32 W Femtosecond Yb-Fiber CPA System based on Chirped-Volume-Bragg-Gratings

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Abstract: Femtosecond (~670 fs) fiber-CPA at 1.063 μm is demonstrated using broadband chirped-volume-Bragg-gratings for pulse stretching and compression. 32 W recompressed pulses are achieved corresponding to a 75% compression efficiency.

OCIS codes: (140.3510) Lasers, fiber; (140.7090) Ultrafast lasers

Large-aperture chirped Volume Bragg gratings (CVBGs) made of Photo-Thermo-Refractive (PTR) glasses have incorporated into fiber chirped-pulse-amplification (CPA) system as the monolithic stretchers and compressors [1,2]. The use of CVBGs overcomes the practical limitations of diffracted-grating based pulse stretchers and compressors that are characterized by large size, high complexity, and limited robustness. Additionally CVBGs exhibit significant power scalability, which has led to the demonstration of a 50 W Yb-doped fiber-CPA 4-ps pulse system [3]. It is noteworthy that the narrow band CVBGs used in this experiment exhibited noticeable spatial chirp because of inhomogeneity induced during writing process. The existence of spatial chirp only allows partially coupling of the whole reflected spectrum from a CVBG stretcher into a fiber amplifier, which explains the compressed pulses are restricted to 4.6 ps duration [3]. Femtosecond CPA requires broadband CVBG stretchers and compressors. In fabrication of the broadband CVBGs, the writing configuration has been refined to significantly reduce the spatial chirp and, consequently, to increase the compressor bandwidth compared to previous narrow-band CVBG operating at 1.053 μm. Here we report a femtosecond fiber CPA system based on 6 nm bandwidth low spatial chirp CVBG, and demonstrate 32 W compressed 670-fs pulses, constituting a significant improvement over previous results.

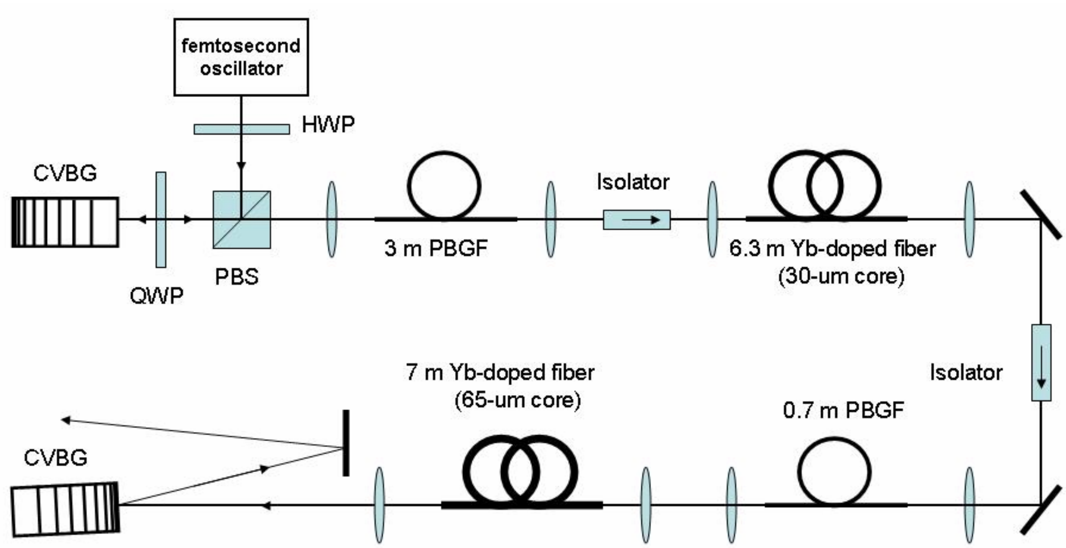

Fig. 1 Experimental setup. CVBG: chirped volume Bragg grating, HWP: half-wave plate, QWP: quarter-wave plate, PBS: polarization beam splitter, PBGF: photonic band-gap fiber

A schematic description of the experimental setup is illustrated in Fig. 1. This high power CPA system includes an oscillator as the seed, two identical CVBGs of 2.5 cm long as the stretcher and the compressor, two Yb-doped fiber amplifiers for power scaling, and two pieces of photonic band-gap fibers (PBGFs). The passively mode-locked Nd:glass oscillator operating at 72 MHz produces 130 mW, 110 fs pulses (centered at1.063 μm) to seed the CVBG based Yb-doped fiber CPA system. Centered at 1.063 μm with a 6 nm bandwidth, two CVBGs are arranged with opposite orientations to achieve dispersion match. Both amplifiers are constructed using LMA core (30 μm core for the first stage and 65 μm for the second), double-clad Yb-doped fibers, pumped at 976 nm 940 nm respectively. The PBGFs provide an anomalous dispersion of 120 ps/nm/km at 1.063 μm in order to compensate for the normal dispersion induced by the Yb-doped fiber. Optical isolators are inserted in between to prevent feedback.

The recompressed power reflected from the CVBG compressor versus the incident power is plotted in Fig. 2(a). This shows that the compressor has an efficiency of 75%, independent of the input power. Up to 32 W of recompressed average power is achieved without any roll-off of the CVBG efficiency, which indicates good average power handling ability.

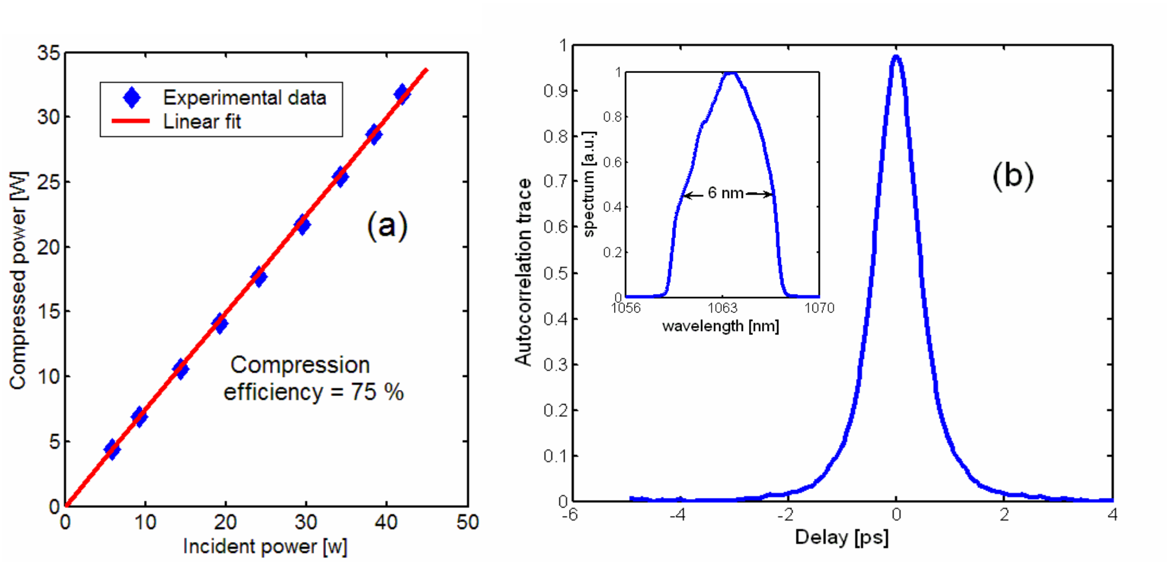

Fig. 2 (a) Compressed power of the CVBG compressor versus the incident power; (b) Autocorrelation trace of the recompressed pulse (inset: the spectrum)

The measured autocorrelation trace of the recompressed pulses is plotted in Fig. 2(b). Estimated to be 670 fs long, the recompressed pulse duration is about 150-fs longer than the transform-limited pulse given by the amplified pulse spectrum. This is mainly caused by the residual dispersion mismatch between the PBGF and the gain fiber in the current setup.

In conclusion, we have demonstrated a 32 W Yb-doped fiber CPA using CVBG stretchers and compressors. The independence of the 75% CVBG compression efficiency implies the possible further power scaling. Experiments to power scale up the present system are in progress. These CVBGs have 6 nm bandwidth with a negligible spatial chirp and therefore allow the implementation of the femtosecond CPA system. It is expected that transform-limited pulses (about 520 fs) may be obtained by optimizing the PBGF length to completely compensate for the dispersion of the Yb-doped fiber. Currently, we are developing CVBGs with >10 nm bandwidths with negligible spatial chirp. Such CVBGs will enable the construction of high power fiber CPA systems with pulse durations of less than 300 fs.

References:

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