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2.3 μm nanosecond passive Q-switching of an LD-pumped Tm:YLF laser using gold nanorods as a saturable absorber

Key words: Gold nanorods; Passive Q-switching; 2.3 μm; Tm-doped laser materials

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Motivation

1. 2.3 μm thulium laser using the $^3H_4 \rightarrow {}^3H_5$ transition has important potential applications in medical diagnosis and gas detection.

2. Gold nanorods have become popular as nanomaterials because of their morphology-dependent anisotropic optical properties. Acting as saturable absorbers, gold nanorods have a number of advantages, such as ultrafast nonlinear responses and broadband saturable absorption.

3. Using LD pumping, we can build a more compact laser with a higher 2.3 μm laser output. Furthermore, the absorption peak of gold nanorods with a large aspect ratio can be extended to longer wavelength. Therefore, the performance of passively Q-switched operation of LD pumped 2.3 μm thulium doped solid-state laser using the gold nanorod saturable absorber is worthy of research.

Main idea

1. A 785 nm LD end-pumped 2.3 μm Tm:YLF laser is configured, generating watt-level continuous-wave output power.
2. The gold nanorods with an average aspect ratio of 15 are exploited to obtain a larger surface plasmon resonance wavelength.
3. To minimize the additional insertion loss, a saturable output coupler was fabricated by drop-casting the gold nanorods on the output coupler.

Method

1. To achieve a compact configuration, a 785 nm LD was used as the pumping source. An input mirror of M1, a laser crystal of Tm:YLF, and an output coupler of M2 were placed successively in the resonator. The gold nanorods were drop-casted on the output coupler to minimize the additional insertion loss.

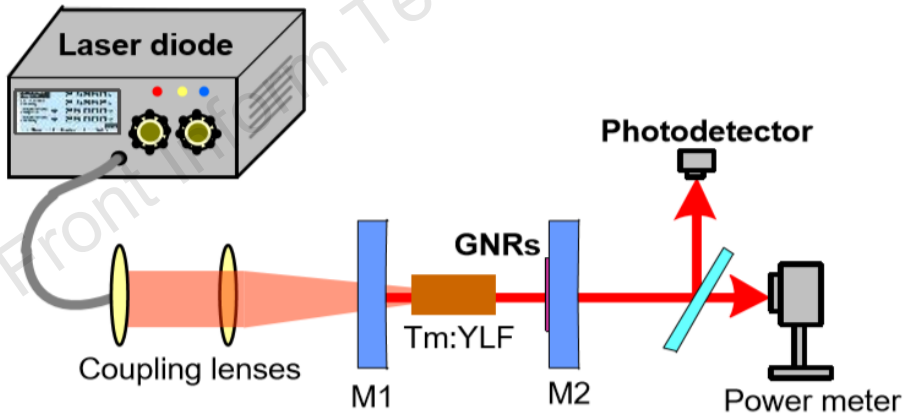

Fig. 1 Sketch of the LD-pumped Tm:YLF laser used in this analysis

Method

2. The gold nanorods with an average aspect ratio of 15 are used. The absorption induced by the surface plasmon resonance of gold nanorods can be extended to the 2.3 μm region.

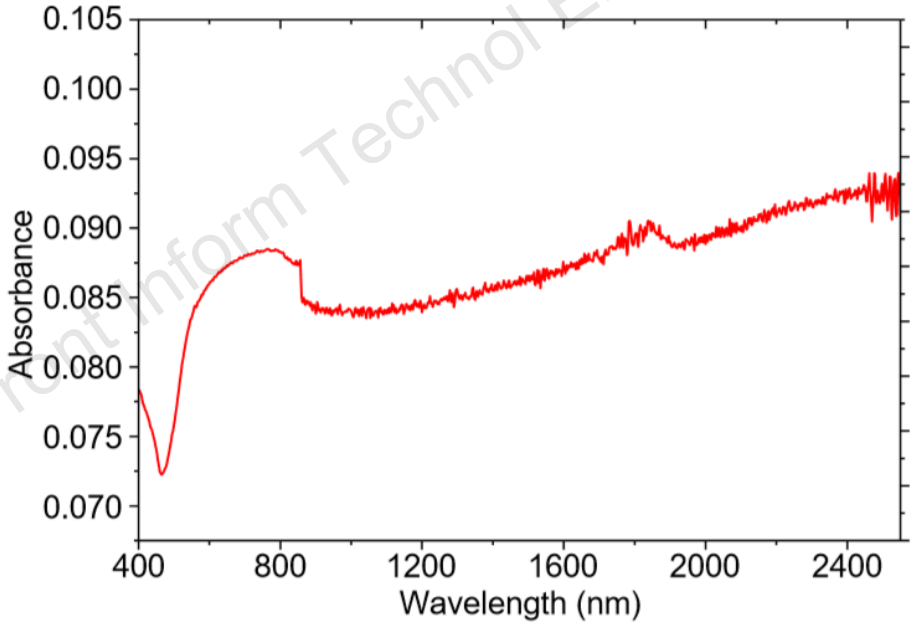

Fig. 4 Absorption spectrum of GNRs used in this experiment

Major results

Output spectrum and output power

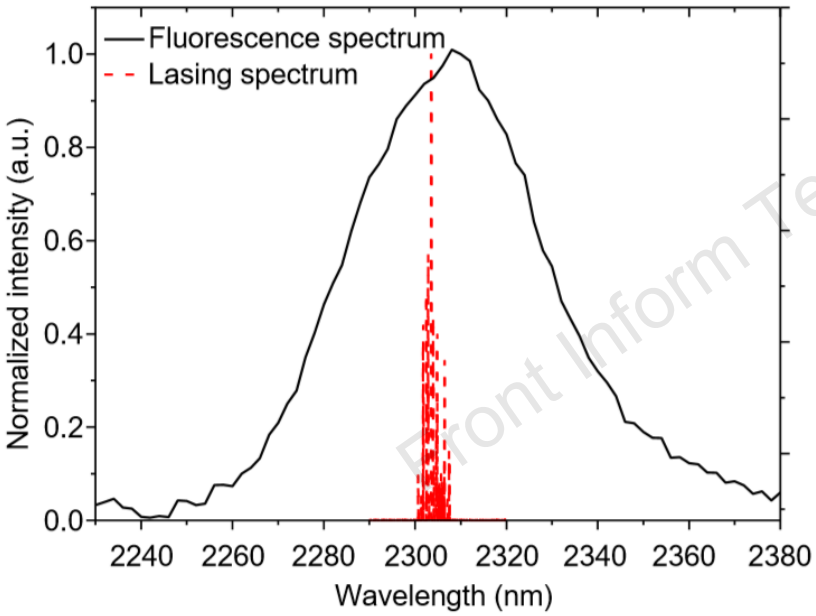

Fig. 2 Lasing spectrum of the LD-pumped Tm:YLF laser alongside the fluorescence spectrum

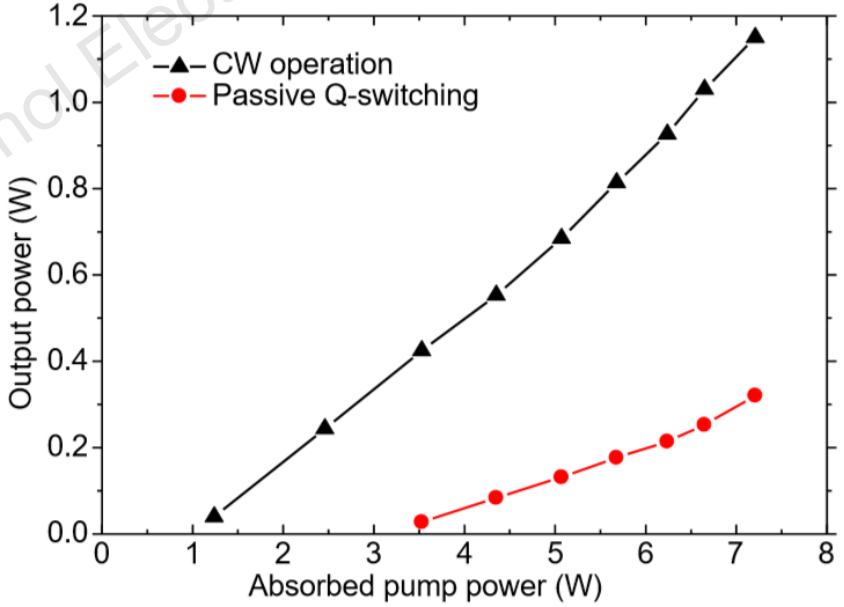

Fig. 3 Output power and absorbed LD pump power

Major results

Pulse characteristics

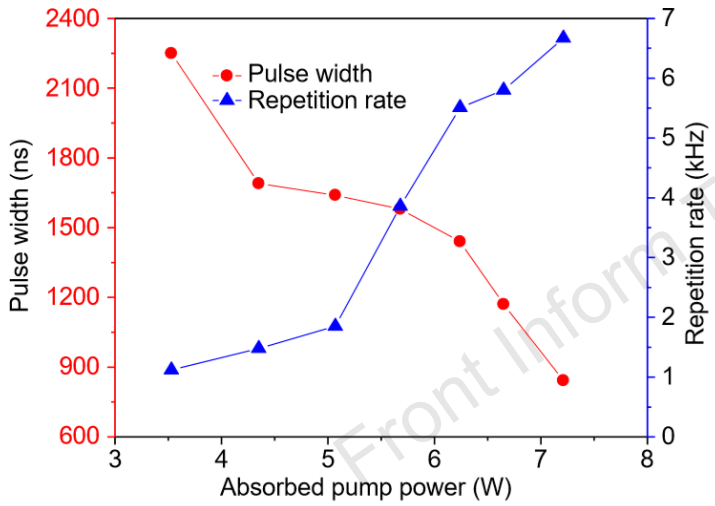

Fig. 5 Pulse characteristic dependence on absorbed LD pump power

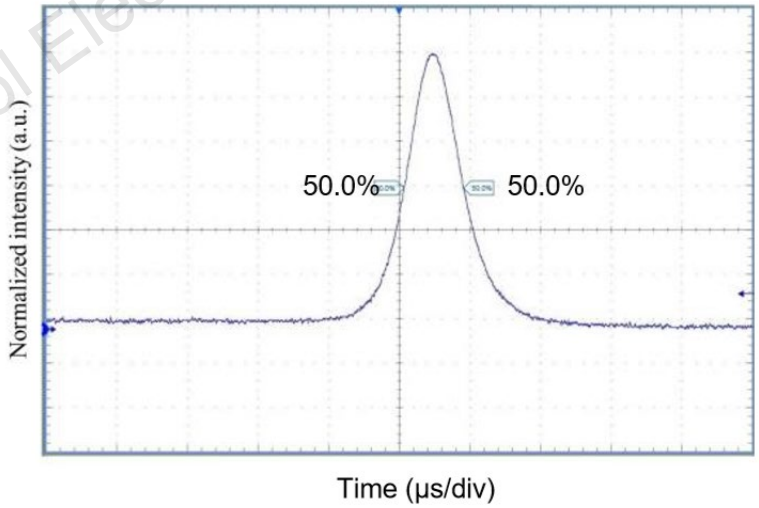

Fig. 6 Shape of the 843 ns pulse

Conclusions

1. Passive Q-switching of an LD pumped 2.3 μm Tm:YLF laser using gold nanorods as saturable absorbers was configured in the experiment.

2. Q-switched pulses with 843 ns pulse width, 6.67 kHz pulse repetition rate, and 320 mW average output power were obtained.