Analysis of pulse trapping of continuous wave in nonlinear optical loop mirror and all-optical switching

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1. Introduction

When two orthogonally polarized ultrashort pulses satisfy a group velocity matching condition and they are temporally overlapped in a birefringent fiber, a nonlinear fiber phenomenon of pulse trapping and amplification is induced. The two pulses trap each other and co-propagate along the fiber due to cross-phase modulation [1]. The pulse trapping phenomenon is also induced between a continuous-wave (cw) beam and an ultrashort pulse in birefringent fibers, and an ultrashort pulse is generated from the cw beam [2].

A nonlinear optical loop mirror (NOLM) is useful for all-optical control techniques. Using the pulse trapping phenomenon in the NOLM, the ultrafast all-optical sampling was demonstrated [3]. In this paper, we investigated the pulse trapping in the NOLM between a cw beam and an ultrashort pulse both experimentally and numerically. We demonstrated the all-optical switching of the cw beam by ultrashort pulse.

2. Results

Experimental setup

Figure 1 shows the experimental setup used for the pulse trapping between a cw beam and an ultrashort control pulse in the NOLM. The NOLM consisted of an optical circulator, a 3-dB coupler, two polarization beam combiners, and a polarization maintaining fiber (PMF). A cw beam and an ultrashort control pulse were coupled into the NOLM. The wavelength of the cw beam was 1560 nm. The center wavelength of the ultrashort control pulse was 1610 nm and the repetition frequency was 50 MHz. The optical spectrum was observed at the NOLM output.

Experimental results

In the optical spectrum at the output port of the NOLM, a pulse component was observed at 1560 nm in addition to the remainder of the cw beam. When the average power of the input cw beam was 9.6 mW and the loop length of the NOLM was 60 m, the average power of the output pulse was 1.4 μW.

Numerical results

Figure 2 shows the numerical result of temporal waveforms at the NOLM output port and rejection port. The loop length of the NOLM was 10 m and the average power of the input cw beam was 1 mW. In the clockwise propagation along the PMF, the temporally overlapped part of the cw beam experiences a nonlinear fiber effect of cross-phase modulation due to the ultrashort control pulse. The clockwise and counter-clockwise cw beams are combined at the 3-dB coupler, and they undergo interference. Then, the ultrashort pulse is obtained at the output port of the NOLM. The peak power of the output pulse is 0.59 mW, and the temporal width was 700 fs full width at half maximum.

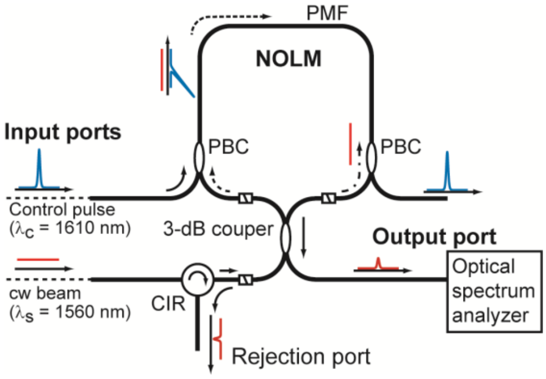

Fig. 1 Setup for NOLM using pulse trapping. PMF, Polarization maintaining fiber; CIR, Circulator; PBC, Polarization beam combiner.

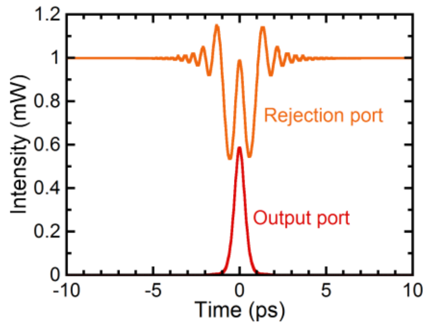

Fig. 2 Numerical results of optical waveform at output and rejection ports for 10 m-long NOLM length.

3. Conclusions

We demonstrated and investigated the pulse trapping in the NOLM between a cw beam and an ultrashort pulse. An ultrashort pulse was sampled from the cw beam.

References

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