Multi-wavelength source based on SOA and loop mirror

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A multi-wavelength fiber ring laser is demonstrated using a semiconductor optical amplifier (SOA) and a Sagnac loop mirror. The output spectrum of the proposed laser is quite stable at room temperature and the output power can be adjusted by controlling the bias current of the SOA. At bias current of 150 mA, 6 lines are obtained with an output power of at least -40 dBm, signal to noise ratio of 25 dB and channel spacing of 1.49 nm. The number of lines is determined by the length of polarization maintaining fiber used in the Sagnac loop mirror. There is no need of optical pump lasers for this multi-wavelength source.

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1. Introduction

Multi-wavelength fiber lasers have received much attention throughout the years due to their potential applications in wavelength division multiplexing (WDM) systems, optical fiber sensors, optical component testing, and spectroscopy. Multi-wavelength lasing can be achieved by many techniques such as erbium-doped fiber laser (EDFL) [1,2] and Brillouin-erbium fiber lasers (BEFL) [3,4]. However, stable multiwavelength sources based on erbium-doped fibers (EDFs) are difficult to obtain due to homogeneous broadening of laser modes. Multiwavelength EDFLs were reported either by immersing the EDF in liquid nitrogen [1] or using specially designed twin-core EDF [2]. BEFLs have a limited channel numbers and a fixed channel spacing of about 0.08 nm at 1550nm region.

Multi-wavelength operation is also possible with semiconductor optical amplifier (SOA) because its broad gain spectrum and heterogeneous spectral broadening [5]. In this paper, a multiwavelength source based on semiconductor optical amplifier (SOA) and Sagnac loop mirror is proposed and demonstrated. The source has several important advantages such as the stable multi-wavelength operation at room temperature, the broad workable wavelength band, and no need of optical pump lasers.

2. Experimental setup

Fig. 1 shows the schematic configuration of the proposed SOA-based multi-wavelength ring laser. An SOA with the saturated power (maximum bias current) of about 10 dBm (400 mA) is employed as the gain medium of the fiber ring laser. The SOA had a peak gain at around 1535 nm with 20 nm bandwidth, providing 23 dB small signal gain with 300 mA bias current. A Sagnac loop mirror is employed as a comb filter in the cavity of the ring laser. It is constructed using a 3-dB coupler and a length of polarization maintaining fiber (PMF). The transmission spectrum of the Sagnac loop mirror has equal wavelength spacing $\Delta\lambda$, which is suitable to be used as a comb filter. The wavelength spacing between the transmission peaks is given by:

$$\Delta\lambda = \frac{\lambda}{BL} \qquad (1)$$

where B and L is the birefringence and the length of the PMF, respectively. In this experiment, the length of PMF is set at 3m, which corresponding to the wavelength spacing of 1.49 nm at 1535 nm region. The wavelength spacing of the loop mirror can be tuned in a large range by changing the PMF's fiber length according to above equation. Immediately before the SOA, an 90:10 optical fiber coupler was used so as to tap the output signal from the ring laser. The output signal is characterized using an optical spectrum analyzer (OSA) with resolution of 0.015 nm.

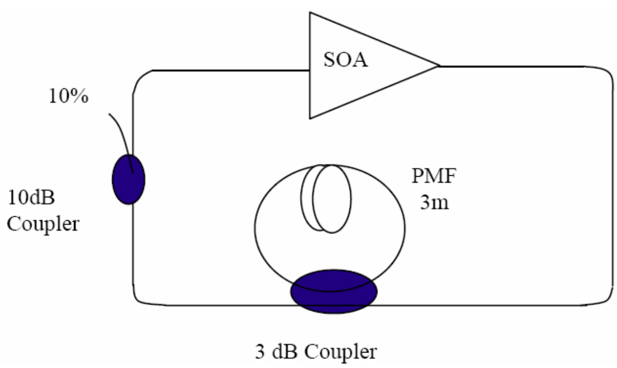

Fig 1.Experimental setup.

3. Results and discussion

In our first experiment, the relationship between the output spectrum and the bias current of the SOA is studied for the proposed fiber laser. The operating temperature of the SOA is set at 30°C. When the bias current is varied from 150 mA to 300 mA, different output spectra are obtained as shown in Fig. 2. As shown in the figure, the output power of lines increases as the bias current reduces especially at the longer wavelength region. This is attributed to the SOA characteristics which has a higher gain at longer wavelength with a lower pump power. Inset of Fig. 2 shows the output spectrum at bias current of 150mA which indicates 6 lines with at least -40dBm output power, 25 dB signal to noise ratio (SNR) and a channel spacing of 1.49 nm. The peak power of -31.9dBm is obtained at 1539.2 nm with SNR of 30 dB. The number of lines and channel spacing are determined by the length of PMF used in the experiment. The higher number of lines is expected with the longer PMF according to Eq. 1.

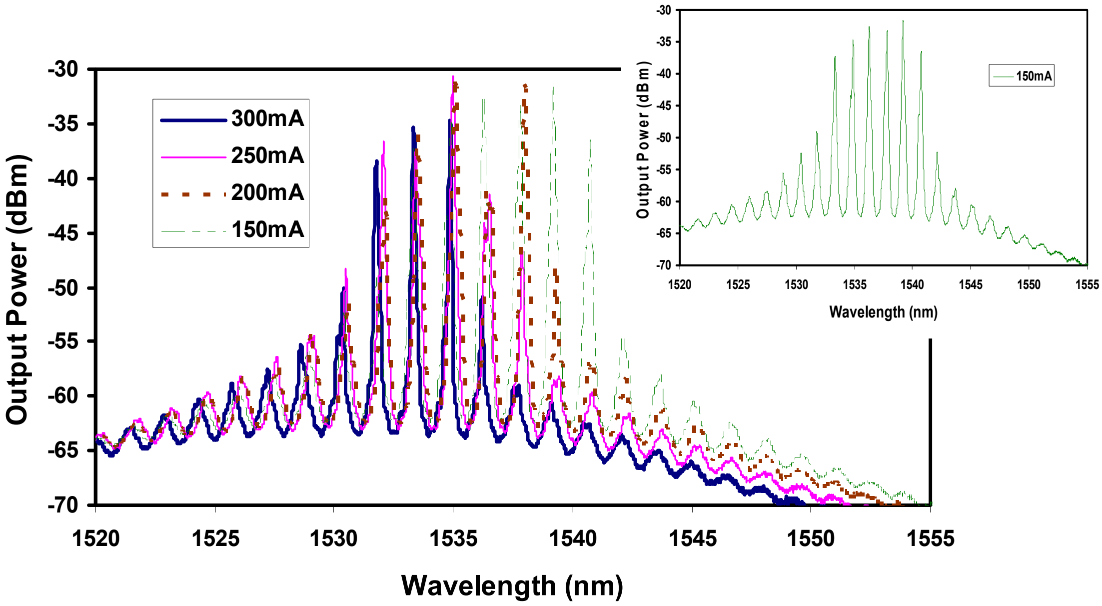

Fig. 2. The output comb of the proposed laser at different bias current for the SOA. The SOA is operated at temperature of 20°C.

Fig. 3 shows the output spectrum of the multi-wavelength laser when temperature settings of SOA are 20°, 25° and 30°C. Other parameters such as the bias current applied to the SOA and the output coupling ratio were kept constant during the tuning process. The experiment results indicate that the comb wavelength is shifted by 7.7 nm as the temperature is increased from 20° to 30°C. The carrier density of the SOA decreases as temperature increases, which shifts the gain profile of the SOA towards the longer wavelength. Therefore, the lasing spectrum of the laser can be tuned by varying the temperature of the SOA. This to tune the comb wavelength of the proposed laser technique is very simple and efficient. The proposed multi-wavelength SOA-fiber ring laser is also quite stable at room temperature. The laser provides design flexibility and functionality which makes this source a good choice for DWDM applications and component characterization.

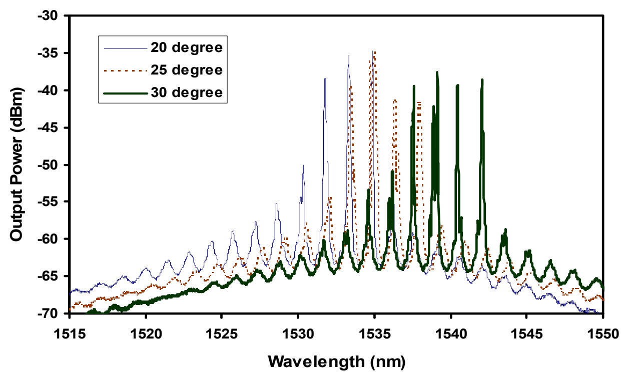

Fig. 3. The output comb at different temperature setting of the SOA. The bias current of the SOA is fixed at 150 mA.

4. Conclusions

A multi-wavelength SOA-fiber ring laser based on Sagnac loop mirror has been demonstrated. Multi-wavelength lasing with channel spacing of 1.49 nm has been achieved with 3m of PMF. 6 lines (with at least -40 dBm output power and 25 dB SNR) are obtained at bias current of 150 mA. The output spectrum of the proposed laser is quite stable at room temperature and output power can be adjusted by controlling the bias current of the SOA.

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