全ファイバ2μmの波長双方向モードロックレーザ

All-Fiber 2μm Wavelength Bi-directional Mode-Locked Laser

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Abstract: Bi-directional passive mode-locked fiber laser in 2μm is demonstrated. The repetition rates are 22.6961MHz and 22.6967MHz, because of the slightly asymmetry of the layout.

Since most of the ultrafast lasers generate pulse in a single direction, the approach of generating pulse train in the opposite direction have attracted interests. Similar experiment has been reported at 1.55 μm for the generation of bidirectional soliton pulses [1]. Here, we demonstrate, for the first time to our knowledge, a novel bidirectional passively mode-locked fiber laser in 2um using CNT-SA for mode locking. Fig. 1 shows the experimental setup schematic, a 3.8-meter-long piece of thulium-doped silica fiber (TDF) is used as the gain medium with an estimated anomalous dispersion of -0.02ps^2/m at 1960nm region. Two FC-APC fiber connectors are used as holders to sandwich the CNT film. A 2*2, 50/50 coupler is used to split the pulses from the single cavity in each direction. No isolator (ISO) is used in the cavity so that the laser could delivering both directional pulse trains in the cavity, clockwise (CW) and counterclockwise (CCW), respectively. However, the optical isolators are added at the outputs in bidirectional to prevent unwanted reflections into the cavity. The pigtails of all the passive fiber components are made of single-mode fiber (SMF) with an estimated anomalous dispersion of -0.06ps^2/m at 1960nm, Carbon nanotube (CNT) saturable absorbers (SA) have the properties of being able to operate in transmission-, reflection-, and bidirectional modes. Fig. 2 shows the outputs spectra with an optical resolution bandwidth of 0.05nm. Since the dispersion of the laser is around -0.33ps2, both directional spectrum has the typical soliton spectrum with Kelly sidebands can be observed when the pump power is set to 79mW. The spectrum has the 3dB bandwidth of 4nm, the central wavelength of the opposite direction is a little bit different, the central wavelength of CW the soliton pulse is 1973.10nm, while for CCW direction is 1973.80nm. The output power of pulses is 2.9mW and 6.1mW. Fig. 3 shows that the RF spectra with 100kHz span and 100Hz resolution bandwidth, the repetition rates of the CW direction and the CCW direction are 22.6961MHz and 22.6967MHz, with the distance of 600Hz. The distance of the opposite direction RF spectrum result from the asymmetry of the laser cavity. This result indicates that two outputs have good phase coherence that has the potential for dual-comb applications. Fig. 3 also shows the autocorrelation traces. The autocorrelation width is 1.81 ps and 1.78 ps, inferring a full width at half-maximum (FWHM) pulse width of 1.21 ps and 1.15 ps, if a hyperbolic-secant pulse shape is assumed. The maximum pulse energy of the CW direction and CCW direction achieved is 0.13 nJ and 0.27 nJ. The outputs of the opposite direction can generate stable ~1 ps pulse trains. Since the spectra of the opposite directions are different, the good coherence property from their slightly different repetition rates could be extended to many interesting applications such as dual-comb spectroscopy and super continuum generation (SCG).

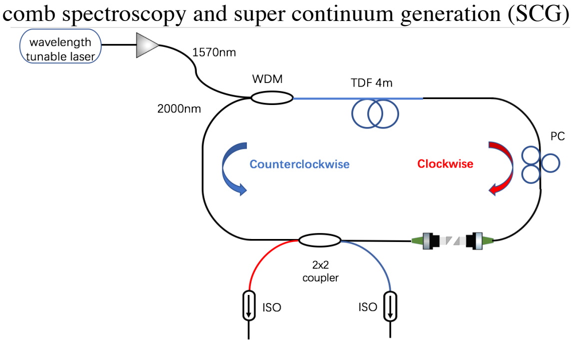

Fig. 1 Schematic of our experimental setup

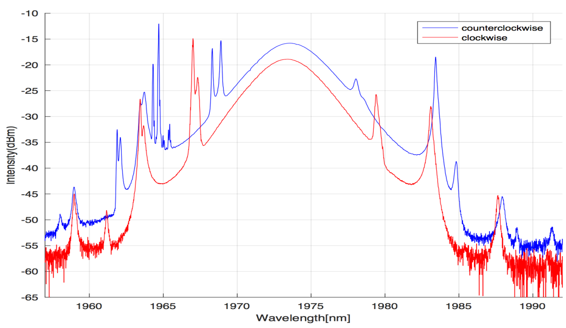

Fig. 2 Output optical spectrum pulse

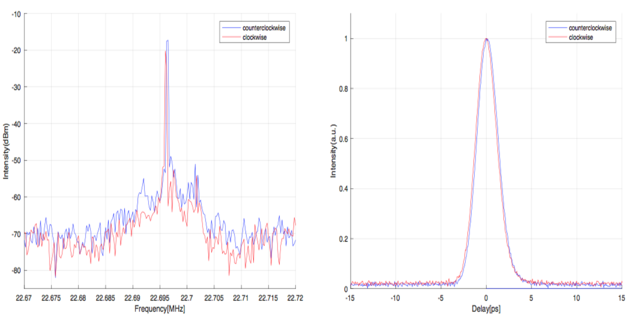

Fig. 3 RF spectrum (left) and autocorrelation trace (right)

Reference

[1] K. Kieu and M. Mansuripur, “All-fiber bidirectional passively mode- locked ring laser,” Opt. Lett., vol. 33, 1, 64 (2008).