Sub-33 fs Pulses from an All-Fiber Parabolic Amplifier Employing Hollow-Core Photonic Bandgap Fiber

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Abstract: Sub-33 fs, 1 nJ pulses are generated in a Er-doped fiber amplifier composed of a normal dispersion gain fiber, a low dispersion slope photonic crystal fiber, and a highly nonlinear fiber.

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Temporal compression of transform-limited pulses from a mode-locked erbium-doped fiber (EDF) laser can be achieved using solitonic compression produced by an EDF amplifier along with self phase modulation (SPM) in an anomalous dispersion single mode-fiber (SMF). Unfortunately solitonic compression can lead to phase distortions that degrade the pulse shape. Parabolic pulse formation [1] in a normal dispersion EDF along with compression in anomalous dispersion hollow-core photonic bandgap fiber (PBGF) offers an alternative that uses linear methods for pulse compression. It is extremely important that the PBGF exhibit a small dispersion slope or the pulse will exhibit higher order dispersion after. By using a novel PBGF [2] that has a low dispersion slope of 0.3 ps/nm^2/km we temporally compressed a 4700 fs after the EDF to a nearly transform-limited 120 fs pulse. Furthermore, we inject this pulse into a short length of OFS highly nonlinear fiber (HNLF) [3] to generate a sub-33 fs pulse using SPM.

Figure 1(a) shows the amplifier design. Transform-limited 20 nm bandwidth, 1 mW average power pulses from a EDF fiber laser were injected into the amplifier with two EDFs: 4.7 m of Liekki Er30-4/125 (EDF1) and 5.8 m Nufern EDFL-980-HP (EDF2). The 4700 fs parabolic pulse from the EDFs was then linearly compressed using 2.9 m of the new PBGF that exhibits anomalous dispersion with small dispersion slope. As a comparison, the new PBGF was replaced with 1.5 m of Crystal Fibre HC-1550-02 PBGF. The new PBGF has many advantages compared to the Crystal Fibre PBGF. The splice loss from SMF to the new PBGF was 0.5 dB compared to 1.2 dB loss to the Crystal Fibre PBGF. Furthermore, the small dispersion slope allowed us to compress the parabolic pulse without any higher order dispersion. As seen in Fig. 1 (b) and (c), the intensity autocorrelation measurements taken after the new PBGF does not exhibits the sidebands seen in the measurements using the Crystal Fibre PBGF. These sidebands are caused by the third order dispersion present in the Crystal Fibre PBGF. The output pulse from the new fiber was 120 fs with 370 mW average power. Next, we spliced 13 cm of OFS HNLF onto the end of the new PBGF. The chirp free pulses from the new PBGF allowed us to use solitonic compression to generate a sub-33 fs, 80 mW pulse that has 84% energy in the main peak (Fig. 1(d)). The authors gratefully acknowledge the support of K.C. Wong Education Foundation, Hong Kong and the support of the Air Force Office of Scientific Research.

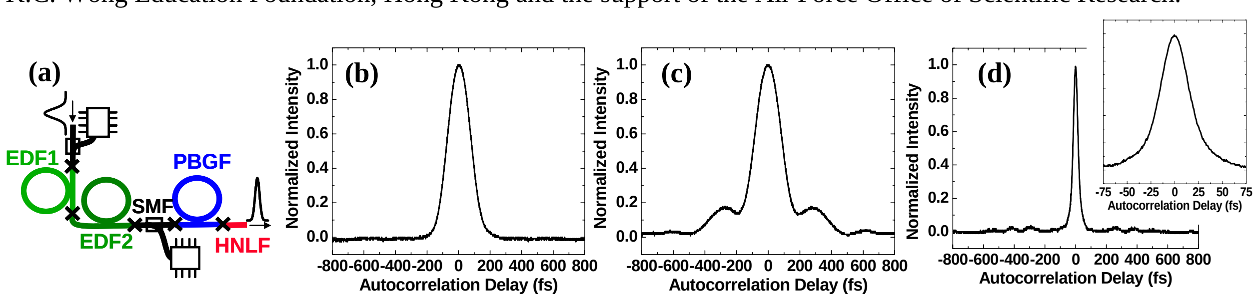

Fig. 1 (a) Parabolic amplifier. (b) Autocorrelation measurement of compressed pulse after the new PBGF that exhibits low dispersion slope. (c) Compressed pulse after Crystal Fibre HC-1550-02 PBGF. (d) Compressed pulse after OFS HNLF.

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