Ultra-short optical soliton pulse (~20fs) propagation in optical fibers

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Abstract: Chirp-compensated gain-switched laser diode pulses of 5 ps were successfully compressed down to 20 fs through a single stage fiber-optic soliton compressor made of a step-like dispersion profiled fiber. The compression mechanism through the higher-order soliton propagation was also investigated experimentally in conjunction with some theoretical simulation works.

Generation of sub-50 fs optical pulses or shorter with the optical soliton compression schemes employed has been one of the most interesting topics in the field of femtosecond technology [1-6]. Recently, the minimum temporal width of gain-switched laser diode pulses thus compressed has reached 20 fs that corresponds to four optical cycles only [4]. While the combination of soliton compressors used therein was rather sophisticated, it has been claimed by our group that sub-50 fs optical pulses are obtainable with a simple step-like dispersion profiled fiber (SDPF) compressor [7] in conjunction with a single EDFA [5]. We report here on an improved SDPF compressor, which was prepared by taking into careful consideration the higher-order soliton compression, and on its successful 20 fs compression.

Figure 1 shows a schematic of the pulse source. 5 ps chirp-compensated pulses generated from a 1.55 μm gain-switched DFB-LD were amplified by an EDFA and subsequently compressed by an SDPF. The shortest pulse width obtained was 20 fs (see Fig. 2), which is the same as the record in Ref. 4.

Here, we used an SDPF containing four kinds of fibers (I: SMF, II: DSF, III: DFF and IV: another DFF). The dispersion profile of the SDPF, the length of each fiber in other words, was determined experimentally by the cutback method. At every fiber length, its optimum SDPF input power P_{in} was also checked. The dispersion profile thus derived is shown in the upper part of Fig.3. The temporal width Δt and the peak wavelength λ_p at output of each step are also indicated in the lower part of Fig. 3.

Detailed investigation on the pulse propagation has suggested the management of both higher-order dispersion and nonlinear effects is indispensable for sub-50 fs fiber-optic soliton pulse compression. Pedestal suppression and clarification of compression limit are the subjects for future studies.

The authors thank M. Hirano and M. Onishi of Sumitomo Electric for their supply of DFFs, and T. Kamiya for his support.

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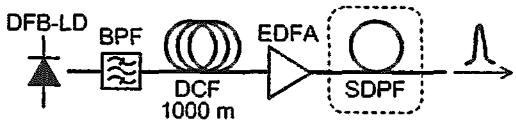

Fig. 1 Schematic of the experimental setup. Dotted box indicates the SDPF compressor.

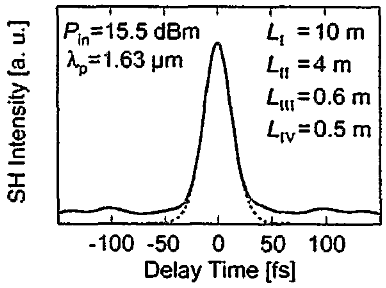

Fig. 2 Autocorrelation trace of the shortest (~20 fs) output pulse from SDPF. P_{in} is SDPF input power. L_i is the i-th fiber length. λ_p is the peak wavelength of optical spectrum. Autocorrelation of ideal 20 fs sech^2 pulse shape is indicated by a dotted line.

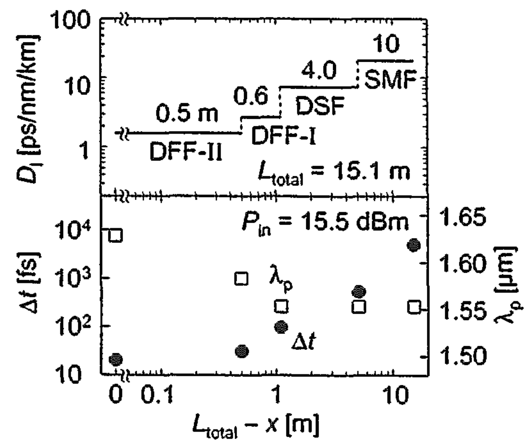

Fig. 3 The fiber dispersion profile of SDPF is plotted in the upper part. Each number indicates fiber length of each step. The output pulse width Δt and the peak wavelength λ_p are plotted in the lower part. x is the distance measured from the SDPF input. L_{total} is the total length of SDPF.