

High power all-solid-state quasi-continuous-wave tunable Ti:sapphire laser system

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This paper reports a high power, all-solid-state, quasi-continuous-wave tunable Ti:sapphire laser system pumped by laser diode (LD) pumped frequency-doubled Nd:YAG laser. The maximum tuned output power of 4.2 W (797 nm) and tuned average power of 3.7 W were achieved when fixing the Ti:sapphire broadband output power at 5.0 W and applying 750–850 nm broadband coated mirror.

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The Ti:sapphire laser has the advantages of broad tunable spectrum range and higher power. So Ti:sapphire laser has been popularly used in laser spectroscopy, laser chemistry, laser remote sensing, laser radar, laser microscope, laser cooling, superconductor investigation, nonlinear optics, atmosphere optics, and iatrolgy^[1]

Recently, an output power of 660 mW, conversion efficiency of 9.4% Ti:sapphire laser system was reported by Zhang *et al.*^[2]. An output power of 940 mW, conversion efficiency of 13.6%, and continuously tuning from 720 to 820 nm Ti:sapphire laser system was achieved by Wang *et al.*^[3]. A maximum output power of 4.7 W, conversion efficiency of 19.6% Ti:sapphire broadband laser system was attained by Wei and Zou *et al.*^[4,5]. In this paper, a high power and high efficiency laser diode (LD) pumped *Q*-switched intracavity doubling Nd:YAG laser is employed as a Ti:sapphire laser pump source and the original pump source of continuous wave (CW) LD array is 240 W. When the all-solid-state quasi-continuous Ti:sapphire broadband output power is 5.0 W, we attained the maximum tuned output power of 4.2 W at 797 nm and average power of 3.7 W with tuning range from 750 to 850 nm continuously.

The experimental setup is illustrated in Fig. 1. It consists of a Nd:YAG laser pumped by LD, KTP frequency-doubling crystal, and Ti:sapphire resonant cavity. M_1 has high reflectivity at 1064 nm. The input mirror Har- M of KTP frequency-doubling cavity has high reflectivity at 532 nm and high transmissivity at 1064 nm and the output mirror M_2 has high reflectivity at 1064 nm and high transmissivity at 532 nm. F is the focusing

lens with the focal length of 150 mm, so as to reduce the pump beam diameter to 100 μm . M_3 and M_4 are Ti:sapphire resonant cavity mirrors for the 750–850 nm broadband, M_3 has high transmissivity at 532 nm and high reflectivity at 750–850 nm, M_4 has a transmission of $T = 10\%$ at the central wavelength of 800 nm. The Ti:sapphire is provided by Shanghai Institute of Optics and Fine Mechanics, Chinese Academy of Sciences, its dimension is $7 \times 7 \times 16 \text{ mm}^3$, the figure of merit (FOM) is 300. Both end faces are Brewster angle cut relative to the c axis. To extract the deposited heat, the laser crystal is in contact with a water-cooled copper plate.

In this work, when the pump current is 20 A, the output power of 532 nm is 23 W with the repetition rate of 5 kHz and pulse width of 61.2 ns. The broadband output power of Ti:sapphire is 5 W and the pulse width is about 15 ns at this moment. The output fluorescence spectrum was measured, as shown in Fig. 2. From it, we can find that the fluorescence spectrum of Ti:sapphire is very broad.

Tuning the wavelength was carried out by rotating a birefringent filter (BF). With fixing the Ti:sapphire total power of 5 W, we rotated the BF, and measured the narrowband output power and output wavelength with power meter and spectrum analyzer, respectively. Figure 3 illustrates the output wavelength of Ti:sapphire laser versus output power. Figure 4 shows the spectrum profile at the center wavelength of 842.6 nm after tuning and the FMHW is about 2 nm.

Because of the limitation of experiment, we did not use the designed BF, and in this case the dual-wavelength

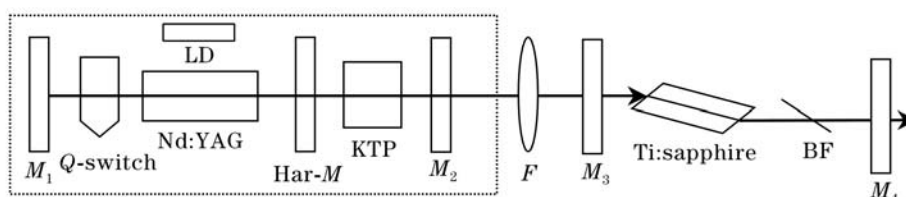


Fig. 1. All-solid-state quasi continuous tunable Ti:sapphire laser system.

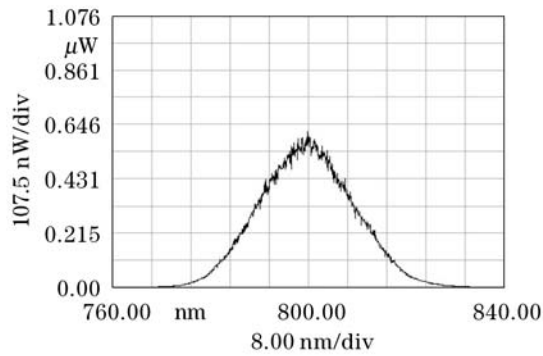


Fig. 2. Output spectrogram of the Ti:sapphire laser.

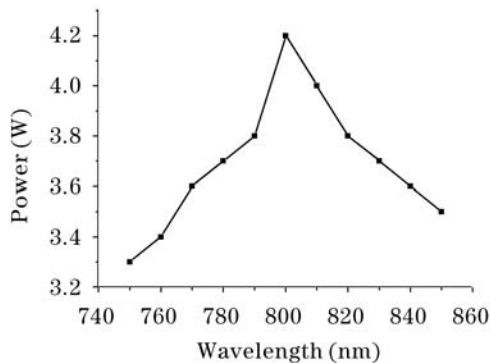


Fig. 3. Variation of output power with output wavelength by rotating BF.

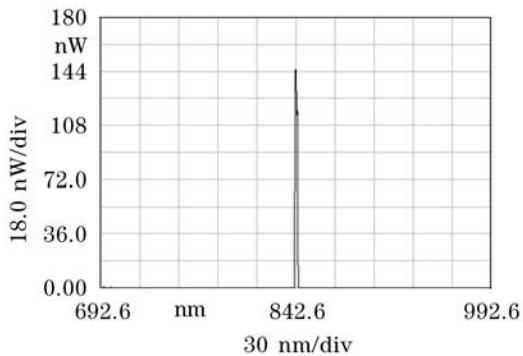


Fig. 4. Spectrum profile of 842.6 nm.

competition appeared in certain wavelength as shown in Fig. 5. Whereas this phenomenon validates the possibility of Ti:sapphire dual-wavelength operation by using birefringent from another side^[6,7].

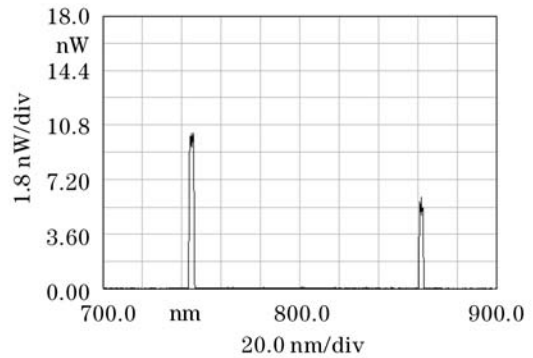


Fig. 5. Spectrum of the dual-wavelength Ti:sapphire laser.

In the experiment, when the Ti:sapphire output power is 5 W, we got the maximum tuned power of 4.2 W at 797 nm and average power is 3.7 W while tuning from 750 to 850 nm continuously.

Although the birefringent in our experiment did not accord with optimal design, it still indicates its advantage of low loss, this provides the necessary foundation of wavelength tuning in the range of 650—750 and 850—950 nm in the future. If we exchange the optimal birefringent to minimize the tuning loss and to restrain secondary peak, we should attain higher tuned power, meanwhile wider tuning range. Continuing development is currently underway.

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