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Ti:Sapphire CPA booster amplifier for a 5 PW laser system

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In the recent years, 10 Peta-watt (PW) laser system is a hot topic in the field of laser technology. Many countries and laboratories are building or having a plan to build a 10 PW laser system [1, 2]. The CPA technique particularly using Ti:sapphire (Ti:S) CPA systems is still the main method to achieve PW and 10 PW-levels laser pulses for its high efficiency and stability [3, 4]. However, the transverse amplified spontaneous emission (TASE) and parasitic lasing (PL) within the booster amplifier volume are the main barriers to achieve a higher energy amplification when the larger-aperture Ti:S crystals are pumped at higher pump fluence and energy. In this letter, we reported on the energy amplification for a 5 PW laser system based on Ti:S CPA by using a new method to restrain the PL. The amplified energy was up to 202 J based on a Ti:S crystal with diameter of 150 mm. The pulse was compressed to 24 fs in pulse duration and the peak power was up to 5.3 PW.
After being amplified by a regenerative amplifier and three multi-pass amplifiers, the energy of the stretched pulse was about 7 J and the spectrum width was 90 nm from 750 nm to 840nm. And then, the pulse was send to a Ti:S amplifier with diameter of 80 mm. The pump energy was generated by frequency-doubled Nd:glass amplifiers at 527 nm. The amplified pulse energy was about 48 J pumped by a pump pulse energy of 100 J. The amplified pulse was expanded to a diameter of 120 mm and then injected into a 150-mm-diameter Ti:S booster amplifier. The pump energy was 320 J with diameter of 130mm. To suppress the PL in the booster amplifier, we used the Cargille Series M refractive index liquid doped with an absorber (IR 140) as the cladding material. Besides, we used a method called temporal-dual-pulse pump as an important method to suppress the PL in the booster amplifier. After optimizing the time delay among the pump pulses and the signal pulse, the PL was suppressed when the 150-mm-diameter Ti:S was pumped by a 320 J pump energy. The amplified energy was up 202 J and the conversion efficiency was about 49%. The amplified spectrum width was about 85 nm from 750 nm to 835 nm.

The amplified pulse from booster amplifier was expand to 300 mm by an achromatic spatial filter and send to a compressor with four gratings. After being compressed, the pulse duration was 24 fs. The total transmission of the spatial filter and the compressor was 64% and the peak power was 5.3 PW.

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