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150-W continuous wave laser emission at 2.09 μm from a Tm^{3+} , Ho^{3+} -codoped single-oscillator monolithic fiber laser

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Laser sources emitting around 2 μm match with the infrared atmospheric window, giving them a particular interest for applications such as surgery, material processing, or optical countermeasures by pumping mid-infrared optical parametric oscillators (OPOs) [1]. Thanks to their high robustness and compactness, monolithic fiber lasers constitute one of the most promising OPO pump sources. However, for a large variety of OPOs based on ZnGeP_2 nonlinear crystals, pumping at wavelengths beyond 2 μm can be of great interest in order to avoid multiphoton absorption. To date, infrared monolithic fiber lasers have been based predominantly on thulium-doped (Tm^{3+}) active media pumped at 793 nm, for efficient laser emission at 1.95 μm wavelength, and on holmium-doped (Ho^{3+}) media pumped at 1.95 μm , to generate efficient radiations beyond 2 μm [2]. For both active media, monolithic fiber laser architectures delivering high powers around 2 μm have been largely demonstrated with MOPA (Master Oscillator Power Amplifier) systems [3]. Nevertheless, the high number of amplification stages needed to get a high average output power, and limitations due to MOPA laser physics (amplification stages isolation, ASE filtering, nonlinear effects) lead to high complexity and volume for such laser sources. In this contribution, we present a high power monolithic fiber laser emitting at 2.09 μm in continuous waves (CW) regime. This fiber laser takes advantage of a simple all-fiber single-oscillator architecture design, and a Tm^{3+} , Ho^{3+} -codoped fiber to provide a compact and robust laser source.

The laser setup (Fig. 1a) consists of a 5 m-long silica double-clad PM fiber (iXblue Photonics) with a Tm^{3+} , Ho^{3+} -codoped core of 20 μm diameter, surrounded by a low index Ge-doped pedestal, and a round-shaped cladding of 300 μm diameter. The high reflectivity (HR) mirror of the laser cavity is a Fiber Bragg Grating (FBG) reflecting intracavity light at 2.09 μm . The output coupler (OC) consists of a passive fiber cleaved at 0° (4% Fresnel reflection). The active fiber is symmetrically pumped by four high-power 793 nm fiber-coupled diodes, fusion-spliced to two 2+1x1 fiber pump combiners which directly inject the total pump power of 540 W into the active fiber. The fiber is cooled by deionized water at 18°C.

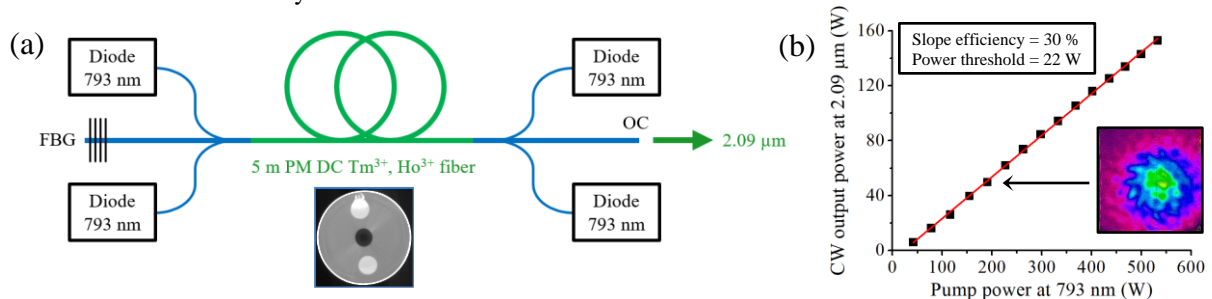


Fig. 1 (a) Schematic of the setup. Passive and active fibers are represented in blue and green lines, respectively. **(b)** Measured output power at 2.09 μm as a function of the total 793 nm pump power. Inset: laser beam at 50 W.

With this fiber laser, a maximum CW output power of 153 W has been achieved at 2.09 μm , with 30% slope efficiency and 22 W laser threshold (Fig. 1b). To the best of our knowledge, this is the highest output power demonstrated at 2 μm from a Tm^{3+} , Ho^{3+} -codoped single-oscillator fiber laser. As shown in Fig. 1b inset, the output power is linked to a bad laser beam quality coming from core/pedestal light transfer in the active fiber [4]. As a result, 33% of the total output power (measured with a cladding light stripper) propagates in the cladding of the passive output fiber and contributes to degrading the emitted spatial beam of the fiber laser.

In conclusion, we report on a Tm^{3+} , Ho^{3+} -codoped fiber laser source based on a simple monolithic all-fiber single-oscillator architecture delivering more than 150 W of optical power at 2.09 μm . Degradations in spatial beam quality have been observed, and improvements are under investigation. The technology presented in this paper can be adapted to an actively Q-switched fiber laser by adding an intracavity acousto-optic modulator.

References

- [1] N. Dalloz, T. Robin, B. Cadier, C. Kieleck, M. Eichhorn, and A. Dhollande, Proc. of SPIE, Photonics West conference, 10897 (2019).
- [2] A. Hemming, N. Simakov, M. Oermann, A. Carter and J. Haub, "Record efficiency of a holmium-doped silica fibre laser," Conference on Lasers and Electro-Optics (CLEO), San Jose, CA, 1 (2016).
- [3] W. Yao, C. Shen, Z. Shao, Q. Liu, H. Wang, Y. Zhao, and D. Shen, "High-power nanosecond pulse generation from an integrated Tm-Ho fiber MOPA over 2.1 μm ," Opt. Express **26**(7), 8841 (2018).
- [4] N. Simakov, A. V. Hemming, A. Carter, K. Farley, A. Davidson, N. Carmody, M. Hughes, J. M. O. Daniel, L. Corena, D. Stepanov, and J. Haub, "Design and experimental demonstration of a large pedestal thulium-doped fibre," Opt. Exp. **23**(3), 3126 (2015).

Abstract

A bi-directionally 793-nm diode-pumped Tm^{3+} , Ho^{3+} -codoped silica PM double-clad fiber laser based on a single-oscillator architecture is reported, providing output power of up to 153 W at 2.09 μm . In order to improve the output beam quality, a complete analysis of the intracavity laser beam is presented.