OGC 2022
Optoelectronics Global Conference

Ultra Narrow Linewidth Distributed Feedback Fiber Laser Based on Self-injection Locking

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***Abstract*—**We have reported an ultra narrow linewidth fiber laser based on π phase-shift fiber Bragg grating (π-FBG) and self-injection locking, in which the π-FBG is inscribed on Erbium-ytterbium co-doped fiber with scanning phase mask method. Using self-injection locking, the relaxation oscillation frequency (ROF) peak was reduced about 25 dB from -103 dB/Hz to -128 dB/Hz. The 20-dB linewidth of the laser was suppressed to around 500 Hz.

Experimental setup

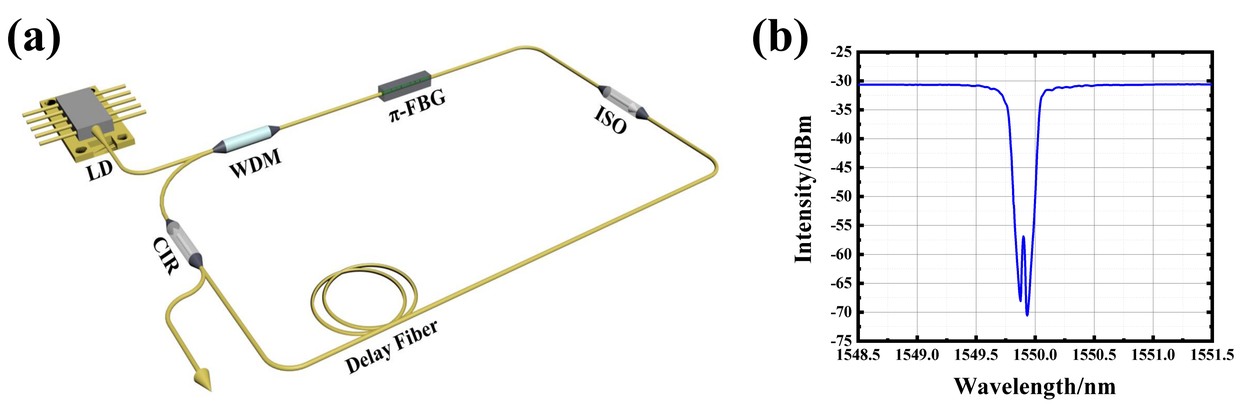

Fig. 1. (a) Schematic of DFB-FL based on self-injection locking, (b) The transmission of the π-FBG.

The configuration of the proposed distributed feedback fiber laser (DFB-FL) based on self-injection locking is shown in Fig. 1(a), which is composed of a 980 nm laser diode (LD), a 980/1550 wavelength division multiplexer (WDM), a 5-cm π-FBG, an isolator (ISO), a10-m delay fiber and a circulator (CIR). The π-FBG was fabricated in 6-cm long Erbium-ytterbium co-doped fiber (Coractive EY305). The transmission spectrum of the π-FBG was shown in Fig. 1(b), The π-FBG was encapsulated with vibroisolating material, the temperature near the π-FBG was monitored by a thermistor, a thermoelectric cooler (TEC) was used to cooling the π-FBG and keep temperature constant inside. The entire optical path was packaged in a sealed box and fixed with flexible glue.

Results

As shown in Fig. 2(a), the threshold of the laser was approximately 62 mW, corresponding to the slope efficiency of about 0.15%. The center wavelength of the laser is 1549.8 nm, and the optical signal to noise ratio (SNR) is nearly 70 dB.

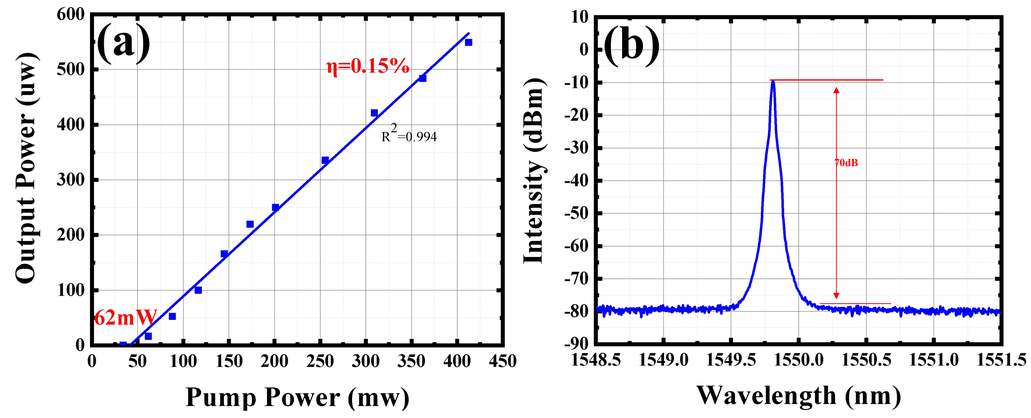

Fig. 2. (a) Output power versus pump power, (b) Measured optical spectrum of the DFB-FL.

The single longitudinal mode output of the DFB-FL was confirmed by using a scanning Fabry-Perot interferometer (FPI) with free spectral range of 4 GHz and fineness of 2000 as illustrated in Fig. 3(a), the absence of any peaks between the main resonances of the FPI indicates the operation on only one longitudinal mode. The relative intensity noise (RIN) shifted from 500 kHz to 400 kHz and the ROF peak was reduced by about 25 dB from -103 dB/Hz to -128 dB/Hz after self-injection locking, and the noise level was better than that of commercial NKT E15.

The 20-dB Lorentz linewidth of the free running DFB-FL is about 5 kHz, and decreased to 500 Hz after self-injection locking. The phase noise of the DFB-FL is shown in Fig. 3(d), the phase noise decreased from -30 dBc/Hz to -40 dBc/Hz at 3 kHz, while the NKT E15 fiber laser has lower phase noise of -50 dBc/Hz at 3kHz.

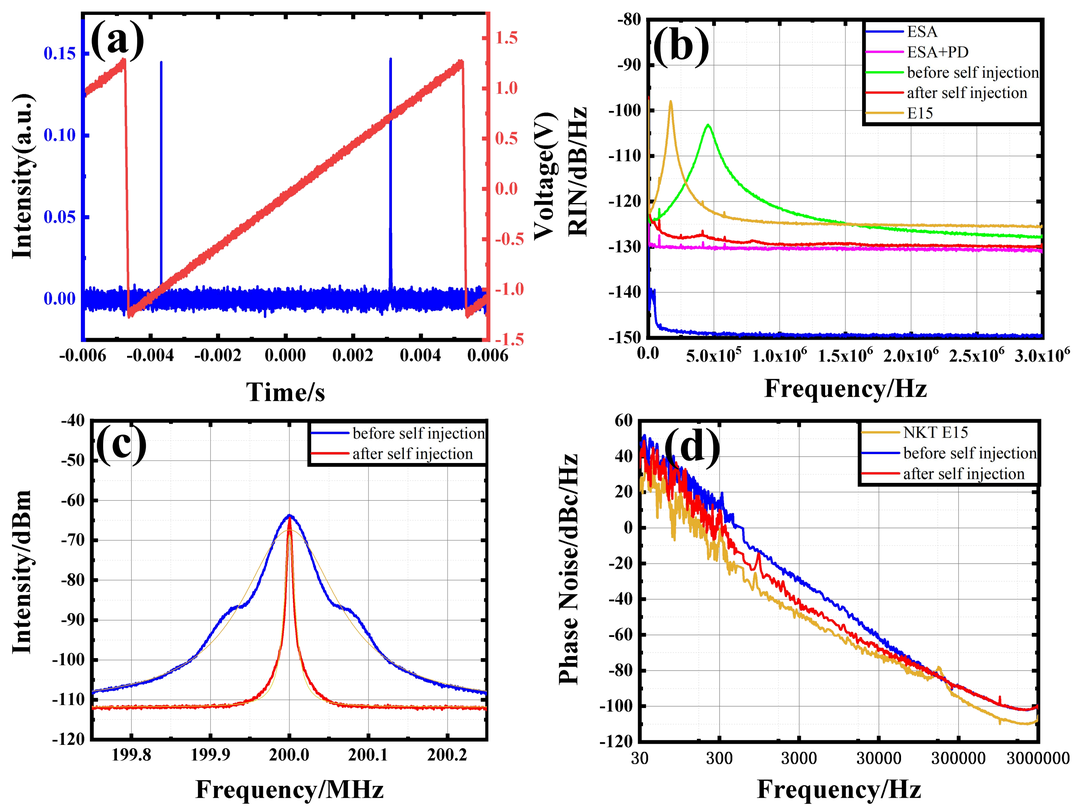

Fig. 3. (a) Longitudinal mode characteristics of the DFB-FL, (b) Measured RIN of the DFB-FL, (c) Measured self-heterodyne spectra of the DFB-FL, (d) measured phase noise of the DFB-FL.