Improvement of output energy in OPCPA based on Ti:sapphire laser by the gain distribution among the nonlinear crystals

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Abstract: We report the design and experiment on an OPCPA system with a home-made femto-second Ti:Sapphire laser as the seeding pulse. Amplified seed pulses with energy of 4mJ and bandwidth of 30nm were obtained.

Introduction

As one kind of promising technique of ultra-short and ultra-intense lasers, OPCPA performs many advantages in contrast to the conventional CPA technique, such as: extremely broad gain bandwidth(>100THz), high gain in single pass, low thermal effect (high output beam quality), high contrast ratio (reduced ASE) and so on. In this presentation, we report the design and experiment on an OPCPA system with a home-made femto-second Ti:Sapphire laser as the seeding pulse. Amplified seed pulses with energy of 4mJ and spectrum bandwidth (HMFW)of about 30nm were obtained.

Design and experimental layout

To maximize the parametric bandwidth, a suitable phase matching angle θ and the corresponding noncollinear angle α should be chosen. The dependence of the noncollinear angle on the signal center wavelength under the condition that the pump is at 532nm and BBO acts as nonlinear crystal is shown in figure 1. The curves reveals that θ = 23.84° α =2.39° are the optimal angles. Moreover, with the small signal approximation, the gain under different pump levels has been calculated as well.

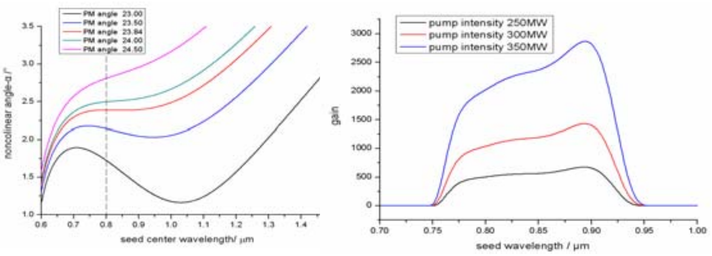

Fig.1. left: The dependence of the noncollinear angle on the signal center wavelength; right: the gain versus seed wavelength under different levels

The OPCPA consists of three amplification stages, three BBO crystals with length in 14mm are used as the gain media for parametrical amplification. The pump laser is a 532nm Nd:YAG laser at 10Hz repetition rate which is capable of 270mJ energy and 7ns pulse duration. The oscillator generates stable laser pulses at a repetition rate of 80MHz. After stretching the laser pulse to approximate 600ps by an öffner stretcher, a DG535 is used to synchronize the pump laser and the seed pulse with timing jitter of about ±1.5ns.

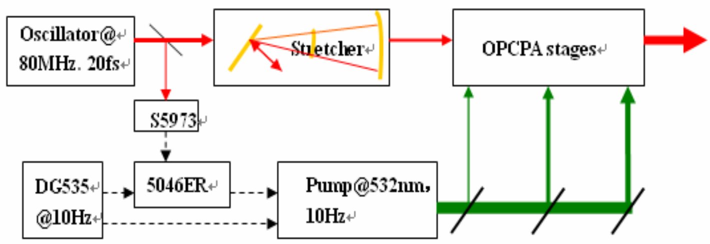

Fig.2. Schematic diagram of the overall experimental configuration

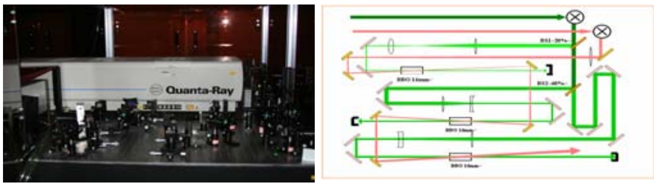

Fig.3. Photo and schematic diagram of the OPCPA layout

Experiment results and conclusions

Stage / parameters	Stage one	Stage two	Stage three
Pump energy（mJ/pulse)	35	74	113
Pump cross-section (mm^2)	1.57	3.4	5.1
Pump intensity (MW/cm^2)	~320MW	~310MW	~300MW
Phase matching angle (°)	~23.84	~23.84	~23.84
External noncolinear angle (°)	~3.99	~3.99	~3.99
Internal noncolinear angle (°)	~2.39	~2.39	~2.39
Incident signal energy (/pulse)	~0.4nJ	~200nJ	~0.1mJ
Amplification ratio	~500	~500	~40

Table.1. Parameters used in the experiment and amplified pulse energy

After the amplification of front two stages, the energy of the signal pulse was increased from ~0.4nJ to 0.1mJ. The third stage amplifier boosted the energy of the signal pulse to 4mJ. The spectra bandwidth at the output of the last stage is about 30nm (HMFW), and keeps the same as the bandwidth of 30nm before amplification. The calculated amplified spectrum is with small signal approximation.

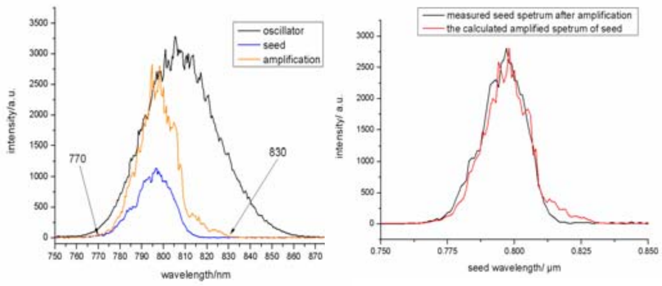

Fig.4. left: Spectra of the oscillator, stretched seed for the OPCPA and signal after three stage amplified right: The comparison between measured and calculated amplified seed spectrum

However, the stability of amplified pulse energy is not good enough because of the large timing jitter between the pump-signal laser, we observed the standard deviation of the amplified pulse energy is about 0.55mJ. To solve this problem, a new synchronized electronics is designed. By improve the stability, we will inject the amplified signal pulse into the subsequent boosted multi-pass and main multi-pass amplifiers in our CPA system to generate an ultraintense laser pulse with high contrast ratio .

Reference:

1: *A. Dubietis et al., opt. commun., Vol. 88, 437(1992)*

2: I.N. Ross et al., Opt. Commun., Vol. 144, 125(1997)