Control of Amplified Optical Parametric Fluorescence in Hybrid Chirped-pulse Amplification

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The amplified optical parametric fluorescence (AOPF) from optical parametric chirped pulse amplifier (OPCPA) was controlled by injecting a residual fundamental pulse of the seeded Q-switch Nd:YAG pumping laser as a quenching beam. The output pulse from the OPCPA was used as a seed pulse for Ti:sapphire chirped-pulse amplifier (CPA) system to generate up to 10 TW peak power with a high-contrast ratio. This intense laser pulse was focused on the supersonic Ar gas jet. High-energy electrons up to 30 MeV were observed.

1 Introduction

Recent technologies in ultrashort high peak power laser have opened various new fields. The focused intensity of these high peak power laser pulses can now reach to $10^{19}$ W \cdot cm$^{-2}$. Such lasers are capable of high energy charged particle generation, $\gamma$-ray generation, and fast ignition physics in ICF study, etc. The direct interaction between relativistic high field and over-dense materials is especially attractive. Here the development of high-contrast and high peak power laser system is essential for avoiding a generation of low-density preformed plasmas. To obtain a high-contrast pulse, the prepulse should be suppressed to low level. At this point of view, optical parametric chirped pulse amplification (OPCPA) is an attractive method.

In the conventional energy storage type laser amplifier, after amplification the main pulse is sliced out from amplified pulse train with Pockels cell and polarizer. Therefore the contrast ratio is determined by the performance of the pulse slicer. The typical contrast ratio is $10^6$ at most. In OPCPA, however, only the main pulse can be amplified by using short enough pump pulse. In this case, the amplification factor becomes the contrast ratio. Moreover, noncollinear OPCPA enables the wideband amplification over 100 nm in bandwidth [1,2]. Therefore,
we can expect the development of a prepulse free ultrashort high peak power laser system.

2 Three-Stage OPCPA

The seed source was a self-mode-locked Ti:sapphire oscillator (Femtolasers Femtosource), which produces 10-fs pulses, with an energy of 6 nJ, a center wavelength of 770 nm, and a bandwidth of 77 nm. The output pulses from this oscillator propagated through a 4-pass Offner-type stretcher, which stretches the pulses to 500 ps. The bandwidth of the output pulse from this stretcher was limited to 55 nm (FWHM) by the allowance. These stretched pulses were delivered to the preamplifier stage composed of a three-stage noncollinear OPCPA amplifier and a one-stage double-pass Ti:sapphire amplifier. The schematic of this preamplifier is shown in Fig. 1. We used a commercial seeded Q-switched Nd:YAG laser (Spectra-Physics LAB-150) as a pump and a quench for this preamplifier. The pump pulse was 230 mJ/6 ns at 0.532 µm in wavelength at a 10-Hz repetition rate. In order to obtain a good spatial beam quality, the near-field pump beam profile was imaged on each β-barium borate (BBO) crystal. The BBO crystals, 15 mm in length and 5 mm × 5 mm in cross section, were cut at 26.5° for type I angular phase matching. The external noncollinear angle between the pump and the signal was carefully aligned to be 4.5° to obtain a wideband phase matching. The output energy after this three-stage OPA was 3 mJ.

However, if we block the seed pulse before this preamplifier, some AOPF is observed. In Fig. 2, the temporal profiles of amplified pulses with and without seed pulse are represented by a thin solid curve and a thick dotted curve, respectively. The pulse width of AOPF is 2.1 ns (FWHM). This profile represents the temporal

![Figure 1. Schematic of the OPCPA/Ti:sapphire preamplifier in the hybrid system.](image-url)