# A High Power and Narrow Linewidth 1908nm Tm: YLF Laser with Volume Bragg Grating

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**Abstract:** A high power and narrow linewidth 1908nm Tm: YLF laser with Volume Bragg Grating as the reflection mirror is reported. The maximum output power of 18.1W with absorbed pump power of 52.0W, and the corresponding slope efficiency and optical-to-optical conversion efficiency are 45.28% and 34.77%, respectively. The Tm: YLF laser operated at 1908.94nm with a narrow linewidth is about 0.2nm, the shift of the laser wavelength is only 0.74nm.

## 1. Introduction

2μm eye-safety laser is located in the atmospheric window, widely used in laser medical, environmental monitoring and optical communication, etc [1-5]. In addition, 2μm laser also can be used as pump source of 3-5μm and 8-12μm optical parametric oscillator and photoparametric amplifier [6-8]. $Ho^{3+}$ crystals are the preferred working materials for producing high-performance 2μm laser, meanwhile 1.9μm Tm: YLF laser is the ideal pump source of $Ho^{3+}$ laser [9-11]. Tm: YLF laser crystal is suitable to be pumped by laser diode because that could lead to two ions in the upper laser level for one pump photon through cross relaxation process [12-14]. However, the free running Tm: YLF laser can not be an efficient pump souce of $Ho^{3+}$ laesr, on account of that the linewidth of Tm: YLF is about 3nm. While use Volume Bragg Grating (VBG) insteal of laser resonator mirror that can realize stable and narrow linewidth laser output, owing to VBG is a new kind of narrow band pass filter element which is developed based on the sensitivity of diffraction on wavelength and angle.

In this paper, a high power and narrow linewidth 1908nm Tm: YLF laser with VBG is established, and the maximum output power of 18.1W. The output wavelength was 1908.94nm with a narrow linewidth of 0.2nm, the shift of the laser wavelength is only 0.74nm.

## 2. Experimental setup

The experimental setup is shown in Fig. 1. The Tm:YLF crystal is a-cut with dimensions of $3\times3\times12mm^3$, and its two end surfaces are AF-coated at both 792nm (R < 0.5%) and 1.91μm (R < 0.4%). The doped concentration is 3.0at. %. The Tm: YLF crystal is wrapped in the indium foil and clamped in a copper heat sink, and maintain at 16℃. The pump source is a 70W laser diode with core-diameter of 400μm and numerical aperture of 0.22. The pump beam radius is nearly 430μm. One of the pump beam throuth coupling lenses which are 35mm and 75mm focal length, respectively. The other pump beam through 45° dichroic mirror (R > 99.5% @1.91 μm and T~95%@792 nm). While incident into the crystal. The dimension of VBG is 6×6×5.4(in thickness) $mm^3$, and two end surfaces of it are AR-coated at both 792nm (R < 0.5%) and1.91μm (R < 0.5%). The laser resonant cavity is plano-concave, the length of resonant cavity is 100mm.

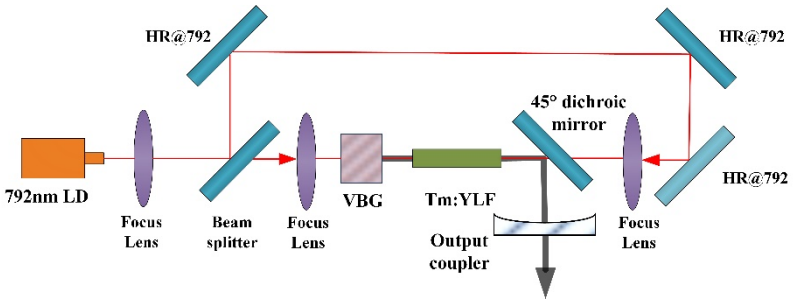


Figure 1. The experimental setup of high power and narrow linewidth 1908nm Tm: YLF laser with VBG

## 3. Experimental

Firstly, the ordinary reflection mirror of the resonant cavity mirror is presented. The results are shown in Fig. 2. The maximum output power of 18.78W with the absorbed pump power of 51.82W, the corresponding slope efficiency and optical-to-optical conversion efficiency are 40.7% and 36.24%, respectively. The Tm: YLF laser operated at 1907.90nm with a linewidth of 2nm. With the increase of pump power, the laser wavelength is red-shift, when the output power reaches the maximum value, the wavelength red-shifted to 1910.11nm, the linewidth is still about 2nm.

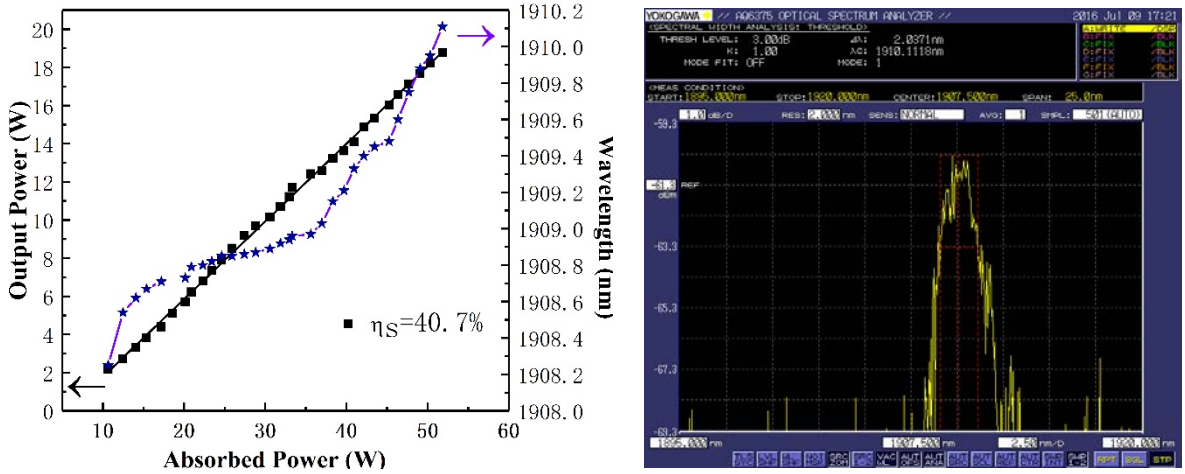


Figure 2. The output power and spectrum of Tm: YLF laser with reflective mirror

Secondly, we use VBG instead of the ordinary reflection mirror. The experimental results are shown in Fig.3. The maximum output power of 18.1W is obtained with the absorbed pump power of 52.0W, the corresponding slope efficiency and optical-to-optical conversion efficiency are 45.28% and 34.77% respectively. The wavelength of Tm: YLF laser is 1908.94nm with a lindwidth of 0.2nm. And the increase of output power, the laser output wavelength from 1908.2nm to 1908.94nm, and the red-shift range is 0.74nm. This is because that the wavelength of the LD shifts. Compared with the results of Fig. 3, the maximum output power reduced about 0.7W when the VBG is used as the cavity mirror. This may be mainly because the VBG reduce the injected power.

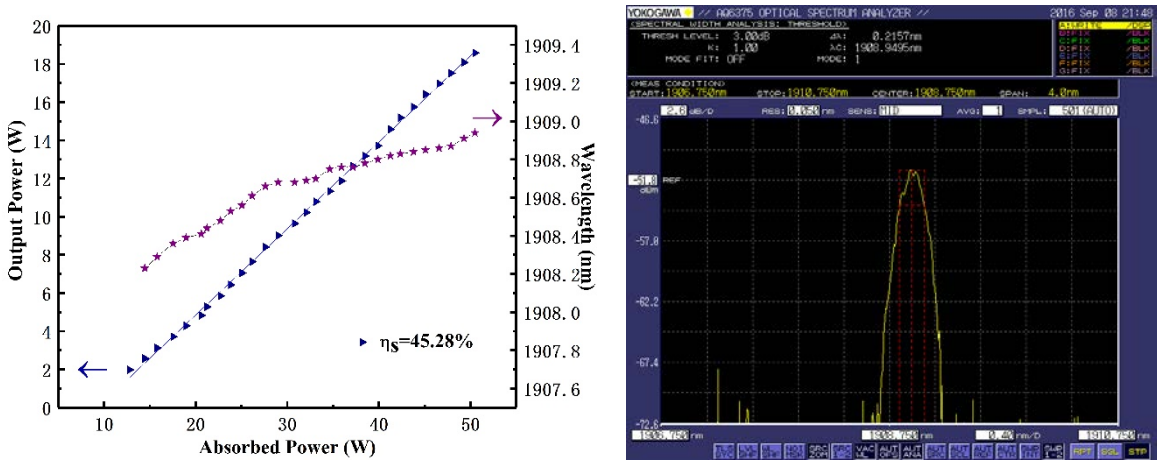


Figure 3. The output power and spectrum of Tm: YLF laser with VBG

## 4. Conclusion

In conclusion, a high power and narrow linewidth 1908nm Tm: YLF laser with Volume Bragg Grating as the reflection mirror is reported. The maximum output power of 18.1W with the absorbed pump power of 52.0W, the corresponding slope efficiency and optical-to-optical conversion efficiency are 45.28% and 34.77%, respectively. The output wavelength is 1908.94nm with linewidth of 0.2nm, the shift of the laser wavelength is only 0.74nm.

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