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Thulium Holmium co-doped tunable fiber laser

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ABSTRACT

We report a Tm-Ho co-doped fiber laser with continuous tunability between 1965-2120 nm thanks to a rotating diffraction grating in the laser cavity. It delivers an OSNR of over 60 dB at the central wavelength 2060 nm. The output is linearly polarized with a 0.7% RMS instability. This laser is tailored for spectroscopy of Ho-doped materials.

KEYWORDS: Tm-Ho fiber laser; tunable laser; Ho spectroscopy

1. Introduction

The 2 μm wavelength range is important for applications like atmospheric transmission and nonlinear frequency conversion [1]. Holmium (Ho) doped materials emit within this range, but at narrow, material-dependent wavelengths [2]. To characterize the gain of Ho-doped gain media, we need a tunable laser that can adjust to these specific wavelengths from 2.0-2.1 μm . Our Thulium (Tm)-Holmium (Ho) co-doped fiber laser system addresses this need. It takes advantage of energy transfer between Tm and Ho ions to emit light at the desired Ho wavelength. Tm ions absorb the pump and transfer energy to Ho ions, resulting in Ho emission. By tuning the cavity, we achieve a broad tuning range covering the Ho ion emission region.

2. Architecture

Our Tm-Ho oscillator has a linear cavity design with an amplifying fiber medium between two reflective elements as shown in Figure 1. On one side is a broadband fiber retroreflector linked to a 30/70 fiber coupler, with the 30% branch as the output. On the other side is a tunable filter comprised of a rotating diffraction grating at the Littrow angle and an aspherical lens. By rotating the grating, we can adjust the central wavelength from 1965-2120 nm. The active medium is a 5.2 m double-clad Tm-Ho co-doped fiber. The 2 μm signal propagates in the 6 μm core while the 793 nm pump propagates in the 130 μm cladding. The pump laser is coupled into the active fiber via a 2+1 \rightarrow 1 combiner. The residual pump is removed by stripping the cladding end and applying a polymer.

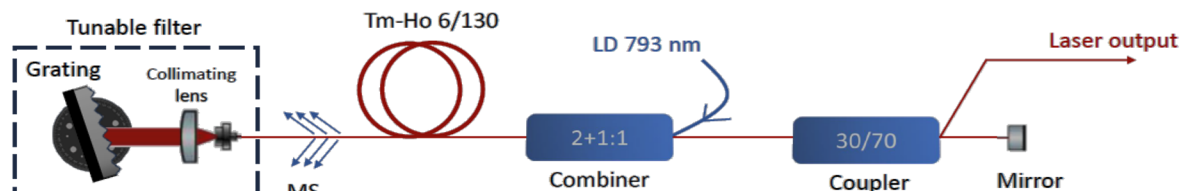


Figure 1: Optical architecture of the Thulium-Holmium oscillator.

3. Results

Using a 5.2-meter-long active fiber, the tuning of the laser's wavelength was from 1965 to 2120 nm (Figure 2 (a)). The laser output spectra at different wavelengths are depicted in Figure 2 (b). At the central wavelength of 2060 nm, the OSNR is > 60 dB with the lasing threshold stands at about 3.2 W of pump power, the slope efficiency is approximately 5.4% with maximum output power about 250 mW for 8 W of pumping. The Polarization Extinction Ratio (PER) for different wavelengths was calculated to be between 16-27 dB which suggests that the laser maintains a robust level of linear polarization. We also calculated the laser stability and the polarization stability over time using a polarizer beam splitter. The RMS instability value at 2050 nm is 0.7% over 30 min.

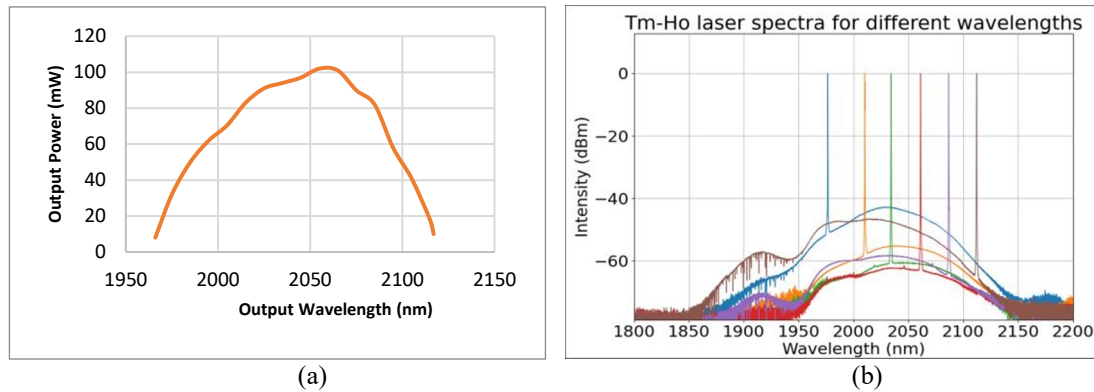


Figure 2: Tm-Ho laser: (a) tunability tested at 5.2 W pumping power, (b) spectra at different wavelengths.

4. Conclusion

In conclusion, we demonstrated a tunable Tm-Ho fiber laser with 1965-2120 nm tuning range. The 5.2 m active fiber provides high performance across 2 microns. The polarized output has 16-27 dB PER and 0.7% RMS stability with sufficient cooling. The tunability makes this laser suitable for injecting into Ho-doped media for spectroscopy. Further work could improve power and efficiency.

5. References

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- [2] Walsh, Brian M., Norman P. Barnes, and Baldassare Di Bartolo. "Branching ratios, cross sections, and radiative lifetimes of rare earth ions in solids: application to Tm $3+$ and Ho $3+$ ions in LiYF 4 ." Journal of applied physics **83.5** (1998): 2772-2787.