Thulium-ytterbium co-doped fiber laser with 32 W of output power in the 2 μm wavelength range

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Abstract: We report an ytterbium-sensitized thulium-doped silica fiber laser that generated up to 32 W of output power in the 2 μm wavelength-range when cladding-pumped by a 975 nm diode stack.

Cladding-pumped thulium-doped silica fiber lasers are capable of efficient high-power operation at wavelengths around 2 μm [1], [2]. Thulium has an absorption peak at ~790 nm, and while diode sources are available at this wavelength, they are relatively scarce. Efficient 2 μm operation has also been demonstrated with Yb-sensitized fibers [1]. In such a thulium-ytterbium co-doped fiber (TYDF), pump energy is absorbed by the Yb^{3+}-ions, and then transferred non-radiatively to the Tm^{3+}-ions, which can then emit in the 2 μm wavelength range. This is similar to the operation of the more widespread erbium-ytterbium co-doped fibers. Ytterbium-sensitization takes advantage of the strong broadband absorption of Yb^{3+}-ions in the 900 – 980 nm wavelength range. This overlaps with high-power diode sources at 915, 940, and 975 nm. The strong absorption allows shorter fibers to be used, which can lower the threshold and which leads to emission at shorter wavelengths. For longer fibers, the emission shifts to longer wavelengths where reabsorption is smaller.

Here, we present further power-scaling of a cladding-pumped Tm:Yb codoped fiber laser emitting in the 2 μm wavelength range. The experimental setup is shown in Fig. 1. The double-clad TYDF was fabricated at the OFTC. Its details have already been published [1]. Briefly, the fiber had an 18.5 μm diameter, 0.22 NA aluminosilicate core doped with Tm and Yb in equal concentrations (weight fraction 2%). The pure-silica inner cladding had a 300 μm diameter, D-shaped geometry. The inner cladding was coated with a low-index polymer and had an NA of 0.3. The absorption at the pump wavelength (975 nm) was 4 dB/m. A 2.5 m long TYDF was used in the experiments. The laser cavity was formed between a perpendicularly cleaved fiber facet at the pump launch end and an external, lens-coupled dichroic mirror in the other end of the cavity. A diode-stack pump source was launched into the TYDF through a simple lens arrangement. The laser output was taken from the pump launch end via a dichroic mirror, HR around 2 μm (Fig. 1) An additional dichroic mirror was in place in case there would be any emission from Yb-ions at ~1 μm. Figure 2 shows the resulting power characteristics. The slope efficiency was 26% and the threshold was 7 W, with respect to launched pump power. The maximum output power (32 W) was limited by fiber failure due to overheating of the coating. The absence of roll-over suggests that higher powers will be possible if coating damage can be avoided. We did not measure the beam quality or the emission spectrum, but we did determine that the laser operated in the 2 μm wavelength range. Emission at ~1 μm was negligible. We believe that the output power of 32 W is the highest ever reported from a diode-pumped Tm-doped fiber. Further measurement data and further power-scaling will be reported at the conference.

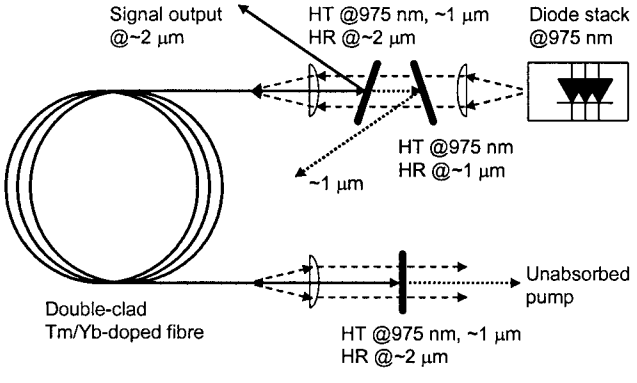

Figure 1. Experimental set-up.

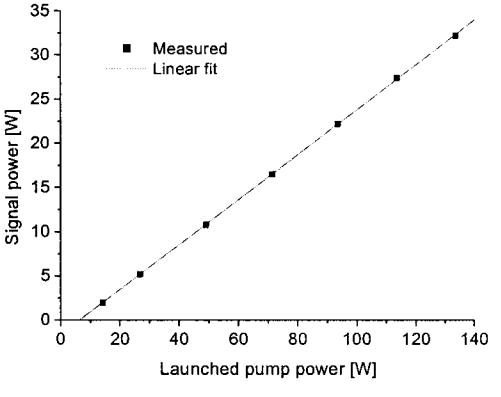

Figure 2. Power characteristics of fiber laser.

References

[1] S. D. Jackson, Opt. Lett., **28**, 2192 – 2194 (2003).
[2] S. D. Jackson, Opt. Commun., **230**, 1972 – 203 (2004).