Amplification of pulsed radiation at a wavelength of 2.27 μm in a Tm^{3+}- doped tellurite fiber

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Compact laser sources operating in the spectral range of 2.2 - 3 μm are of interest both for scientific and applied problems. Such sources can be used in spectroscopy, gas detection (CO, CH_4), laser ranging, material processing, medicine and etc. [1, 2]. Researches of tellurite glasses show that fibers based on them, doped with rare earth elements, in contrast to standard silica fibers, are a promising medium for lasers and amplifiers emitting in this spectral range [3, 4].

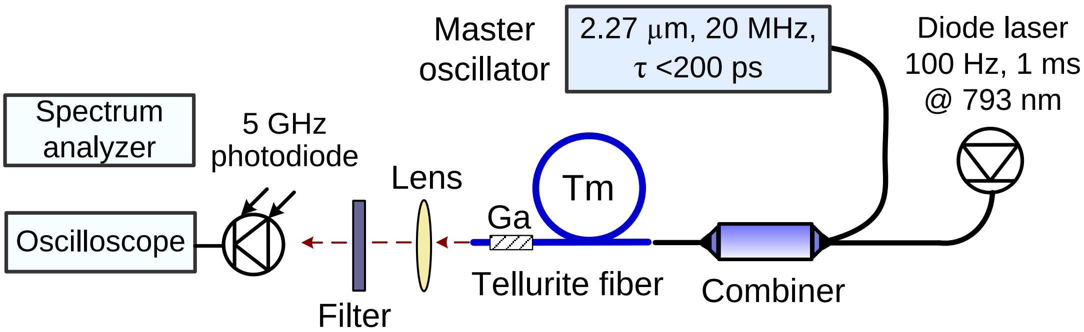

Fig. 1. Experimental setup.

Fig. 1 shows the scheme of experimental setup for amplifying of pulsed radiation at a wavelength of 2.27 μm in tellurite fiber doped with thulium ions (Tm^{3+}). A laser system consisting of a holmium-doped (Ho^{3+}) fiber laser and amplifier, a nonlinear fiber, and a spectrally selective element was used as a master oscillator (MO). The Ho^{3+}- doped fiber laser generated pulsed radiation at a wavelength of 2.07 μm with a pulse duration of about 1 ps and a repetition rate of 20 MHz. The amplified pulsed radiation was transformed in a 5 m long nonlinear fiber with a GeO_2 concentration in the core of more than 30 mol. %. Thus, broadband radiation with a peak at a wavelength of 2.28 μm was obtained. A fiber Bragg grating with a high reflection at a wavelength of 2.27 μm was used to obtain spectrally-selected pulsed radiation. Fig. 2(a) shows the spectrum of reflected part of the broadband radiation. Then, the pulsed radiation was introduced through a fiber combiner into a 1.5 m long Tm^{3+}-doped tellurite fiber. The estimated signal power at the combiner input was 30 μW. The concentration of Tm^{3+} ions in the tellurite fiber was 5×10^{19} cm^{-3}, and the diameters of the cores and cladding were 35/100/280 μm. The Tm^{3+} amplifier was pumped by a laser diode with a radiation wavelength of 793 nm and a power of 4 W. The diode radiation was modulated to prevent the destruction of tellurite fiber ends due to overheating. Modulation parameters are shown in Fig. 1.

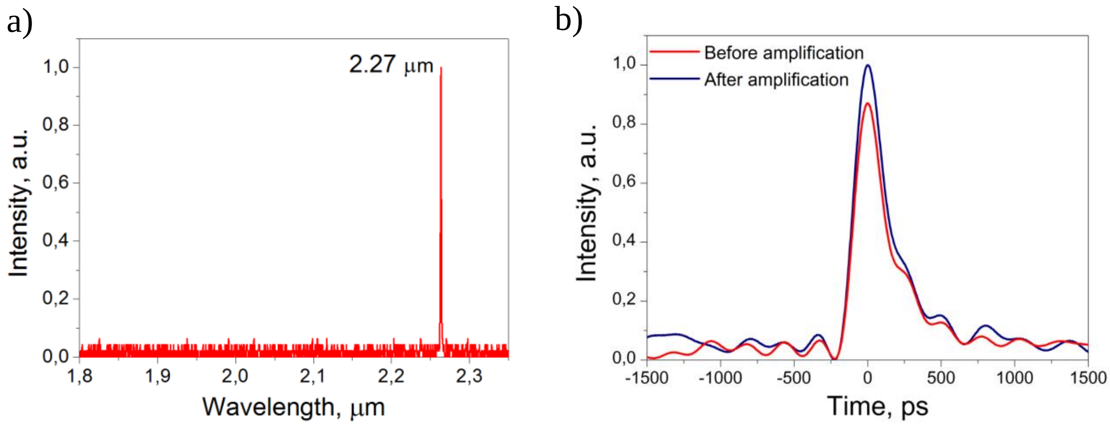

Fig. 2. (a) Reflected part of the broadband spectrum, (b) the pulse oscillograms before and after amplification in Tm^{3+}-doped tellurite fiber.

Fig. 2(b) shows the pulse oscillograms before and after amplification, measured using a 5 GHz photodiode (PD). A bandpass filter (2 – 2.5 μm) was used to cut-off the pump radiation, as well as lens for the pulsed radiation focusing at a wavelength of 2.27 μm. The spectral composition of the amplified pulsed radiation did not differ from that shown in Fig. 2(a).

Thus, we have demonstrated the amplification of spectrally selected pulsed radiation at a wavelength of 2.27 μm in a tellurite fiber doped with Tm^{3+} ions. The overall gain can be estimated as 0.8 dB/m.

References

[1] J. Ma, Z. Qin et al., *Applied Physics Reviews* **6.2**, 021317 (2019)

[2] D.C. Sordillo, L.A. Sordillo et al., *Photonic Therapeutics and Diagnostics XII*, Proc. SPIE **9689**, 96894J (2016)

[3] B.I. Denker, V.V. Dorofeev et al., *Laser Physics Letters*, **16(1)**, 015101 (2018)

[4] S.V. Muravyev, E.A. Anashkina et al., *Scientific reports*, **8(1)**, 1-13 (2018)