Optically parametric chirped-pulse amplification pumped by optically synchronized sub-nanosecond Nd:YAG laser

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Optically parametric chirped-pulse amplification (OPCPA) is a general technique used in ultra-high intensity lasers to obtain broadband spectrum pulses. In the J-KAREN-P laser, a petawatt-class laser system developed in our facility, the OPCPA also contributes to high-contrast pulse generation by moderate gain amplification to avoid superfluorescence.[1] Timing jitter between signal and pump pulses in the OPCPA causes instabilities of amplified pulse energy and spectrum. Optically synchronization is powerful method to suppress the timing jitter. Less than 1 ps timing jitter is realized by generating pump pulses from signal pulses.[2] Here, we report a highly stable optically synchronized frequency-doubled Nd:YAG pump laser and optically synchronized OPCPA result. [3]

Figure 1 shows the schematic diagram of our OPCPA laser. Part of signal pulses provided form a Ti:sapphire oscillator was focused into a photonic crystal fiber (PCF) for spectrum extension to obtain a wavelength of 1064 nm. Output spectrum from the PCF was stabilized to 1064 nm by controlling input intensity. The stabilized pulses were stretched to 1 ns by a fiber Bragg grating (FBG) and were amplified by 4-stage Yb:fiber amplifiers to 1.8 nJ at 80 MHz. The repetition rate was reduced to 10 Hz by a pockels cell to amplify the pulses by LD-pumped Nd:YAG amplifiers. The pulse energy of 20 mJ (less than 0.3% RMS) was obtained by a regenerative amplifier, and 200 mJ (less than 0.2% RMS) was achieved by a 2-pass main amplifier. After frequency -doubling by LBO crystal, pulse energy at 532 nm was 130 mJ (less than 0.6% RMS). Pulse durations after regenerative amplification and frequency-doubling were 360 ps and 330 ps, respectively.

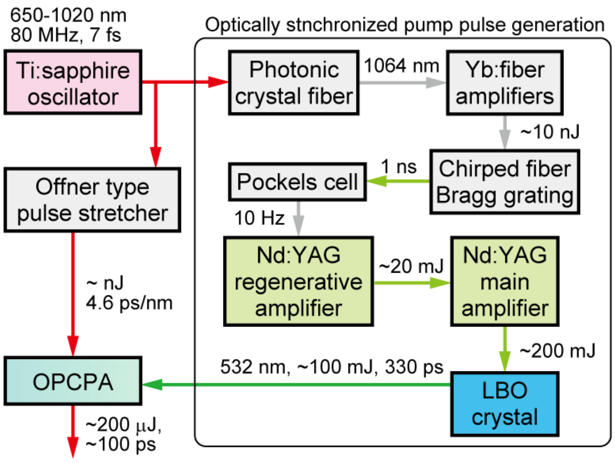

Figure 1. Schematic diagram of optically synchronized OPCPA laser .

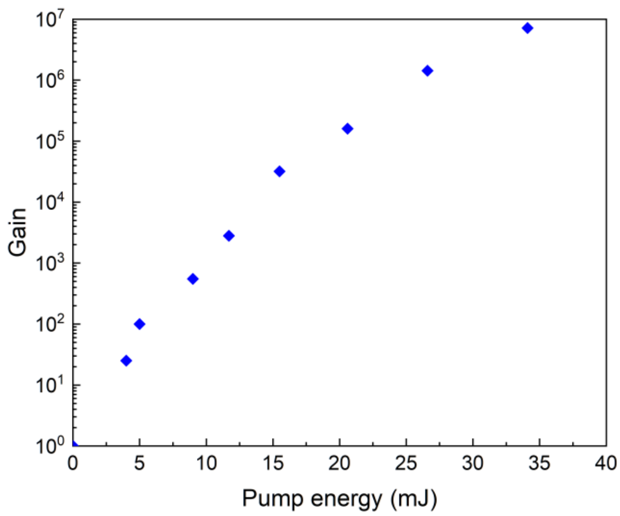

Figure 2. Dependence of output pulse energy form 1st stage optically synchronized OPCPA.

Another part of signal pulses is stretched by offner-type pulse stretcher with a chirp rate of 4.6 ps/nm. The spectral bandwidth of the signal pulse corresponds to about 70 nm for a pump light pulse duration of 330 ps. After increasing the pumping energy of the OPCPA, a high amplification gain was confirmed, and a pulse energy of 200 μJ was obtained. The pulse duration after OPCPA was approximately 100 ps, and the center wavelength varied by adjusting the delay, with a spectral bandwidth of about 20 nm. We consider that this is due to the high gain of the OPCPA, which emphasized the gain near the peak of the pumping pulse. We plan to add a second stage OPCPA to achieve a broader spectrum and higher energy pulses.

References

[1] H. Kiriyama *et al*, High Pow. Laser Sci. Eng., **9** (2021) e62.
[2] S. Prinz *et al*, Opt. Exp. 22 (2014) 31050
[3] Y. Miyasaka *et al*, Opt. Exp. 29 (2021) 32404.