Femtosecond Laser Based on 7-cm-Long Heavily Er-Doped Multicomponent Fiber

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High repetition rates mode-locked fiber lasers and are in the focus of recent investigations due to a number of applications in the fields of fiber communications, frequency comb, and optical sensing. [1]. One of the promising active media for such sources is heavily-rare-earth-doped phosphate fibres [2-6]. They allow obtaining an order of magnitude higher rare-earth ions concentration in comparison with silica glasses without ions clusterisation [7]. Thus, the pulse repetition rate may be extremely improving through shortening of a fiber gain medium. However, all-fibre laser design often becomes impossible or hard while phosphate fibres are used due to the significant difference of phosphate and silica glasses physical properties [8,9].

This work devoted to an investigation of mode-locked all-fibre laser based on a short multicomponent fiber with high-concentration Er-doped phosphate core and silica cladding.

We used in our experiments traditional ring-cavity fiber laser configuration. Mode-locking by nonlinear-polarisation evolution was obtained by appropriate orientation setting of the polarisation controllers. Multicomponent fiber doped with 3 wt.% of Er\textsuperscript{3+} ions was used as an active medium. Its length was varied from 7 to 19 cm. The erbium-doped fiber was pumped by a laser diode at 976 nm into the fiber core.

The output optical spectra, interferometric and intensity autocorrelation traces and radio frequency spectra were studied. The cavity group delay dispersion, Er-doped multicomponent fiber dispersion parameter and pulse phase modulation were estimated. The ultrashort pulses at the main pulse repetition rate corresponding to the fiber cavity length of about 24 MHz were observed with all investigated active fiber lengths. The fiber laser operated in the soliton regime. Pulse phase modulation and pulse duration reduced with Er-doped fiber shortening, while the signal-to-noise ratio increased at the same time.

The best results were achieved with 7-cm long active fiber. The laser average output power was about 2.2 mW. The output spectrum is shown in Figure 1. The pulse duration estimated from measured autocorrelation traces was 480 fs assuming a sech\textsuperscript{2} pulse shape. Time-bandwidth product was of 0.6. The calculated pulse energy and peak power were about 90 pJ and 185 W, correspondingly. The noise suppression for fundamental harmonic was about 50 dB. Laser demonstrated enough high stability in the radio frequency range up to 1 GHz.

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![Figure 1: The fiber laser output spectrum](image-url)
References


