Novel polarization maintaining actively mode locked fiber ring laser

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Abstract: A 10 GHz polarization-maintaining actively mode-locked fiber ring laser was demonstrated. A Fabry Perot laser diode was incorporated into the ring cavity as an all-optical polarizer.

OCIS codes: (140.4050) Mode-locked lasers; (140.3520) Lasers, Injection -locked

1. Introduction

Fiber lasers usually suffer from instability in the output state-of-polarization (SOP) if non-polarization maintaining fiber is used. Recently, it is demonstrated that an injection locked Fabry Perot laser diode (FP-LD) can function as an all-optical polarizer, where an injected signals with varying SOP can be polarization-stabilized using injection locking [1]. In this report we present a novel actively mode-locked fiber ring laser using a FP-LD in the ring to stabilize the SOP of the laser output.

2. Operating principle

Fabry-Perot laser diodes typically emit in TE polarization because the lasing threshold of TE mode is smaller than that of the TM mode [2]. An external beam with varying SOP will injection lock a FP-LD whenever the TE component of the signal is above the injection locking threshold. Once injection locked, the FP-LD output will be TE polarized and clamped at the same intensity. Thus if we incorporate a FP-LD in the cavity of a mode-locked fiber ring laser, the FP-LD will realign the randomly varying SOP of the light circulating in the fiber cavity at every round trip through injection locking. The polarization state of the mode-locked laser output will therefore be maintained.

3. Experimental results

Figure 1 shows the experimental setup for the all-optical polarization maintaining actively mode-locked fiber ring laser. The laser cavity consists of a 12-meter erbium-doped single mode fiber. The 980 nm pump was coupled into the active fiber through a 980/1550 nm wavelength division multiplexer. The isolators rejected any residual pump and guaranteed unidirectional operation of the ring. A polarization sensitive Mach-Zehnder modulator was used as a mode-locker offering periodic intracavity loss modulation. The modulator was dc-biased and driven by a sinusoidal signal from a 10 GHz synthesizer through an electrical amplifier. The signals circulating in the fiber cavity were injected into a FP-LD through a polarization independent circulator. The erbium doped fiber amplifiers provided extra gain to the cavity and extended the injection locking range. Figures 2a and 2b show the mode-locked laser output without and with the FP-LD. The amplitude jitters of the output due to the variation of the SOP (Fig. 2a) were removed by the use of FP-LD (Fig. 2b). The 3 dB spectral width was 0.18 nm (Fig. 3) while the FWHM pulsewidth was 20 ps. The time-bandwidth product is 0.45 implying a nearly Gaussian transform limited pulse.

The output pulse trains were then externally modulated using a 10 GHz polarization dependent modulator. Figures 4a and 4c show the eye-diagrams of the modulated output without and with the FP-LD in the laser cavity respectively. The injection locked FP-LD improved the eye diagram and reduced timing jitters by stabilizing the polarization in the cavity. Figures 4b and 4d give the RF spectra at 10 GHz without and with the FP-LD respectively. The additional frequency components at ±50 kHz from the carrier frequency shown in Fig. 4b were due to the beating of the two polarization modes in the cavity, thus confirming multi-polarization operation without the FP-LD.

4. Conclusions

We successfully generated a stable and polarized 10 GHz transform limited pulse train from an actively mode-locked fiber ring laser using injection locking in a FP-LD to maintain polarization.

5. References

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[2] B. M. Yu and J. M. Liu, J. Appl. Phys. , **69**, 7444 (1991)

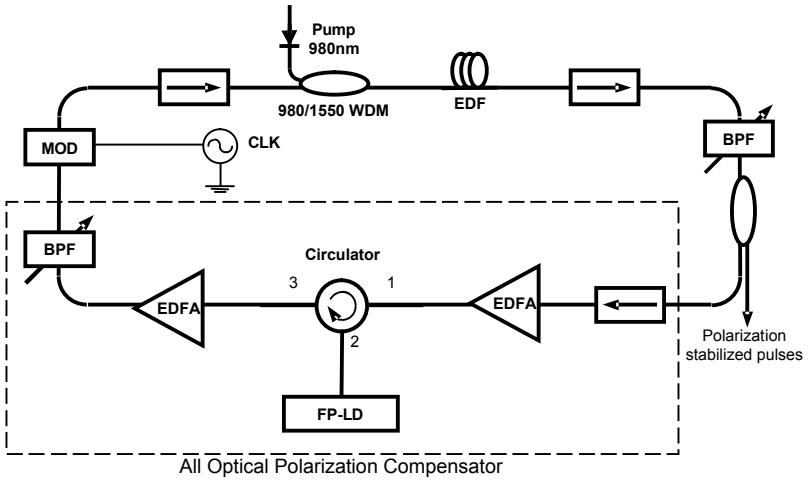

Fig. 1. Experiment Setup. WDM: Wavelength-division multiplexer. EDF: Erbium-doped fiber. EDFA: Erbium-doped fiber Amplifier. BPF: Bandpass filter. MOD: Intensity modulator. FP-LD: Fabry-Perot Laser Diode.

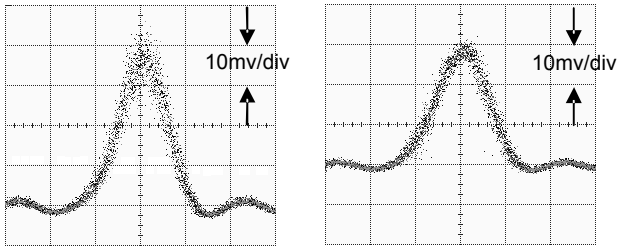

Fig. 2. Output temporal pulse shape (a) without (b) with the FP-LD. Timebase: 20 ps/div.

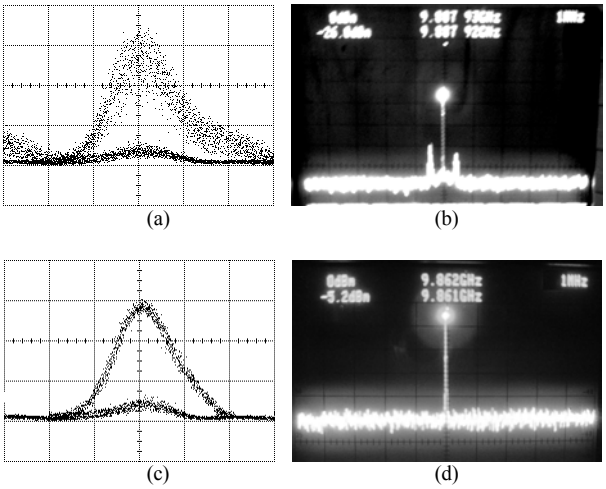

Fig. 4. Eye diagrams and RF spectra of the mode locked fiber ring laser, (a, b) without and (c, d) with, the FP-LD. Timebase: 20 ps/div.

Fig. 3. Wavelength spectrum of the mode locked pulse train.