Optimization of a highly-chirped dissipative soliton fiber oscillator operating at 1.55 μm

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High power mode-locked (ML) fiber lasers generating femtosecond pulses in telecom window near 1.55 μm is a field of growing interest due to the apparent success of all-normal dispersion (ANDi) fiber lasers generating chirped pulses in the wavelength region around 1 μm [1,2]. Such lasers have a wide range of practical applications, from CARS and Terahertz spectroscopy to few-cycle pulse synthesis and telecommunications. In a majority of practical applications, short duration and high pulse energy are as important as long-term stability and usability. From this perspective the all-fiber lasers look the most appropriate due to their compact size, absence of complicated adjustments, high efficiency, intrinsic stability and perfect beam quality.

In this paper, we demonstrate an all-fiber oscillator providing stable generation of highly-chirped dissipative solitons (DSs) at 1.55 μm. In order to provide stable NPE mode-locking, we applied the approach previously developed for Yb-doped all-fiber laser [2], namely, using a combination of polarization maintaining (PM) and non-PM parts to build the laser cavity and optimizing their lengths to achieve the best laser performance.

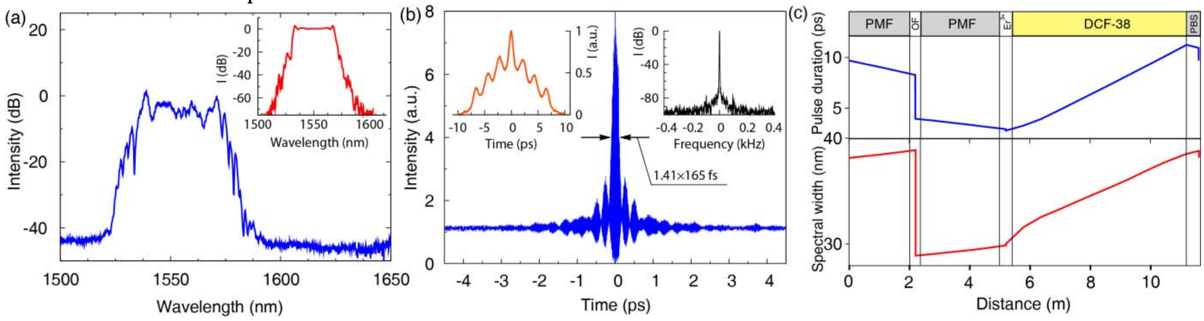

Fig. 1 (a) Output spectra realized in experiment and simulation (inset). (b) Autocorrelation traces of the compressed DS and DS before compression (left inset) and the corresponding RF spectrum (right inset). (c) Variation of the pulse duration and spectral width (at -10 dB level) along the cavity. PMF: PM fiber, OF: optical filter, Er^{3+}: PM erbium-doped fiber, DCF-38: dispersion compensated fiber, PBS: polarization beam splitter.

Fig. 1a depicts output spectra obtained in experiment and simulation demonstrating their agreement. 6 ps pulses at the output of the laser were dechirped to ~165 fs (spectral limit: 150 fs), showing the chirp parameter as high as 40.

The pulse train stability is characterized by RF beat signal at the fundamental frequency of the laser cavity (1 Hz bandwidth in 1 kHz range). The RF spectrum demonstrates a high contrast (≥90 dB, Fig.1b). The energy of the pulses is estimated to be 0.9 nJ according to the average output power 16 mW at 17.2 MHz repetition rate. The results of numerical simulation, based on the generalized nonlinear Schrödinger equation, show that the laser can be treated as a passive self-similar oscillator, in which the pulse shaping process is based on both spectral filtering of a chirped pulse and self-similar evolution in fiber with large normal dispersion, namely DCF-38 (Fig. 1c). However, the observed regime of mode-locking is closer to the DS regime than to the active self-similar regime with local nonlinear attraction [3]. At the next steps, we are going to perform a numerical optimization of DS generation over extended area of laser parameters to determine a way of more efficient energy scaling towards Raman threshold. The details of the numerical and experimental results will be presented at the conference.

References

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