Optics & Laser Technology 82 (2016) 72–75

Contents lists available at ScienceDirect

Optics & Laser Technology

journal homepage: www.elsevier.com/locate/optlastec

Research Note

Selectable dual-wavelength erbium-doped fiber laser with stable single-longitudinal-mode utilizing eye-type compound-ring configuration

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ARTICLE INFO

Article history:
Received 27 November 2015
Received in revised form
25 February 2016
Accepted 25 February 2016
Available online 1 March 2016

Keywords:
Fiber lasers
Fiber optics
Communication optical

ABSTRACT

In this paper, a tunable dual-wavelength erbium-doped fiber (EDF) ring laser with stable single-longitudinal-mode (SLM) under a tuning range of 1530.0–1560.0 nm is proposed and demonstrated. Here, the mode spacing of lasing dual-wavelength from 1.0 to 30.0 nm can be selected arbitrarily in any wavelength position. To accomplish the SLM output, the eye-type compound-ring scheme is proposed inside ring cavity for suppressing the multi-longitudinal-mode (MLM) highly. The entire measured output power and optical signal to noise ratio (OSNR) of each dual-wavelength are larger than −13.3 dBm and 60 dB respectively. In addition, the output stability measurement of proposed EDF laser is also performed and analyzed.

1. Introduction

Tunable and stable dual-wavelength erbium-doped fiber (EDF) laser has interested a huge consideration due to the useful applications in optical fiber sensing [1], radio photonics [2], optical fiber communication [3], and optical instrument testing [4]. Because of the mode-hopping and homogeneous broadening of EDF ring laser configuration, around the central oscillating mode in a longer cavity would result in unstable wavelength output [5].

To resolve the problem, two key technologies of optical filters have been demonstrated in EDF laser structure to generate dual-wavelength lasing. One is using narrow-band optical filter, such as fiber Bragg grating (FBG)-based Fabry-Perot filter [6,7] and polarization-maintaining (PM) FBG filter [8]. As mentioned above, these FBG filters only provide fixed mode-spacing for dual-wavelength EDF laser architecture. The other one is utilizing comb filter, such as a reconfigure dual-pass Mach-Zehnder interferometer (DPM-ZI) filter [9], fiber Fabry-Perot tunable filter (FP-TF) [10], and PM-EDF laser scheme [11]. However, the maximum mode-spacing of Ref. [11] is around 4.32 nm. Moreover, employing compound-ring or multi-ring configurations have also been proposed to produce Vernier effect for suppressing the multi-longitudinal-mode [12–15].

In this investigation, we propose and investigate a tunable dual-wavelength EDF ring laser with stable single-longitudinal-mode (SLM) in a tuning range of 1530.0–1560.0 nm. Here, the mode spacing of lasing dual-wavelength from 1 to 30 nm can be chosen randomly in any wavelength location, when two tunable bandpass filters are used inside ring cavity. In the measurement, to achieve the SLM output, an eye-type compound-ring scheme is proposed inside a ring cavity for suppressing the densely multi-longitudinal-mode (MLM). In addition, the entire optical signal to noise ratio (OSNR) and output peak power can be larger than 60 dB and −13.3 dBm of each dual-wavelength respectively. Moreover, the output stability performance of lasing dual-wavelength has also been performed and analyzed.

2. Experiment and results

Fig. 1 shows the experimental setup of proposed stable and tunable SLM dual-wavelength EDF laser architecture. The proposed fiber laser is consisted of a C-band EDFA (Manufactured by SDO, Taiwan), three polarization controllers (PCs), an in-line fiber polarizer (Pol), one 1×2 and 50:50 optical coupler (OCP), three 2×2 and 50:50 OCPs, and two tunable bandpass filters (TBFs). The signal gain and saturated power of EDFA are 30 dB and 13 dBm in the range of 1528–1562 nm. Besides, the inset of Fig. 1 is the amplified spontaneous emission (ASE) spectrum of C-band EDFA. In the experiment, these OCP_s are utilized to construct the eye-type compound-ring scheme, which is constructed by fiber $ring_1$, $ring_2$, and $ring_3$, respectively, as illustrated in Fig. 1. Here, to

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http://dx.doi.org/10.1016/j.optlastec.2016.02.020
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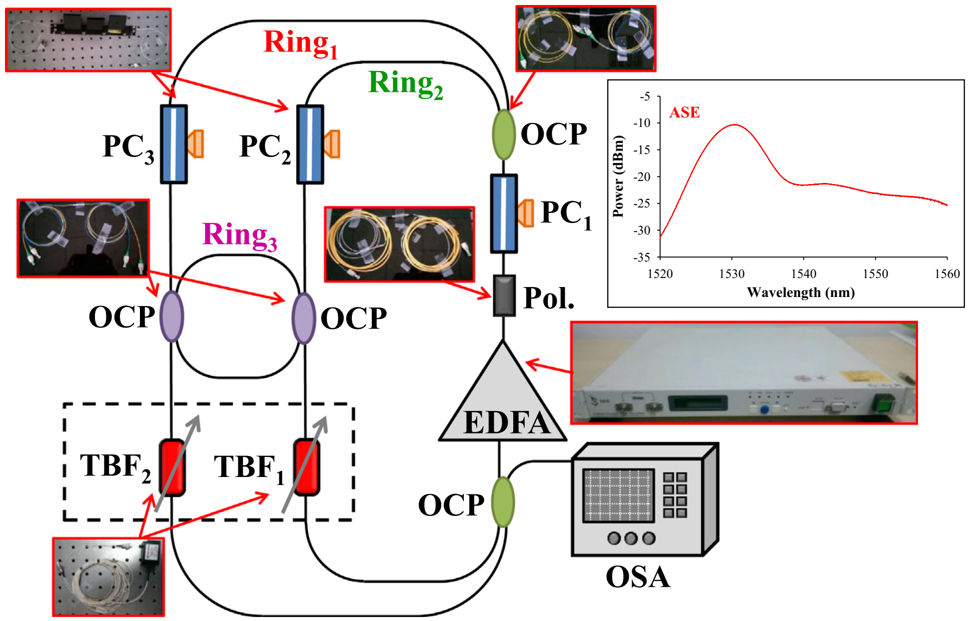

Fig. 1. Proposed dual-wavelength EDF eye-type compound-ring laser structure. The photos of insets are corresponding optical components.

decrease the number of longitudinal-mode and prevent mode-hopping, the fiber-based polarizer (Pol) and three PCs are utilized to fix the single-polarization status and provide polarization-dependent loss (PDL) [16]. Besides, the 3 dB bandwidth, wavelength-tuning range and insertion loss of two used TBFs are 0.4 nm, 30 nm (1530–1560 nm) and 6 dB, respectively. Hence, two TBFs can be used inside ring cavity to generate the dual-wavelength output with various mode-spacing randomly in any wavelength location. In addition, to measure the output wavelength and power of proposed EDF laser, an optical spectrum analyzer (OSA) with a 0.05 nm resolution is utilized.

When two TBFs are employed to select different pass modes, then the lasing dual-wavelength with various mode-spacing can be generated. Fig. 2 shows the measured output spectra of lasing dual-wavelength with different mode-spacing in the proposed EDF eye-type compound-ring laser. As shown in Fig. 2, the mode-spacing can be tuned arbitrarily from 1.0 to 30.0 nm in whole C-band operation. In this measurement, the observed optical signal to noise ratio (OSNR) and output peak power of each dual-wavelength could be larger than 60 dB and −13.3 dBm respectively, as shown in Fig. 2. Then, we fix the mode-spacing of 1.0 nm for dual-wavelength tuning in C-band range for measurement. Hence, Fig. 3 presents the measured output spectra of tunable dual-wavelength with a 1.0 nm mode-spacing in the tuning range of 1535.0–1548.0 nm. Here, we observe that the maximum and minimum peak powers of lasing wavelength are −9.8 dBm and

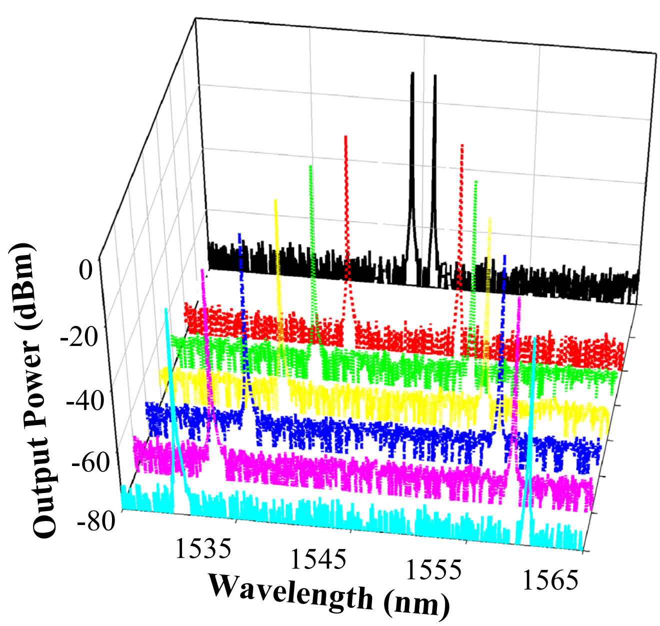

Fig. 2. Measured output spectra of lasing dual-wavelength with different mode-spacing in the proposed EDF eye-type compound-ring laser.

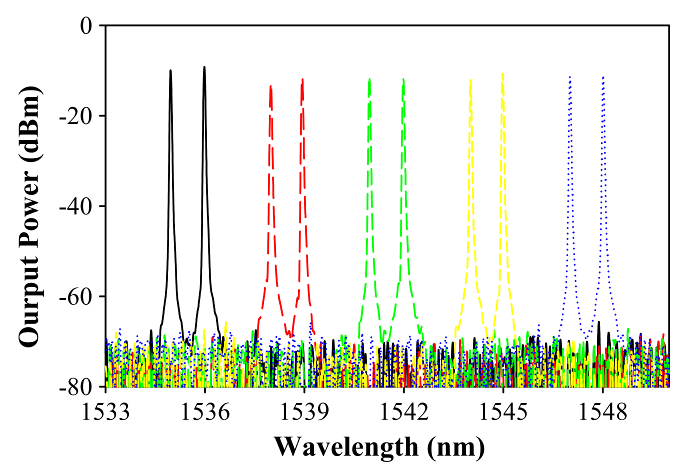

Fig. 3. Measured output spectra of lasing dual-wavelength with 1.0 nm mode-spacing in the proposed EDF eye-type compound-ring laser.

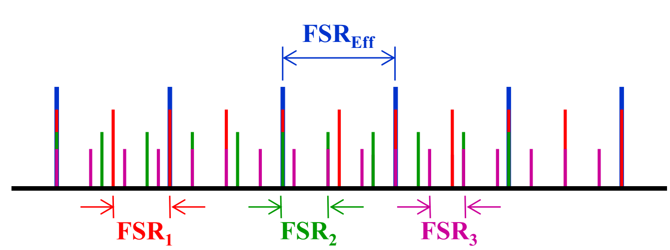

Fig. 4. The schematic diagram of FSRs for mode selection.