P2-24 High Peak-Power Passively Q-switched Microchip Nd:S-VAP Lasers for Remote Sensing Applications

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Abstract

A compact diode-pumped passively Q-switched Nd:S-VAP laser has been demonstrated with Cr^{4+}:YAG crystal as the saturable absorber. When CW pumped with a 1 W high-brightness laser diode, stable laser pulses of duration of 2.9 ns and energy of 13.7 μJ are observed with with a peak power of 4.6 kW.

Compact, all-solid-state Q-switched lasers are of potential interest for numerous applications such as micromachining, ranging, remote sensing and microsurgery. Compared with active Q-switching, passive techniques that use saturable absorbers can significantly simplify the operation, improve the efficiency, the reliability and the compactness, and reduce the costs of laser sources. Neodymium-doped strontium fluoro-vanadate ($Nd:Sr_5(VO_4)_3F$ or Nd:S-VAP) shows single, narrow line emission at 1.065 μm with a high emission cross-section of 5×10^{-19} cm^2. The absorption bandwidth at 809 nm is nearly twice that of Nd:YAG, and the fluorescence lifetime of 230 μs is more than 2 times that of $Nd:YVO_4$. Thus, Nd:S-VAP should be another favourable candidate for laser-diode-pumped, compact, and passively Q-switched laser sources in spite of its inferior thermal properties. So far, CW and dye film Q-switched Nd:S-VAP lasers have been demonstrated [1,2], but no, to the best of our knowledge, Cr^{4+}:YAG passively Q-switched Nd:S-VAP laser has been reported. In this letter, we report the demonstration of pulsed Nd:S-VAP lasers passively Q-switched whith Cr^{4+}:YAG saturable absorbers. When CW pumped with a 1 W laser diode, stable laser pulses as short as 2.9 ns with peak power of 4.6 kW were generated by using a simple two-mirror cavity configuration, in which no intracavity focusing is needed like in that of the $Nd:YVO_4$ lasers [3].

The Q-switched operation was achieved with the insertion of Cr^{4+}:YAG samples into the laser cavity. The cavity length used for Q-switching measurements was ~ 5 mm and the output coupler has a transmission of 10% at 1.06 μm. The temporal pulse shape was recorded by a HP 54600B digital oscilloscope and a fast photodiode. Figure 2 summarizes the pump-power dependence of the pulse energy, the pulse width (FWHM) and the peak power for the three Cr^{4+}:YAG saturable absorbers. For the T_0 = 95% sample, 14.9 ns pulses with a repetition rate of 25.6 kHz were observed at the maximum incident of 904 mW, the corresponding pulse energy and peak power are 7.1 μJ and 0.5 kW, respectively. As saturable absorbers with a lower initial transmission are used, pulses with higher peak power were generated although the average output power reduced. Pulses of 5.5 ns width with a repetition rate of 18.0 kHz are generated by using a T_0 = 90% Cr^{4+}:YAG, which correspond to a pulse energy of 9.3 μJ and a peak power of 1.7 kW. The highest pulse energies and peak powers are generated when the saturable absorber with initial transmission of 80% is used. At maximum pump power of 904 mW, pulses of 2.9 ns duration with a repetition rate of 7.7 kHz are detected. Compared with the average output power, the pulse energy and peak power are 13.7 μJ and 4.6 kW, respectively. The experimental results show that the peak-to-peak intensity fluctuations and the interpulse time jittering are < 5% and < 3%, respectively. For the

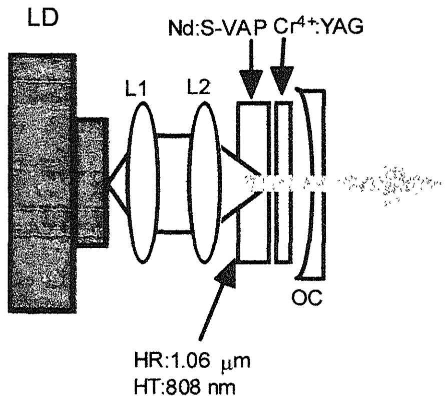

Fig. 1 Schematic diagram of the passively Q-switched Nd:S-VAP laser

T_0 = 95% Cr^{4+}:YAG Q-switched laser, we noted that the pulse train had an obvious tendency to bifurcate and produce alternating strong and weak pulses when the pump power grater than 500 mW (f_{rep} > 20 kHz). It seems that the relative intensity ratio of the two set pulses depend directly on the pump intensity. Stable pulses of uniform amplitude can be obtained at the highest pump power of 904 mW by using a larger pump beam size in the laser crystal.

Compared with a passively Q-switched $Nd:YVO_4/Cr^{4+}:YAG$ laser [4], $Cr^{4+}:YAG$ passively Q-switched Nd:S-VAP lasers can offer pulses with much more higher peak powers even though the $Nd:YVO_4$ laser possess a lower threshold power and a higher optical conversion effciency. In addition, to optimize the passive Q-switching effect, special design has to be made in a $Nd:YVO_4/Cr^{4+}:YAG$ laser to ensure a much smaller beam size in $Cr^{4+}:YAG$ than in $Nd:YVO_4$ [3], which makes the laser design more complex than that of the passively Q-switched Nd:S-VAP and Nd:YAG lasers. We observed that, in a passively Q-switched Nd:S-VAP laser, stable pulses can still be generated even when the beam size in $Cr^{4+}:YAG$ is larger than that in laser crystal. When the output coupler was replaced by a one with a radius of curvature of 25 cm and the cavity length is extended to ~ 10 cm, stable pulses are detected when the distance between Nd:S-VAP and $Cr^{4+}:YAG$ are smaller than 7 cm. At this position, the beam area in $Cr^{4+}:YAG$ is estimated to be about 1.3 times that in laser crystal.

Compared with $Nd:YVO_4$, the main drawback of Nd:S-VAP is its inferior thermal property. But thermal problems are not so serious in the low-power level lasers. We believe that Nd:S-VAP is suitable for laser-diode-pumped, compact, high peak power laser sources in the low average power region.

In conclusion, we have demonstrated the performance of a diode-pumped passively Q-switched Nd:S-VAP laser with $Cr^{4+}:YAG$ as the saturable absorbers. Stable laser pulses with peak power of 4.6 kW, pulse energies of 13.7 μJ, and pulse durations of 2.9 ns are generated. In addition, effective Q-switched operation can be realized by using a conventional plano-concave cavity, no intracavity focusing is needed like in that of the $Nd:YVO_4$ lasers.

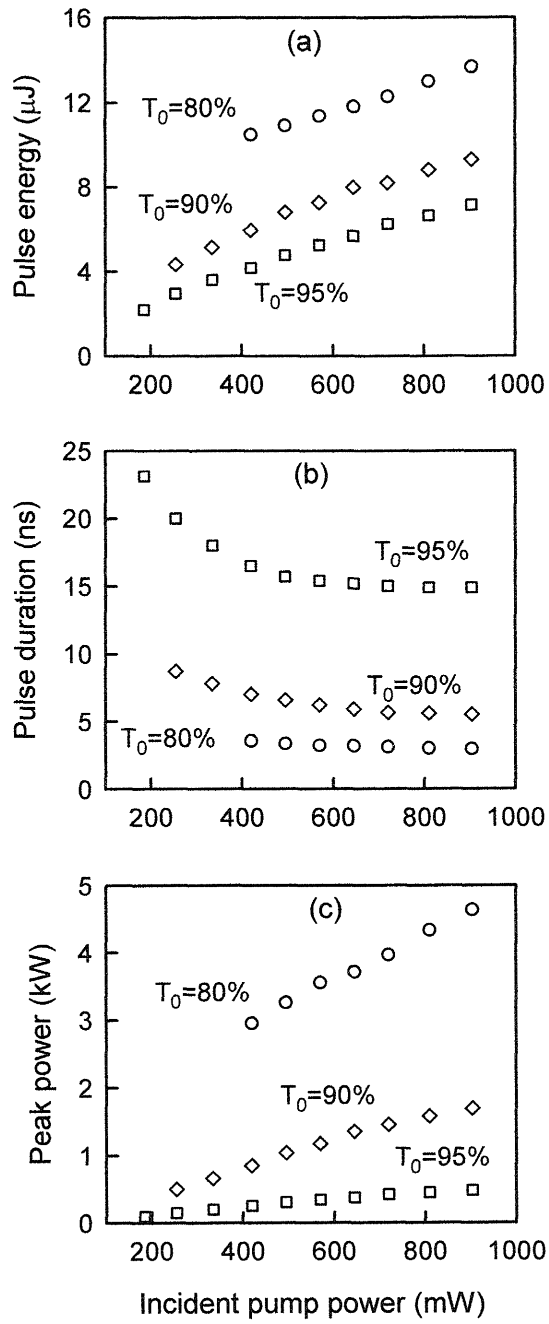

Fig. 2 Pulse parameters versus incident pump power for $Cr^{4+}:YAG$ saturable absorbers of initial transmission T_0 = 80%, 90% and 95%, respectively. (a) Pulse energy, (b) Pulse duration, (c) Peak power.

References

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