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Theoretical analysis of fiber lasers emitting around 810 nm based on thulium-doped silica fibers with enhanced $^3\text{H}_4$ level lifetime

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Most exploited operating wavelengths offered by rare-earth doped fiber lasers are situated around 1, 1.5 and 2 μm . In this paper we investigate thulium-doped fiber (TDF) laser operating around 800 nm that would extend the spectral range already covered by high-power fiber lasers. The single-transverse mode, high-power laser source in the 800 nm spectral band can be used for fiber sensors, instrument testing and for pumping of special types of lasers and amplifiers. Particularly, bismuth-doped fibers pumped around 800 nm may shift their gain to 1300 nm telecommunication band, where highly reliable silica-based fiber amplifiers are still unavailable. The proposed laser has a compact all-fiber setup (see Fig. 1) with upconversion pumping scheme according to Fig. 2a. Amplification and lasing at 800 nm band has already been investigated using low-phonon energy fluoride-based TDFs. Output power of up to 2 W and 37% slope efficiency was achieved [1]. However, usage of fluoride fibers results in difficulties with fabrication, hygroscopicity and aging of the host material and low pump power damage threshold as observed in [1].

Using a comprehensive numerical model of TDF we investigate performance of the proposed laser at around 810 nm in three different hosts: fluoride glass (ZBLAN), standard silica and silica modified by high alumina codoping. This last fiber composition is of interest because we have shown that with modification of local environment of the thulium ions by alumina, the fluorescence lifetime of the $^3\text{H}_4$ level is significantly increased [2, 3]. The spectroscopic parameters of the modified silica fiber used in the modelling are summarized in [4]. The main difference between the three hosts relevant to the proposed application is the $^3\text{H}_4$ fluorescence lifetime of the three different materials as noted in Fig. 2b. Because the laser characteristics of the laser output power vs. input pump power is not strictly linear due to possible population of the $^1\text{G}_4$ level, we do not compare performance of the three host materials in terms of slope efficiency and threshold. Instead, they are compared simply in terms of the output power. It can be seen in Fig. 2b that lasing at 810 nm is hardly to achieve with silica based Tm-doped fiber in contrast to the fluoride host materials. However, the lasing might be possible even for silica based fiber for specific short ranges of the fiber and laser cavity parameters, especially when $^3\text{H}_4$ lifetime is enhanced. The laser tunability and effect of photodarkening will be also discussed in the presentation.

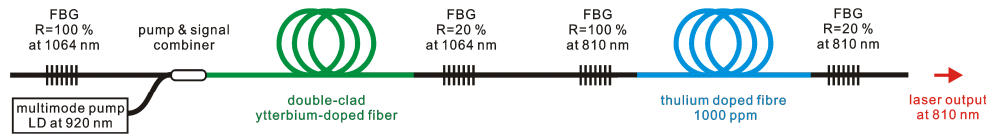


Fig. 1 Fiber laser setup in compact all-fiber arrangement.

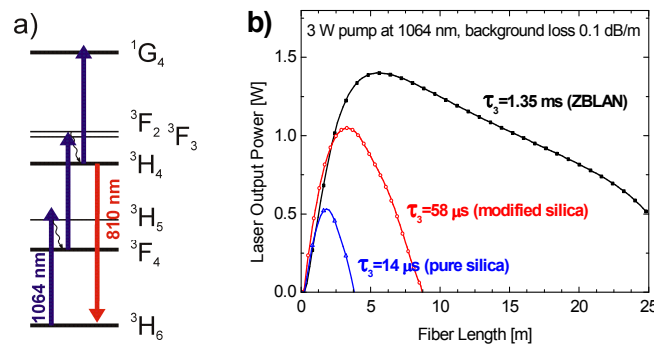


Fig. 2 Single wavelength upconversion pumping scheme (a), effect of host material (b). The optimized waveguide parameters were used: the core diameter of 3.4 μm and numerical aperture of 0.2.

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