Passively Mode-Locking Emission in All-PM Thulium-Doped Fiber Lasers at 1.95 and 2.07 μm

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Light sources in the 2 μm range are useful for a variety of applications, including eye-safe LIDAR, medicine, spectroscopy, remote sensing, etc. [1]. Although thulium-doped fibers (TDF) are generally preferred below 2 μm, their use at wavelengths > 2 μm is marginal in favor of holmium-doped fibers. In this work, we have demonstrated passively modelocked polarization-maintaining (PM) emission in two TDF lasers, with emission at 1.95 μm in one case and 2.07 μm in the other.

In Fig. 1a, we show the experimental setup, which was essentially the same for both fiber lasers. The only differences between the two resonators were first, the use of two different PM fiber Bragg gratings (FBG 1, centered at 1951 nm, and FBG 2, centered at 2069 nm) and, second, the use of two different wavelength division multiplexers (WDM, one at 1950/1550 nm and the other at 2070/1550 nm). The TDF length (Nufern PM-TSF 9/125) for the resonator centered at 1.95 μm was 2 m, while it was longer (3.2 m) for the resonator at 2.07 μm to compensate for the smaller emission cross-section at this higher emission wavelength for TDFs [2]. In both cases, the TDF at 1561 nm was pumped with a CW all-fiber laser due to its superior efficiency, which in turn was pumped with a laser diode at 976 nm (LD). The cavity for emission at 1.95 μm was 6.25 m long, while for emission at 2.07 μm was 7.89 m. In both cases, the chromatic dispersion of the resonator was moderately anomalous (-1 ps2 and -1.58 ps2 for roundtrip, respectively).

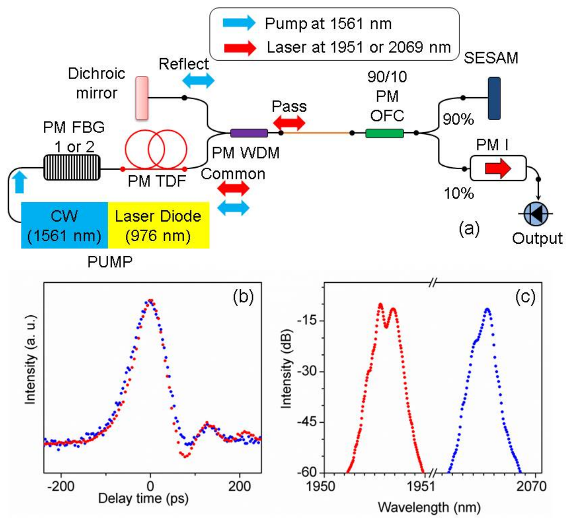

Figure 1: (a) Fiber laser setup. (b) Oscilloscope traces of the output light pulses and (c) optical spectra, in both cases the red dots are for the 1.95 μm cavity, and blue dots are for the 2.07 μm resonator

In one case, when the pump power of the LD was increased to 2.5 W, we obtained a sequence of light pulses at 15.6 MHz, with each light pulse having an FWHM of 81 ps, centered at 1950.6 nm. In the other case, when the pump power of the LD was increased to 3 W, we obtained a sequence of light pulses at 13.084 MHz, with each light pulse having an FWHM of 94 ps centered at 2069.5 nm. Our instantaneous angular frequency measurements show that these light pulses are free of chirp immediately at the output of the resonator. The properties of these lasers make this design a promising candidate for several applications, including low-latency communications, spectroscopy, LIDAR, and fiber optic sensing.

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References

[1] C W Rudy, M J F Digonnet and R L Byer, Opt. Fiber Technol. **20**, 642 (2014)

[2] M A Khamis and K Ennser, in: A Reimer (ed.), Horizons in World Physics **299**, chapter 3, Nova Science Publishers, 2019