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Self-Q-switched Nd:GGG laser

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ABSTRACT

In this paper, the self-Q-switched Nd:GGG laser at 1061 nm was demonstrated. The self-Q-switched pulses were obtained by adjusting the output coupler. Under pump power of 2.1 W, the output power of 89.5 mW and pulse energy of 1.83 μJ was obtained with 1.5% output coupler, the corresponding pulse width was 4.8 μs with a repetition rate of 48.94 kHz. In addition, we have firstly reported the SQS operation in Nd:GGG crystal.

1. Introduction

Passively Q-switched (PQS) lasers were demonstrated with high pulse energy and high efficiency [1]. With saturable absorber (SA) inserted into the laser cavity or combined the laser medium and cavity, the PQS lasers could be obtained. The PQS lasers can be divided as SA-based lasers and self-Q-switched (SQS) lasers. Recently, SA-based Nd-doped lasers are widely reported by using Nd:YAG, Nd:$LaSc_3(B03)_4$, Nd:LSB, Nd:$GdVO_4$, Nd:GYSGG, Nd:YVO_4, Nd:$GYNbO_4$, Nd:$GdTaO_4$, Nd:GGG and Nd:$GdLaNbO_4$ [2–11]. Compared with SA-based lasers, the advantages of SQS lasers are obviously, such as no insert loss and simple structure. Recently, SQS lasers had been reported by many researchers. The doped crystals became more diverse: Cr,Nd:YAG, Nd:YVO_4, Nd,Cr:YAG, Cr:$Y_3Al_5O_{12}$, Cr,Nd:$Y_3Al_5O_{12}$, Cr,Yb:YAG, Yb:YAG/Cr,Yb:YAG, Yb:$Y_3Al_5O_{12}$/Cr:$Y_3Al_5O_{12}$, Nd:Cr:YVO_4, Cr:LiCAF, Yb:CGB and Nd:GYSGG [12–23]. These early works show that Nd-doped, Cr-doped and Yb-doped crystals are excellent self-Q-switched laser materials, but there still no reports in Nd:GGG crystal due to the fast recover time.

In this paper, we investigated SQS operation in Nd:GGG crystal at 1061 nm for the first time. The SQS pulses were obtained by adjusting the output coupler (OC). Under pump power of 2.1 W, the output power of 89.5 mW and pulse energy of 1.83 μJ was obtained with 1.5% OC, the corresponding pulse width was 4.8 μs with a repetition rate of 48.94 kHz. In addition, we have firstly reported the SQS operation in Nd:GGG crystal.

2. Experiential setup

Fig. 1 shows the schematic setup of Nd:GGG laser on SQS operation, and the Z-folded cavity length is 1.5 m. The emission wavelength of the laser diode (LD) is 808 nm. The spot radius on Nd:GGG crystal was 0.1 mm with numerical aperture of 0.22. The aperture of 3 mm × 3 mm and length of 8 mm was employed in the crystal. The crystal was AR-coated at 808 nm on the pump face, HR-coated at 1.06 μm and HT-coated at 808 nm on the output face. Mirrors M1 and M2 are concave mirrors. The OC with transmission of 1.5% at 1.06 μm was used.

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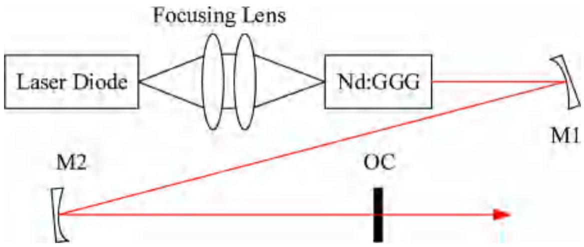

Fig. 1. Schematic setup of Nd:GGG laser on SQS operation.

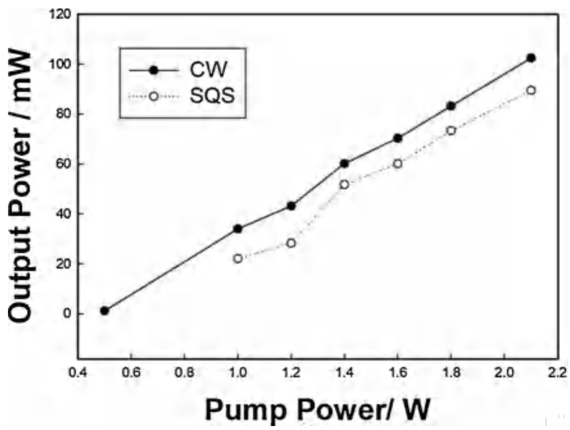

Fig. 2. Relationship between output power and pump power under SQS and CW operations. (a) Pulse trains (50 μs/div) and (b) single pulse profile (10 μs/div).

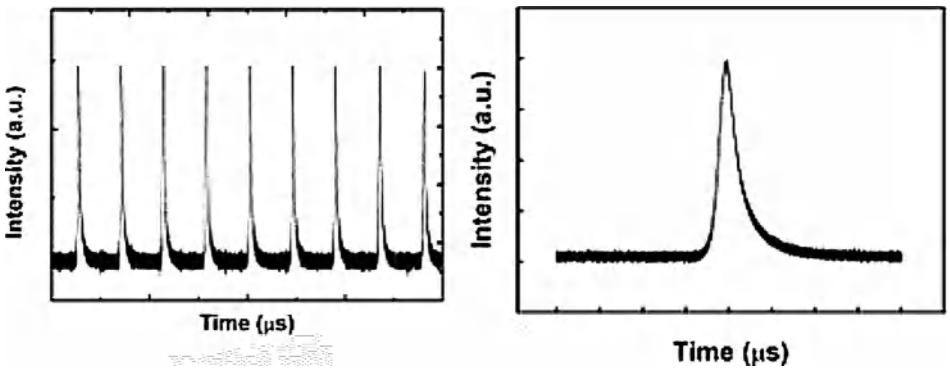

Fig. 3. Pulse profile of the SQS Nd:GGG laser.

3. Results and discussions

The SQS operation in Nd:GGG crystal was observed at some special positions with stable cavity by adjusting the angle of the OC. Fig. 2 shows the relationship between output power and pump power under SQS and CW operations. The threshold pump power of the CW laser was 0.5 W with output power of 1.2 mW. The threshold pump power of the SQS laser was 1.0 W with output power of 22.1 mW. Under pump power of 2.1 W: the output power of the SQS laser was 89.5 mW with optical conversion efficiency of 4.26%; the output power of the CW laser was 102.4 mW with optical conversion efficiency of 4.88%.

The pulse profile of the SQS Nd:GGG laser can be seen in Fig. 3. The pulse trains were stable and had few amplitude jitters in Fig. 3.

Fig. 4 shows the variation of the pulse width and repetition rate with increasing pump power. From this figure we could figure out that: with increasing pump power, the repetition rate increased from 41.20 kHz to 48.94 kHz, and the pulse width decreased from 6.0 μs to 4.8 μs.

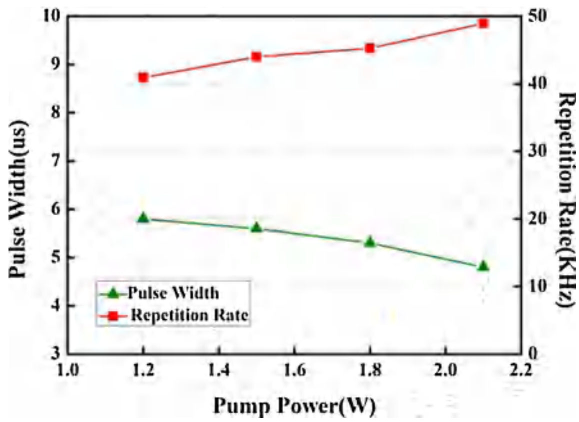

Fig. 4. Variation of the repetition rate and pulse width with increasing pump power.

4. Conclusion

In conclusion, the SQS Nd:GGG laser at 1061 nm was demonstrated with 1.5% output coupler. The train of SQS pulses can be obtained with the angle of output coupler changed under stable CW output condition. The pulse trains were stable and had few amplitude jitters. With pump power of 2.1 W, the output power of 89.5 mW and pulse energy of 1.83 μJ was obtained, the corresponding pulse width was 4.8 μs with a repetition rate of 48.94 kHz. Moreover, we have firstly reported the SQS operation in Nd:GGG crystal.

Declaration of Competing Interest

The authors declare no conflict of interest.

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