Journal of Science and Technology, Vol. 9 No. 3 (2017) p. 92-95

The Generation of Dual Wavelength Pulse Fiber Laser Using Fiber Bragg Grating

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Received 30 September 2017; accepted 30 November 2017; available online 28 December 2017

Abstract: A stable simple generation of dual wavelength pulse fiber laser on experimental method is proposed and demonstrated by using Figure eight circuit diagram. The generation of dual wavelength pulse fiber laser was proposed using fiber Bragg gratings (FBGs) with two different central wavelengths which are 1550 nm and 1560 nm. At 600 mA (27.78 dBm) of laser diode, the stability of dual wavelength pulse fiber laser appears on 1550 nm and 1560 nm with the respective peak powers of -54.03 dBm and -58.00 dBm. The wavelength spacing of the spectrum is about 10 nm while the signal noise to ratio (SNR) for both peaks are about 8.23 dBm and 9.67 dBm. In addition, the repetition rate is 2.878 MHz with corresponding pulse spacing of about 0.5 μs, is recorded.

Keyword: Dual wavelength pulse fiber laser; fiber Bragg gratings; pulse spacing; repetition rate; signal to noise ratio.

1. Introduction

The generation of dual wavelength pulsed lasers is useful for many applications nowadays, for example in medical, areas of environmental sensing, metrology, laser processing, remote sensing, communication, telecommunication, range finding, and metal cutting [1-5]. Pulsed lasers can be applied in many versatile applications.

As reported previously there are advantages of using fiber Bragg grating (FBG) in different ways for different purposes. FBG is a simple optical device to act as a reflector thereby converting the device into a practical component with improved performance [6]. In the reflection and transmission process, FBG has been linear, passive, high dispersion that makes it very interesting components. The gratings on the FBG are determined to achieve the maximum compression ratio in the transmission section [7].

Dual wavelength fiber laser is a laser that emits the radiation on fiber optic in two resonator modes of the spectrum. Besides, the multi wavelength fiber laser has high number of channels over large wavelength span that gives high potential in the fiber optic testing and measurement [8]. The generation of single wavelength pulse fiber laser is widely used today, while the dual wavelength pulse fiber laser has its own advantages compared with the single wavelength pulse fiber laser such as the terahertz generation, the generation of supercontinuum and the nonlinear optics [9-10]. Normally, in generating the dual wavelength pulse fiber laser, it used the various ranges of material such as the tungsten disulphide (WS_2), molybdenum disulphide (MoS_2), graphene and black phosphorus (BP), act as saturable absorber [11-14].

Previous researches also reported the determination of stability of dual wavelength pulse fiber laser using polarization controller (PC), isolator, non linear amplifying fiber loop mirror, dual or multi ring configuration [7,8].

In this study we propose and experiment a stable simple generation of dual wavelength pulse fiber laser as it can easily be constructed with low cost and under room temperature. The experimental results show that this design can stably and uniformly lase two wavelengths pulse simultaneously.

2. Experimental setup

Fig. 1 shows the experimental setup that has been used to generate the dual-wavelength pulse fiber laser. A 1.8 m long piece of erbium doped fiber (EDF) with a 6 dB/m absorption at 980 nm acts as the gain medium and this design is constructed by using a double ring

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cavity configuration. The setup consists of a wavelength division multiplexer (WDM) with 980/1550 nm that connected to the 980 nm laser diode (LD) by (THORLABS CLD1015), used to pump the EDF through a WDM (980/1550 nm). To create the figure eight circuit diagram, the setup use 50/50 coupler that is connected between the two loops. For the first loop it consists of 1.8 m of EDF, 980/1550 nm of WDM, polarization controller (PC) by (THORLABS FPC030) and 1.5 m of highly non-linear fiber (HNLF) that combines a high non-linear coefficient with numerically small group velocity dispersion. The second loop consists of PC, allows one to modify the polarization state of light and also consists of 90/10 coupler where 90% of the light is transmitted through 50/50 coupler and the other 10% to the circulator. The second port of the circulator is connected to FBGs (1550 nm and 1560 nm) and the signal travels through a circulator to the 1550 nm and 1560 nm FBG as the wavelength reflector. The other port of circulator is connected to the 50/50 coupler. 50% of the signal from the coupler is transmitted to the optical spectrum analyzer by (OSA-Anritsu MS9740A) with 0.02 nm resolution, for analyzing the lasing profile of the proposed fiber laser and another 50% of the signal passes through the Oscilloscope by (OSC-Tektronix MDO3104) with 5 GHz photo detector by (THORLABS DET08CFCM) which is used to measure the pulse train.

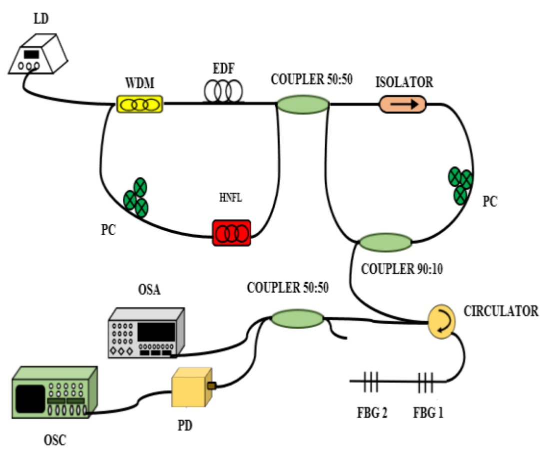

Fig. 1 Schematic configuration of dual wavelength pulse fiber laser.

3. Results and Discussions

Dual wavelength pulse fiber laser is generated from the mode-locked fiber laser. Fig. 2 shows the most stable mode-locked optical spectrum before inserting the FBGs (1550 nm and 1560 nm) in the circuit diagram. The ideal mode-locked operation is achieved when the pump power is increased to 600 mA (27.78 dBm) with the wavelength ranging from 1500 nm to 1580 nm and the central wavelength of 1530 nm at -50 dBm of output power. At 600 mA (27.78 dBm) the bandwidth of the spectrum is about 33 nm. The signal to noise ratio (SNR) is about 30 dBm.

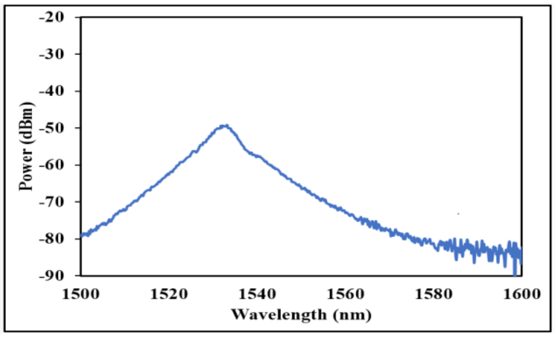

Fig. 2 Spectrum of stable mode locked fiber laser.

After the mode-locked fiber laser has been generated, the FBGs (with 1550 nm and 1560 nm wavelenghts) are inserted in the circuit diagram as in Fig. 1 to produce the dual wavelength pulse fiber laser. Fig. 3 presents the output spectrum of dual-wavelength pulse fiber laser by using 600 mA (27.78 dBm) of LD. At 600 mA (27.78 dBm), the dual wavelength pulse fiber laser appears at 1550 nm and 1560 nm with peak power of -54.03 dBm and of -58.00 dBm, respectively. The wavelength spacing of the spectrum is about 10 nm and the signal to noise ratio (SNR) for both peaks are about 8.23 dBm and 9.67 dBm.

In Fig. 4 the output spectrum of dual-wavelength pulse fiber laser by varying the LD current is shown, starting from 400 mA (26.02 dBm) to 600 mA (27.78 dBm) current. Dual wavelength fiber laser started to lase at 450 mA (26.53 dBm) with two peaks with the respective values of -55.08 dBm and -59.07 dBm. At 600 mA (27.78 dBm), the peak power produced are -54.03 dBm and -58.00 dBm.

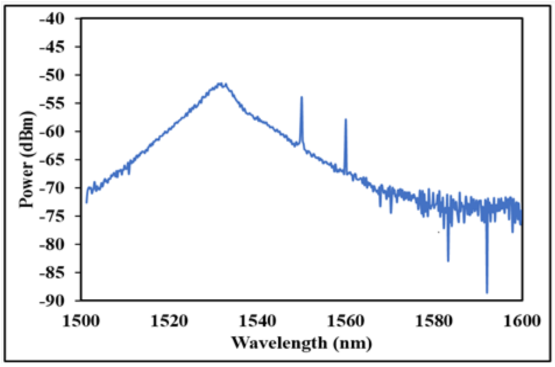

Fig. 3 OSA trace of dual-wavelength pulse fiber laser at 600 mA (27.78 dBm) spectrum of stable mode locked fiber.

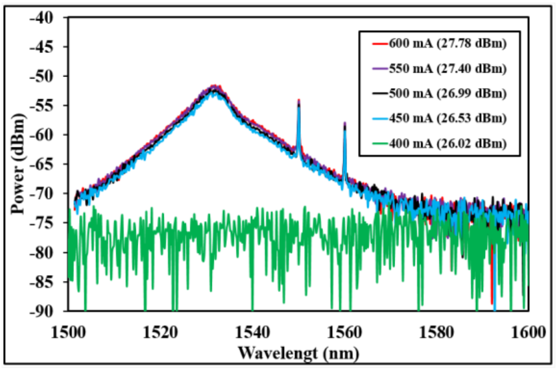

Fig. 4 Spectrum of dual wavelength pulse fiber laser with increasing pump power.

The stability of dual wavelength pulse fiber laser spectrum is shown in Fig. 5. This has been taken for an hour of operation in 10 minutes interval. It describes the stability of dual wavelength pulses due to the small movement in the output power. In addition, this graph also shows that it has high stability because of no shifting on it.

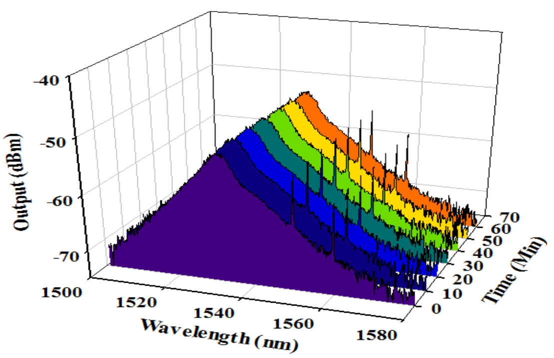

Fig. 5 Spectrum stability in 10 minutes time interval.

Fig. 6 shows the pulse train at 600 mA current (27.78 dBm) that is attained from the oscilloscope. The pulses of repetition rate is 2.878 MHz with corresponding time spacing of about 0.5 μs. The value of repetition rate increases due to the cavity length of circuit diagram. The pulses at the two wavelengths have the same repetition rate.

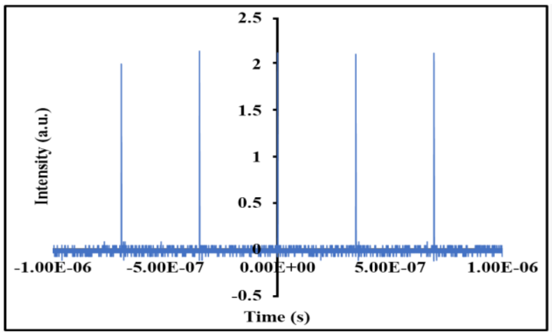

Fig. 6 Pulse train of pulse fiber laser at 600 mA (27.78 dBm) in oscilloscope.

4. Conclusion

In conclusion, dual wavelength pulse fiber laser was created by using the Fiber Bragg Grating (FBG) in figure eight circuit diagram. The dual wavelength pulse fiber laser is generated by using FBG at 1550 nm and 1560 nm with peak power of -54.03 dBm and -58.00 dBm, respectively. The wavelength spacing of the spectrum is about 10 nm while the signal to noise ratio (SNR) for both peaks are about 8.23 dBm and 9.67 dBm. The repetition rate is found at 2.878 MHz with corresponding pulse spacing of 0.5 μs.

Acknowledgement

We would like to thank Universiti Tun Hussein Onn Malaysia for providing the GPPS Grant of (U753), (U757), RAGS Grant (R046) for funding this project. This paper was partly sponsored by the Center for Graduate Studies UTHM.

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