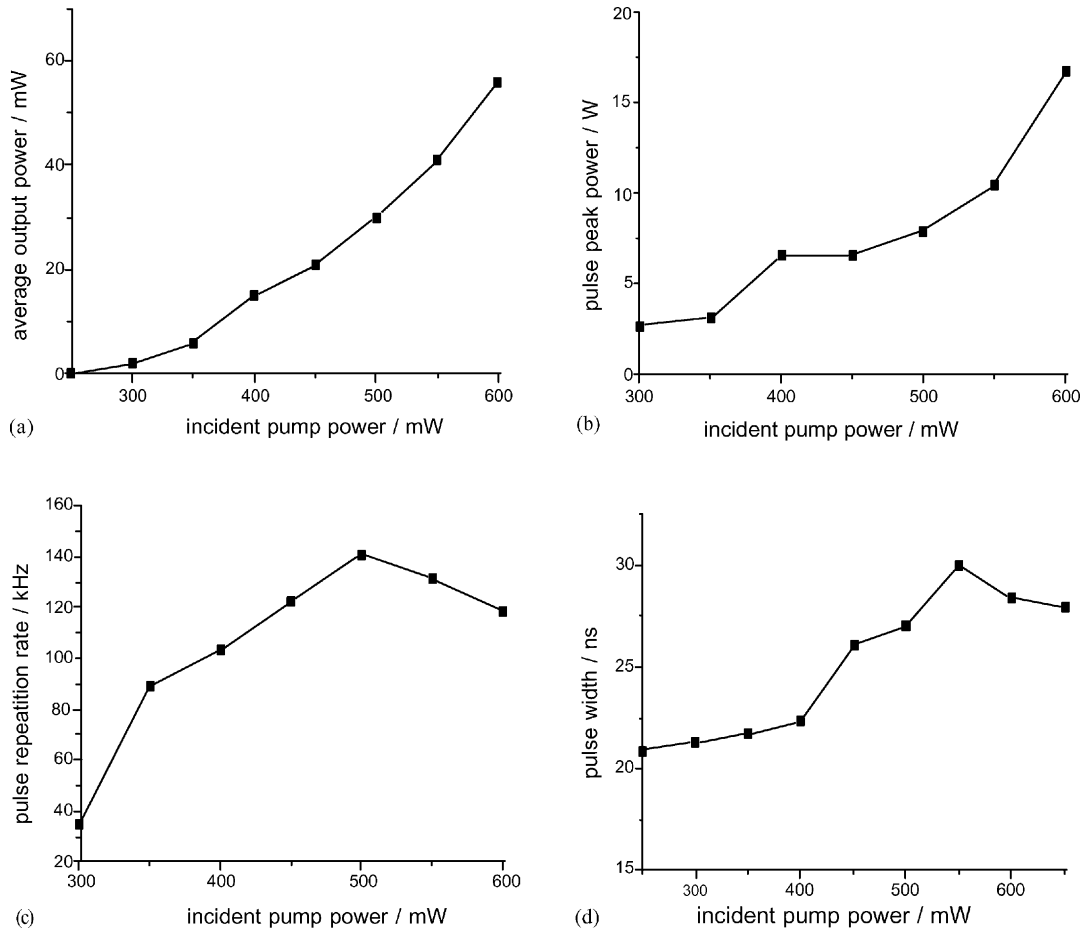

Fig. 4. Parameters of Q-switched 532 nm laser as a function of incident pump power. (a) Average output power vs. incident pump power; (b) Peak power vs. incident pump power; (c) Repetition rate vs. incident pump power; (d) Pulse width vs. incident pump power.

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Further reading

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