L-Band Fiber Laser Mode-Locked by All-Polarization-Maintaining Nonlinear Polarization Rotation

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Abstract: *For the first time in the soliton regime, we demonstrated an L-band fiber laser mode-locked by all polarization-maintaining nonlinear polarization rotation. The self-starting laser centered at 1586.4 nm with long-term stability.*

1. Introduction

Mode-locked ultrashort laser pulses obtained by an artificial saturable absorber (SA), such as nonlinear polarization rotation (NPR), have attracted wide applications in communications systems. In particular, L-band (1565-1625 nm) mode-locked laser source is imperial to expand the capacity of a dense wavelength-division multiplexing (DWDM) network [1]. For the first time in the soliton regime, we report an L-band laser with solid resistance to environmental perturbations by realizing NPR in an all-polarization-maintaining (all-PM) fiber configuration.

2. Design of fiber laser and experimental results

Figure 1 shows the experimental setup of the all-PM NPR mode-locked fiber laser. A slow-axis working PM tap isolating wavelength-division multiplexing (PM-TIWDM) coupler works as a hybrid device to combine a polarizer, WDM, isolator, and 20% output tap. A 1.4 m PM-EDF (Nufern ESF-7/125) serves as the gain medium and is backward pumped by a 980 nm LD through the PM-TIWDM. All the rest passive fibers are PM type (Fujikura SM15-PS-U25A). The artificial SA of all-PM NPR structure consists of a slow-axis working PM circulator (PM-CIR), a PM Faraday rotation mirror (FRM), and the fiber segments in between. The PM-CIR functions as a polarizer and isolator to ensure two orthogonally polarized components along the slow and fast axis after a 30° angle splicing. The required key NPR is obtained with the 21-m, 7 segments PMF by six angle splicing of 90°, followed by the FRM. The total cavity length is about 50 m, and the net dispersion is estimated to be -1.03 ps^2 at 1550 nm.

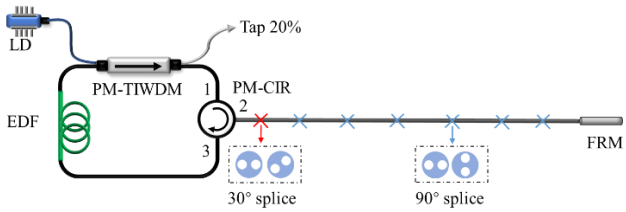

Fig. 1. Experimental setup of all-PM NPR mode-locked fiber laser.

The laser can be self-started when the pump power reaches 260 mW. By slowly lowering the pump down to 90 mW, a stable single pulse of 80 μW average power can be obtained. The repetition rate is 4 MHz in accordance with the cavity length of 50 m. The spectrum centered at 1586.4 nm with a 3 dB bandwidth of 2.4 nm, as shown in figure 2(a). The signal-to-noise ratio (SNR) of the radio frequency (RF) spectrum is about 45 dB. With a pump of 90 mW, the laser is free-running for 48 hours without losing mode-locking.

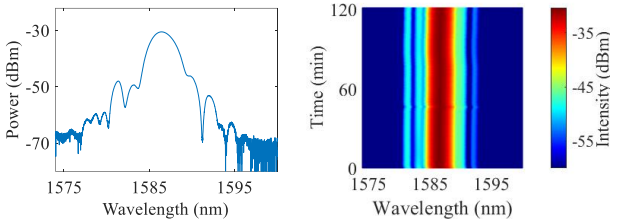

Fig. 2 (a) Output optical spectrum of the L-band fiber laser; and (b) change of output optical spectrum over time.

The environmental stability of the laser is evaluated by a 2-hour free-running performance. As shown in figure 2(b), there is only a slight center wavelength shift of the laser due to the environmental perturbations, while most of the spectrum remains stable. The maximum wavelength shift of 0.24 nm occurs at 50 minutes was due to a significant temperature change induced by a heat gun.

3. Conclusion

In conclusion, for the first time to the best of our knowledge, we demonstrated an all-PM NPR MLFL delivering laser pulse at L-band in the soliton regime. The spectrum centered at 1586.4 nm with a 3 dB bandwidth of 2.4 nm. The laser has 45 dB RF SNR and an average output power of 80 μW. The all-PM laser system features good self-starting ability and good stability over hours of operation.

References

[1] J. Jiang, Q. Huang, Y. Ma, D. Liao, "Wavelength-tunable L-band mode-locked fiber laser using a long-period fiber grating," Opt. Express **29** (17), 26332-26339 (2021).