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Passively Q-switched thulium-doped silica fiber laser

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A thulium-doped fiber laser generated pulses with 12 μJ energy and 16 ns duration at 1822 nm, when passively Q-switched by a Cr^{2+}: ZnSe crystal saturable absorber. The repetition rate varied between 2 - 20 kHz.

Compact and high power pulse lasers in the mid IR optical range are needed for medical application as well as for remote measurements in the atmosphere. Fiber lasers are an attractive way to generate high peak power pulses. Recently, passively Q-switched erbium fiber laser in the eye safe spectral range (~ 1.5 μm) has been demonstrated using Co^{2+}:ZnSe as a saturable absorber[1]. Libatique and co-workers[2] have shown Er:ZBLAN mid-infrared fiber lasers operated at 2.8 μm using liquefying gallium mirror as saturable absorber. This laser gave long pulses of 7 μs with relatively low energy (38nJ). Actively Q-switched Tm fiber laser was reported by Barnes and co-workers[3]. This laser generated quasi-CW pulses of 200-500 ns and with low (2.8kHz) repetition rate.

In this paper we report, for the first time to our knowledge, a passively Q-switched Tm-doped silica fiber laser with a Cr^{2+}:ZnSe crystal as a saturable absorber. The laser generates short pulses of 16ns duration (FWHM) with 12 μJ pulse energy, corresponding to a peak power of 750 W, and repetition rates within 2–20kHz. The conversion efficiency is 23% with respect to launched pump power. The emission wavelength is 1822 nm.

The experimental setup is shown in Fig.1. The Tm-doped aluminosilicate fiber used in this work is fabricated in house using the MCVD technique, and has a core diameter of 8.5 μm with NA ~ 0.16. The outer diameter is 115 μm. The fiber has 6.5 dB/m small-signal absorption at the pump wavelength, 1566 nm. The pump source is an erbium:ytterbium co-doped fiber with isolated output in a single-mode fiber. The pump is launched through a WDM coupler onto the 1 m long Tm-doped fiber. The laser cavity is formed between a 1.8 μm high-reflecting mirror and the perpendicularly cleaved end face (4 % Fresnel reflections) of the WDM coupler. The 1.2 mm thick Cr^{2+}:ZnSe saturable absorber is placed inside the cavity at the focus point between two lenses. The focused beam diameter is estimated ~25 μm. The unbleached loss of the saturable absorber is 10% in the vicinity of 1.8 μm.

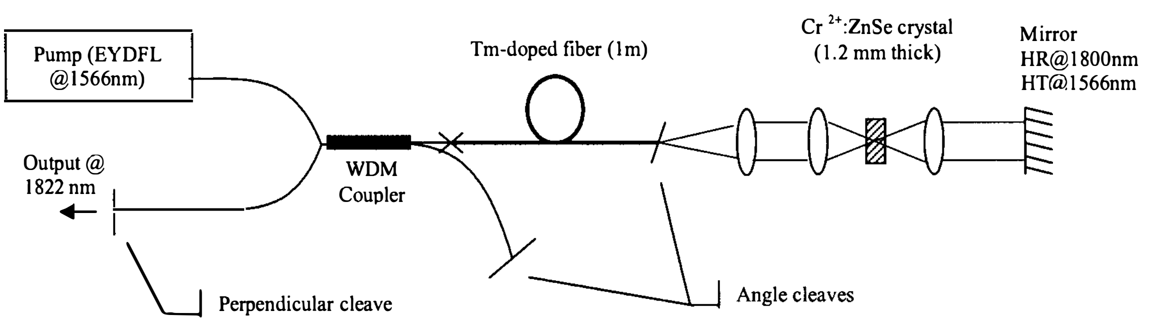

Fig.1. Experimental set-up of the passively Q-switched Tm-doped fiber laser.
WDM : wavelength division multiplexer, HR: high reflecting, HT: high transmitting.

The average output power and the repetition rate versus pump power are plotted in Fig. 2. A maximum average output power of 170 mW corresponding to a 18.5kHz repetition rate is obtained for 1.35 W of absorbed pump power. The average slope efficiency with respect to absorbed pump power is 23%. Figure 3 shows a train of short pulses with 16 ns duration (Fig. 3, inset) from our passively Q-switched fiber laser, generated at 1822 nm. The pulse duration is practically independent of the pump level. Peak powers up to 750 W and pulse energy up to 12 μJ have been obtained.

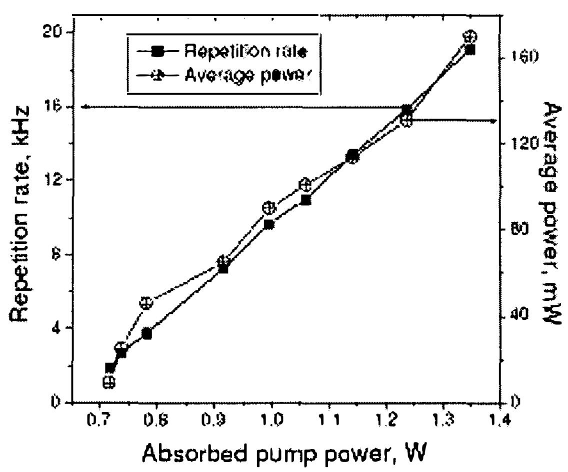

Fig. 2: Average output power and pulse repetition rate versus absorbed pump power.

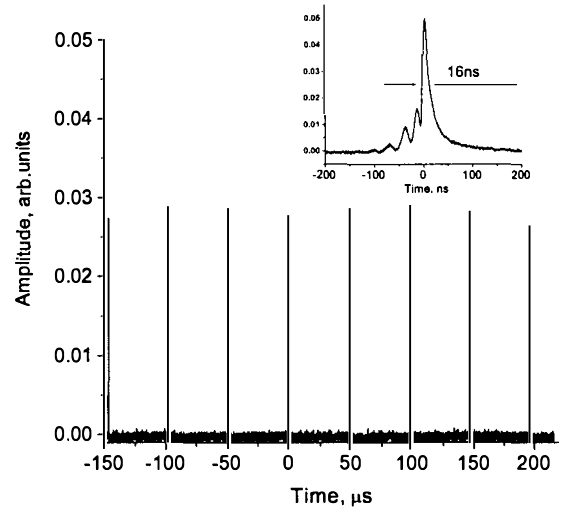

Fig. 3: Typical output pulse train and pulse shape(inset).

In summary, we have demonstrated the first passive Q-switching of Tm-doped fiber laser in the 1.8 μm spectral region with Cr^{2+}:ZnSe as a saturable absorber that yields to 16 ns pulse and an output pulse energy of 12 μJ. In addition to the results presented here wavelength tunability of the fibre laser will be discussed.

References

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[3] N.P. Barnes et al., "Diode pumped, tuneable, Q -switched Tm: glass fiber laser" in Advanced Solid State Lasers, OSA Technical Digest (Optical Society of America, Washington, Dc 2001), pp. 45 -47.