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Actively Mode-Locked Fiber Laser Using Impulse Modulation

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1. Introduction

We report an actively mode-locked fiber ring laser that can generate 290 fs pulses based on very fast impulse modulation.

Active and passive mode-locking of fiber lasers are the essential methods for obtaining high-quality optical pulses. Although passively mode-locked fiber lasers can generate very short optical pulses (femtosecond range), the pulse formation mechanism is sensitive with surrounding conditions and almost untunable since the mode-locking is achieved. On the other hand, actively mode-locked fiber lasers are tunable but the main disadvantage of active schemes is the relatively long pulse generation (picoseconds range) [1-3].

In our previous study [4], we proposed an actively mode-locked scheme that can generate stable 500 fs pulses. Now, we expand the previous work by the development of very fast impulse modulation.

2. Experimental setup

A schematic diagram of the actively mode-locked fiber ring laser is shown in Fig. 1. The fiber ring cavity contains a dual-electrode Mach-Zehnder intensity modulator, an EDFA, a polarization controller (PC), and an output coupler. Two electrodes of the modulator are driven by a sharp pulse generator which includes a function generator, an amplifier circuit, and a nonlinear transmission line pulse shaper. The output of the sharp pulse generator is divided into two paths by a broadband splitter with one path is delayed by a line stretcher.

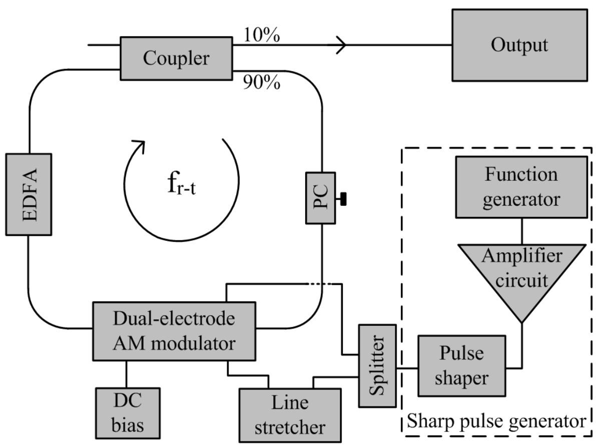

Fig. 1 Experimental setup

To generate very fast driving pulses, we developed an amplifier circuit based on a NPN 4 GHz wideband transistor. The amplifier circuit amplifies and changes input pulses of the function generator with risetime of 5 ns to output amplified pulses with risetime of only about 1 ns. Consequently, after the pulse shaper, very sharp driving pulses with risetime of about 700 ps are generated. The line stretcher makes a delay of about 300 ps. With such driving signals, the modulator makes impulse modulation of optical field inside the fiber ring cavity. The impulse modulation is carried out at the round-trip frequency (f_{r-t} = 9.188 MHz) of the cavity to realize the mode-locking. Thus, after modulation, a short optical pulse is generated inside the ring cavity and further compressed after many round-trip to femtosecond range.

3. Results

The output of the fiber ring laser was characterized by an autocorrelator and an optical spectrum analyzer. Fig. 2 displays the measured autocorrelation trace of the output optical pulse. The FWHM trace width is 450 fs. By assuming sech pulse profile, the pulse width is 290 fs. The inset of Fig. 2 shows optical spectrum of the mode-locking with a 3 dB spectral bandwidth of about 0.52 THz.

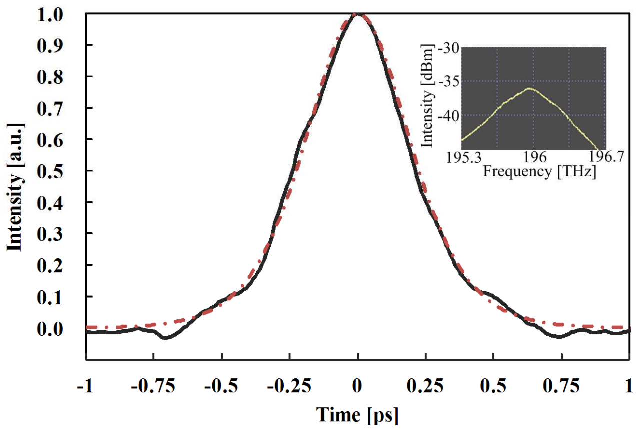

Fig. 2 Measured autocorrelation trace of pulse from the actively mode-locked fiber laser. A sech fit (dashed curve) to the trace gives a FWHM pulse width of 290 fs. The inset shows the optical spectrum.

4. Conclusions

We reported an actively mode-locked mechanism based on the development of very fast impulse electrooptic modulation inside a fiber ring laser. The experimental results show that the mode-locking generates optical pulses of 290 fs temporal width and 9.188 MHz repetition rate.

References

[1] M. Malmstrom, W. Margulis, O. Tarasenko, V. Pasiskevicius, and F. Laurell: Opt. Express **20** (2012) 2905.

[2] M. Bello-Jimenez, C. Cuadrado-Laborde, A. Diez, J. L. Cruz, and M. V. Andres: Appl. Phys. B **105** (2011) 269.

[3] I. L. Villegas, C. C. Laborde, J. A. Afonso, A. Diez, J. L. Cruz, M. A. M. Gamez, and M. V. Andres: Laser Phys. Lett. **8** (2011) 227.

[4] D. T. Nguyen, A. Muramatsu, and A. Morimoto: Electron. Lett. **49** (2013).