Passively Q-switched Er:YAP laser generating 21 ns pulses at 2.9 µm

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Laser sources emitting in the mid-infrared spectral range from 2 to 8 µm can be utilized in various applications (spectroscopy, remote sensing, polymer processing, medicine, etc.). [1,2]. Laser generation in short-wavelength part of this range (around 3 µm) can be directly obtained from diode-pumped erbium-doped active. For medical and spectroscopy applications, there is particularly a desire for compact systems generating short pulses with high peak power in this spectral range. From this point of view, the passive or active Q-switching method is an ideal method for pulse generation. Passive Q-switching with saturable absorber allows building a very compact laser resonator without requirements on additional power sources or special crystals. Moreover it is a simple method to obtain the short pulses close to 3 µm. [1-3] The goal of this contribution is investigation of Er:YAP laser emitting radiation in a Q-switching regime with the shortest possible pulses.

The tested crystal Er:YAP (5 at. % of Er^{3+}, b – cut, Crytur) had a form of a rectangular block (9 mm in length) with polished faces (3 × 3 mm). The Er:YAP was placed inside the hemispherical laser resonator (length 45 mm) consisting of a flat pumping mirror and spherical output coupler (OC, radius 50 mm, R = 95 % @ 2.9 µm). The laser diode (emitted wavelength 976 nm, focusing optic 1:2, and waist beam diameter 250 µm) operated in pulsed regime, repetition rate 10 Hz and pulse duration 5 ms, was used as pumping source. The passive Q-switching was realized by semiconductor saturable absorber (SA-2800-10-10ps-5.0-12.7g-e, Batop GmbH). The energy probe (J10-MB-LE, Coherent) was utilized for the measurement of the output energy of the Q-switched pulses. The pulse duration was measured using a photodiode (PVI-4TE-6, time constant 0.5 ns, VIGO System S.A.) connected to an oscilloscope (TDS3052B, 500 MHz, 5GS/s, Tektronix).

Firstly, the Er:YAP laser was tested in a free-running regime without a saturable absorber to characterize the output laser parameters. In a free-running laser regime, the slope efficiency, maximum output mean power, and laser threshold were reached with respect to the absorbed mean power of 25.5 %, 200 mW, and 67 mW, respectively. Er:YAP laser emitted radiation at 2920 nm in fundamental mode. Consequently, the SA was placed into the resonator within Er:YAP and OC, then the Q-switching laser was successfully realized. In Fig. 1(a) the measured pulse duration (under maximal pumping) is presented. The shortest output pulses reached 21.8 ns at FWHM with peak power with a corresponding peak power of 24.8 W, pulse energy of 0.54 µJ, and a repetition rate of 41.6 kHz. The pulse duration and repetition rate were decreased with decreasing pumping power which is presented in Fig. 1(b). This type of compact laser system can be further utilized in spectroscopy, alternatively in polymer processing if the pulse will be amplified to a sufficient energy level. We believe that using a saturable absorber with higher absorption should further increase the pulse energy and peak power.

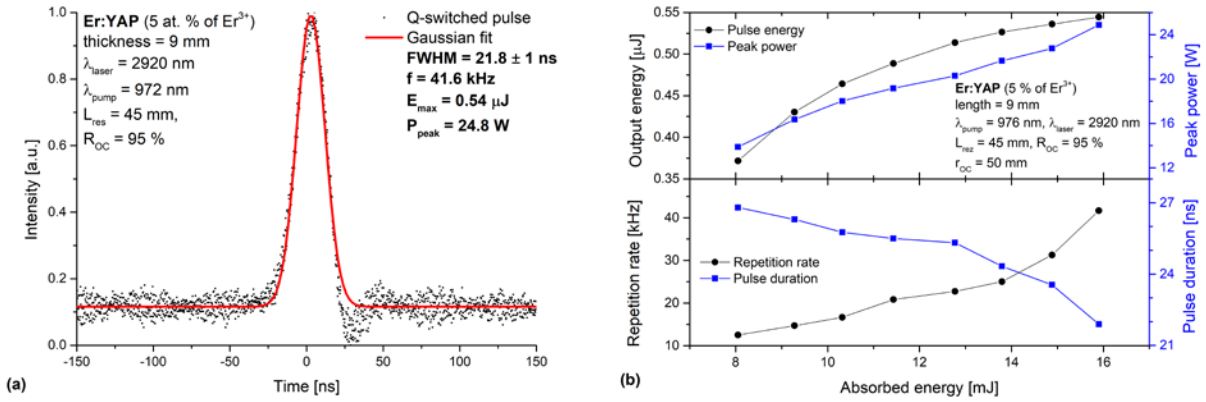

Fig. 1 Short pulse generated in Q-swtichitng (a) and characterization of Q-switching regime (b); Δt – pumping pulse duration, f – frequency, λ_{pump} – pumping wavelength, λ_{laser} – emission wavelength, FWHM – pulseduration, P_{peak} – peak power, E_{max} – maximal pulse

References

[1] Rüdiger Paschotta, *Encyclopedia of Laser Physics and Technology*, 1. Edition (Wiley-VCH, Berlin, 2008).
[2] Švejkar, R., Šulc, J., Jelínková, H., Er-doped crystalline active media for ~ 3 µm diode-pumped lasers, Progress in Quantum Electronics, 2020, vol. 74, p.100276, ISSN 0079-6727, doi:10.1016/j.pquantelec.2020.100276.
[3] J. Frauchiger, W. Lüthy, P. Albers, H. P. Weber, Laser properties of selectively excited $YAlO_3$:Er, Opt. Lett. 13 (11) (1988) 964–966. doi:10.1364/OL.13.000964.