# Mode-locked Yb-doped fiber laser based on saturable absorber

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## Introduction

For wavelengths around 1 μm, ytterbium-doped fiber is one of the most popular active media for fiber-based high power lasers and amplifiers. Various laser cavity designs and mode-locking mechanisms have been reported. The development of fiber-based ultrashort pulse lasers near 1 μm region is difficult due to the high normal group velocity dispersion (GVD) of silica material. The fiber laser design by using the semiconductor saturable absorber mirror (SESAM) combined with a fiber Bragg grating have been studied in recent year. Also, the chirped fiber Bragg gratings (CFBG) that compensate the cavity dispersion have been introduced to achieve stable mode-locked condition.

## Experimental Setup

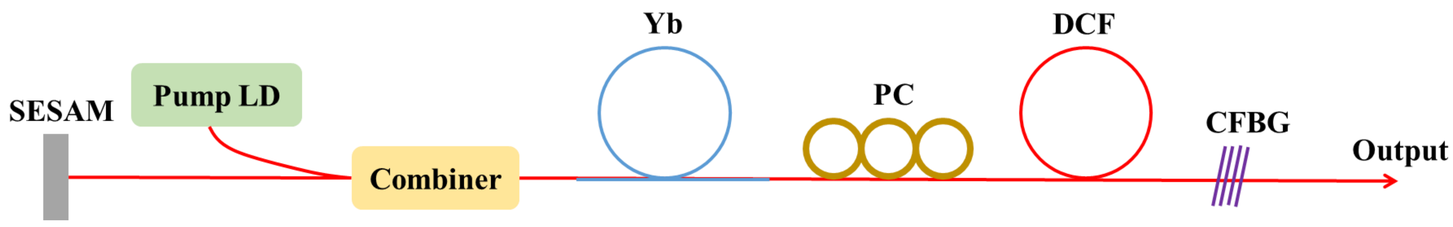



**Fig. 1** Schematic of the experimental setup.

The design of the passively mode-locked fiber laser is illustrated in Fig. 1. We adopt a linear cavity with a length of 5.5-m of 10-μm-core Yb-doped fiber. The active fiber was pumped with a 915-nm multi-mode fiber laser diode. Accordingly, the pumping scheme is used cladding pumped. The SESAM acting as a cavity end mirror ensured reliable self-starting of the pulse formation process. The other end of laser cavity is a CFBG which introduces anomalous dispersion to the cavity. The reflectivity and bandwidth of CFBG are 99.7% and 2-nm, respectively. The central wavelength of the fiber laser is also determined by the CFBG at 1064 nm.

## Results and Discussions

At the beginning, we found an unstable Q-switching rather than the mode-locked pulse in the Fig. 1 setup. To figure out the reason, we put a polarization beam splitter (PBS) before the power meter to detect the output power to analyze the polarization state of the output light during a period. The experimental result showed that the amount of output power change is 8%, which is a high fluctuation that we considered it can't sustain a stable polarization state. As a result, we think the long distance double cladding fiber (DCF) may accumulate nonlinear phase rises that the polarization state of light in every round trip may be different. Therefore, the laser system can't be under a stable mode-locked condition.

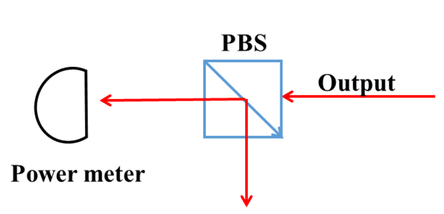
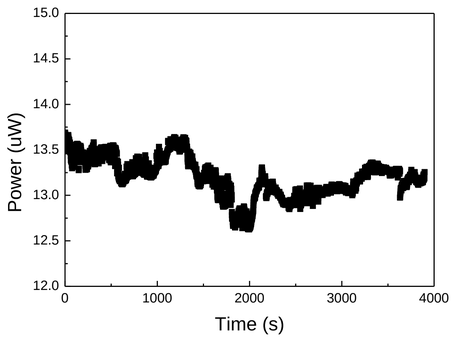



**Fig. 2** Schematic of measure the output polarization.




- The amount of change = 8%.

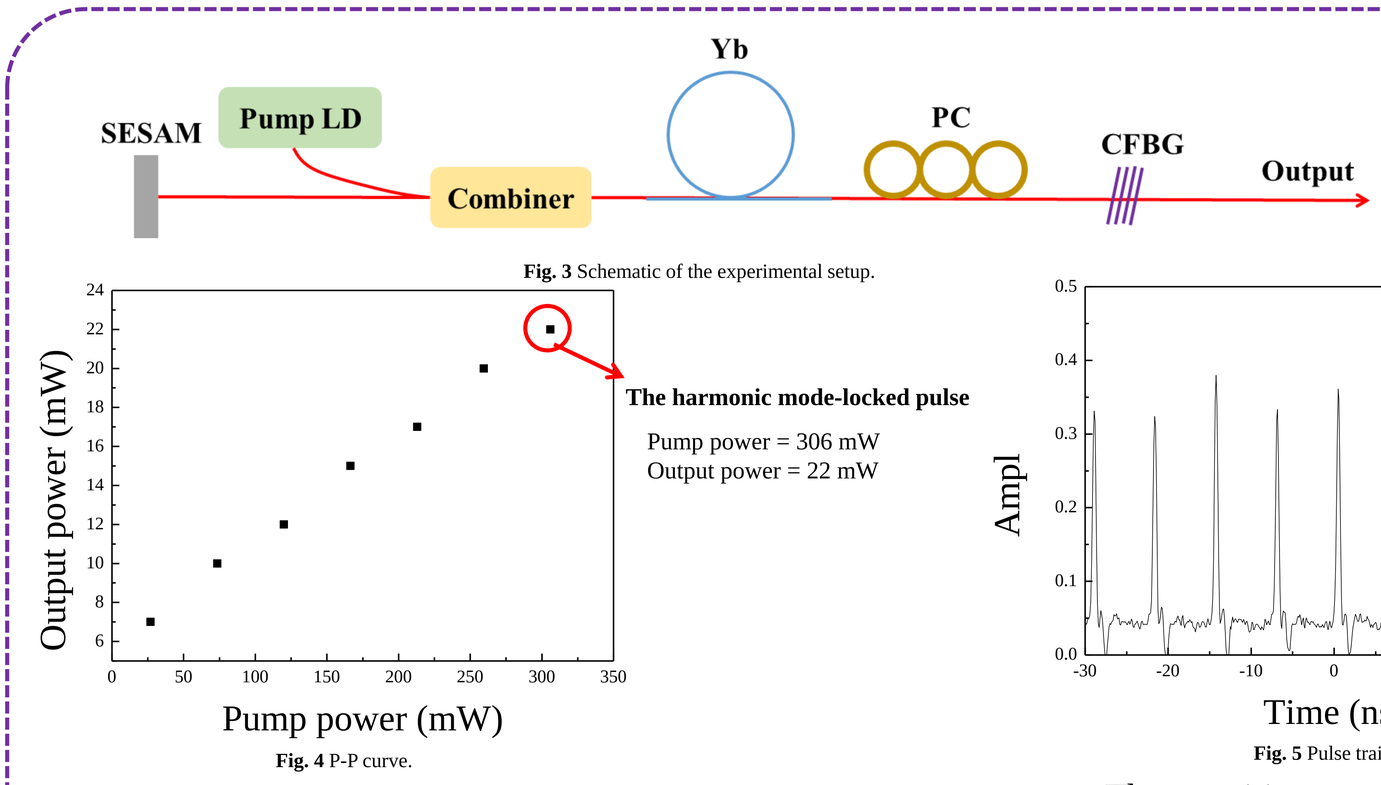



**Fig. 3** Schematic of the experimental setup.




**Fig. 4** P-P curve.

**The harmonic mode-locked pulse**

Pump power = 306 mW
Output power = 22 mW

Next, we removed the DCF to reduce the cavity's length. The harmonic mode-locked pulse operate at the pump power is 306 mW.




**Fig. 5** Pulse train.

- The repetition rate = 137 MHz




**Fig. 6** Spectrum.

- The central wavelength = 1064 nm
- The bandwidth = 0.26 nm (@3dB bandwidth)

## Conclusion

In our experimental result, we proposed a compact fiber laser system, combining a SESAM and a CFBG at 1064-nm wavelength. And observed the harmonic mode-locked pulse at the pumping power is 306 mW, and the output power is 22 mW. Because the CFBG has its select bandwidth that the spectral bandwidth is only 0.26 nm. The repetition rate is 137 MHz. The laser can be a good seed source for further amplification to generate much higher power.