DESIGN OF HIGH ENERGY OPCPA FOR 10-PW CLASS SYSTEMS ON LARGE APERTURE LBO CRYSTALS

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Abstract: A multi-petawatt laser system based on OPCPA was designed with LBO crystals serving as the final amplification stage. The front-end system and pre-amplifiers system of the 10-PW laser system have been developed. The maximum OPA output energy is greater than 6J, and the conversion efficiency is greater than 20%.

The petawatt laser power was achieved as early as in 1997 [1] based on chirped pulse amplification in Nd:glass. Many institutes are going to obtain even higher power levels [2-3], but any further increase is limited in principle by the narrow gain width of Nd:glass, small aperture of Ti:sapphire crystals and low damage threshold of diffraction gratings. Using optical parametric amplifier (OPA) instead of traditional laser amplifier is one of the most promising ways of overcoming the petawatt power barrier [4].

The conceptual layout of the multi-petawatt OPCPA scheme is shown in Figure 1. As can be seen there will be three stages of amplification that fall into two phases of the project. The first stage of amplification will be used to generate mJ level clear seed pulses with short pulse optical parametric amplifier. These pulses will then be stretched for amplification to the ten Joule level before final amplification to more than 200J before compression. The first two stages of amplification represent a front-end system and pre-amplifiers system, which has been designed, built and commissioned as part of phase 1 of the project. The maximum OPCPA output energy was greater than 6J, and the conversion efficiency of a single OPCPA was greater than 20%. The OPCPA system with temporal and spatial shaping capability was studied and demonstrated. Experimental results showed that the near-field modulation ratio of amplified pulses after the saturated OPCPA process was 1.6:1 when we apply the liquid crystal technique to control the near field of the pump pulses precisely. In the time domain, we have studied the change of the OPCPA signal pulse shape after a small signal OPCPA or saturated OPCPA process when the pump pulse shape was flat top or not, which provides foundations for the design of the signal pulse shape and pump pulse shape for high-power OPCPA systems in the future.

![Fig. 1. Schematic of the architecture used to generate 10 PW](image)

The third stage of amplification forms the second part of the project and will be combined with an increase on the capabilities of the current amplification of the existing glass amplifier chain by the addition of further amplification stages. The optical parametric crystal for the final amplification only large aperture LBO crystals (150 mm diameter clear aperture) were considered. The final stage of amplification will be made by taking the output of the XINGGUANG-Ⅲ laser device and doubling it to 527nm with energy 1500 J on 4ns, then pumping large scale LBO crystals with diameters > 150mm. After amplification the pulses are compressed in a four grating double pass compressor, and this will be achieved by generating 10PW class pulses with energies greater than 150J and with durations less than 15fs.

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References


