# 2 μm Passive Mode-Locked Fiber Laser

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## Abstract

**We report a compact 2 μm passive mode-locked Tm/Ho co-doped all fiber laser. The fiber oscillator is constructed in the linear cavity. The gain medium is 1.6 m Tm/Ho co-doped fiber, and the pump source is a fiber laser with a central wavelength of 1550 nm and a maximum output power of 1 W. The ultrashort pulse is achieved by passive mode-locked technology and a SESAM is used as saturable absorber. The laser generates 18 ps pulses with a repetition rate of 12.9 MHz, and the corresponding central wavelength is 1925 nm.**

## Keywords

**Mode-locked, Tm/Ho co-doped fiber, SESAM, 2 μm.**

## 1. Introduction

Ultrafast light sources at 2 μm wavelength region have been widely investigated in recent years due to their eye-safe property, as well as their various scientific applications in the fields of mid-infrared spectrum generation, remote sensing, nonlinear microscopy, medical treatment and free-space communication[1][2]. Mode-locking is the most typical and commonly-used approach to generate ultrafast laser pulses. Different from active mode-locking techniques, passive mode-locking is simple, compact and low-cost without using active modulators in the laser cavity. Among them, mode-locked fiber laser based on SESAM attracted people's attention very much.

## 2. Experimental laser schematic

Fig. 1 shows the experimental schematic of the mode-locked Tm/Ho co-doped fiber laser based on SESAM. The laser is composed by 1550 nm fiber laser, TH512 Tm/Ho co-doped fiber, 1550/1950 nm WDM, 30:70 coupler, high reflectivity gold mirror, circulator and SESAM. The total length of the laser resonator is about 8.1 m, and the length of the gain fiber is 1.6 m. SESAM in the cavity is used as mirror and saturable absorber, and the high reflectivity gold mirror in the cavity is used as a mirror, so that the laser can be formed between the two mirrors. The 30% of the laser is output through the 30:70 coupler for the measurement of the laser's characteristics, and the other 70% of the laser is used as a positive feedback in the cavity.

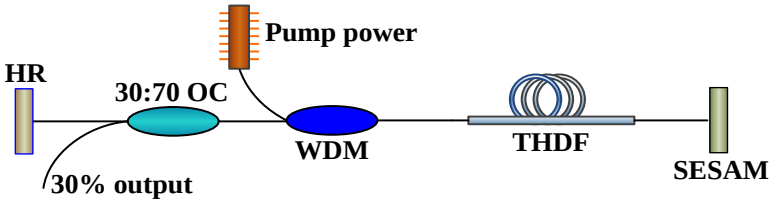


Fig. 1 Schematic diagram of the Tm/Ho co-doped fiber laser

## 3. Experimental results and analysis

In this system, the spectral performance of the laser is measured by an optical spectrum analyzer with a maximum resolution of 6.3 nm. The lasing emerged when the pump power is increased to 138 mW. Under the pump power of 400 mW, the typical spectrum collected at room temperature is shown in

Fig. 2. The central wavelength of the main peak is 1925 nm. Besides, the output power of the laser is measured by an optical power meter, and the results are shown in Fig. 3. It can be seen that the threshold pump power of the laser is 138 mW, and the output power of the laser is correspondingly increased with the increasing of pump power. After calculation, the slope efficiency is about 10.6%.

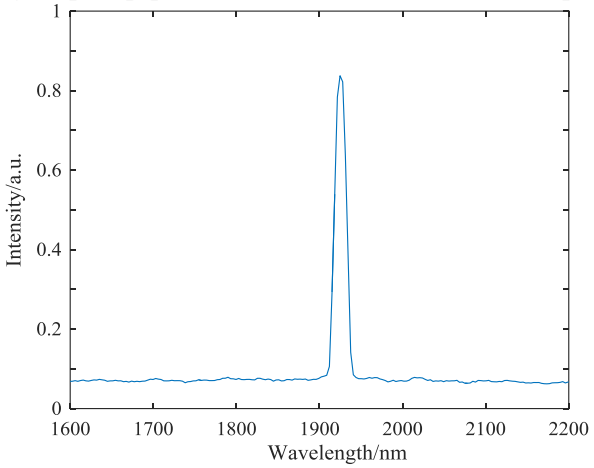


Fig.2 The spectrum of the Tm/Ho co-doped fiber laser

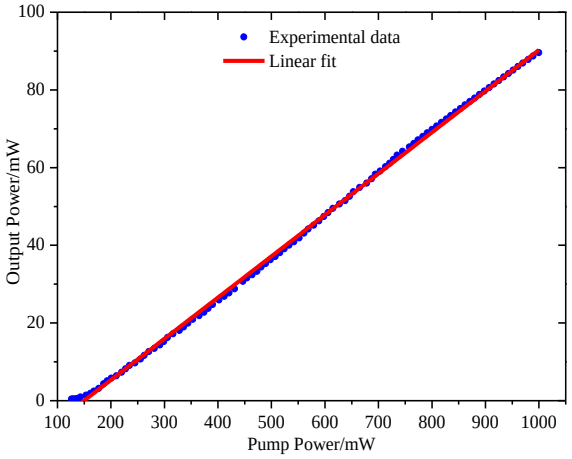


Fig.3 The output power of the fiber laser with increasing the pump power

In order to detect the stability of the output power, the average output power of the laser was tested by the power meter at room temperature. When the pump power is 490 mW, the output power is collected every 10 s during 60 minute, and the output power varies with time as shown in Fig. 4. We can find that it is very stable.

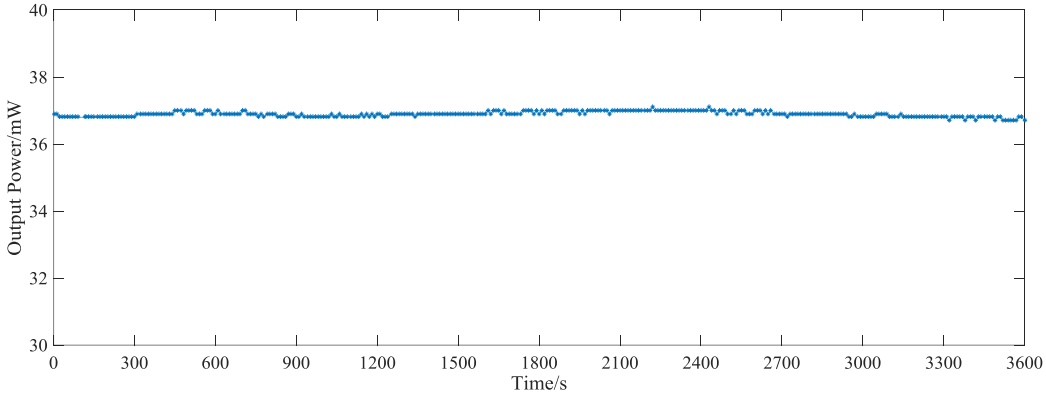


Fig. 4 60 min laser average output power stability test chart

The output laser was coupled into a 2 μm high-speed InGaAs PIN photodetector (EOT, ET-5000F), which was connected to an oscilloscope (Lecroy, WaveRunner 610Zi). We can find that when the pump power is 138 mW, the continuous laser is output, and increasing the pump power to 270 mW, a stable mode-locked pulse with a repetition frequency of 12.9 MHz is output. After calculation, the

repetition frequency is agreed with the cavity length. The oscilloscope trace of the pulse train corresponding to a pump power of 400 mW is displayed in Fig. 5. The autocorrelation trace of the optical pulse shown in Fig. 6 is measured by an upgraded optical autocorrelator (Femtochrome, FR-103WS) with a measuring range of 700 to 3400 nm. The pulse duration is evaluated to be around 18 ps.

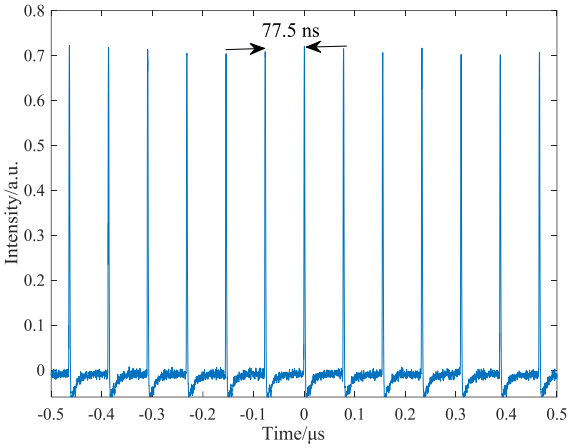


Fig.5 The mode-locking pulse trains

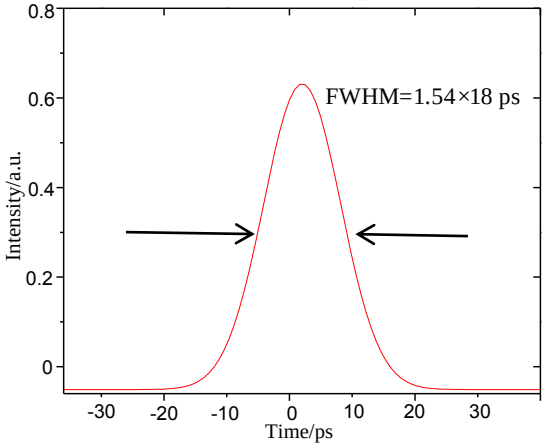


Fig. 6 Autocorrelation trace of the optical pulse

## 4. Conclusion

A compact 2 μm passive mode-locked Tm/Ho co-doped all fiber laser with a linear cavity is reported in this paper. By inserting a SESAM into the cavity, the pulsed laser is output. The pulse width of the laser is 18 ps, and the repetition rate is 12.9 MHz. After measuring the spectrum, we get the corresponding central wavelength of the output laser is 1925 nm.

## References

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