Effect of Semiconductor Optical Amplifiers Types on Multiwavelength Fiber Laser Performance

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***Abstract*—This paper demonstrates a multiwavelength fiber laser (MWFL) using different types of semiconductor optical amplifiers (SOAs) in conjunction with Lyot filter as comb filter. Three different SOAs were compared; linear, non-linear and booster optical amplifier (BOA). The multiwavelength generation using BOA had produced the best performance with extinction ratio (ER) of $52\,\mathrm{dB}$ and peak power of $-13.2\,\mathrm{dBm}$.**

***Index Terms*—multiwavelength fiber laser, Lyot filter, semiconductor optical amplifier**

I. Introduction

MWFL has been the main solution to be used for detecting temperature [1], fiber link monitoring system [2], and so on. The inhomogeneous property of SOA reduces cavity mode competition thus able to produce stable flat multiwavelength lasing output as demonstrated in [3]. Previous works on SOA have reported investigations on the effect of intensity [4], bidirectional Lyot filter [5] and different types of SOAs [6]. This paper presents a study on effect of non-linearity at different types of SOA to the performance of MWFL. The performance investigation of BOA with other SOAs were hardly reported. BOA has exhibited the best laser performance in terms of ER and peak power as compared to other SOA types.

II. Experimental Setup

In this experiment (refer Fig. 1), three different SOA type were used which are linear SOA (Thorlabs SOA1013S), non-linear SOA (Thorlabs SOA1117S) and BOA (Thorlabs BOA1004S). The linear SOA has the lowest value of non-linearity in the record of previous literature. Their amplified spontaneous emission (ASE) sources were pass through Lyot filter comprising polarization controller 2 (PC2) in $90°$ of half wave plate (HWP) linear polarized direction and $13.3\,\mathrm{m}$ (a known length) polarization-maintaining fiber (PMF). Subsequently, PC1 was used to flatten the multiwavelength spectrum. The oscillation was in counter clockwise direction fixed by the isolator. The laser output was tapped out to optical spectrum analyzer (OSA) for measurement by a 10/90 coupler. The total cavity loss and the ring cavity length is approximately $6\,\mathrm{dB}$ and $25\,\mathrm{m}$, respectively. Resolution of the OSA was set to $0.02\,\mathrm{nm}$ with high sensitivity setting for the best spectrum observation.

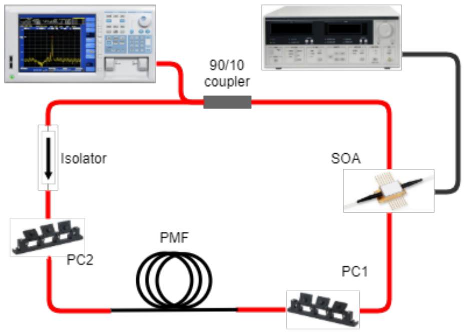

Fig. 1. The configuration setup of MWFL utilizing Lyot filter.

The multiwavelength lasing is achieved due to constructive interference from the Lyot filter. The incoming light with polarization direction to the birefringent axis produced two lights; ordinary and extraordinary. Both lights travel at x and y axes at the same polarization state and amplitude but at different phase, ultimately combined in phase at the end of the PMF to generate the multiwavelength spectrum.

III. Results and Discussions

The linear SOA, non-linear SOA dan BOA is operated at maximum driving current of 500 mA for former two and 600 mA for BOA. All MWFL lasing output were generated correspond to their respective flat region of the ASE spectrum as shown in Fig. 2. The BOA has the widest spectrum which peaks at $-35\,\mathrm{dBm}$, while the non-linear SOA has lesser ASE width and peak power. The linear SOA has high peak power of $-30\,\mathrm{dBm}$ and provides a flat spectrum at shorter bandwidth from 1450 to $1500\,\mathrm{nm}$.

Fig. 3 depicts the multiwavelength spectrum for setup using linear SOA. The generated lasing lines is 35, calculated for output within $5\,\mathrm{dB}$ bandwidth, with highest peak power is $-20.7\,\mathrm{dBm}$. The best ER obtained is $20\,\mathrm{dB}$ as it was measured from the peak power to the noise floor, after both PCs were adjusted. The channel spacing is $0.5\,\mathrm{nm}$, controlled by the length of PMF used in the setup.

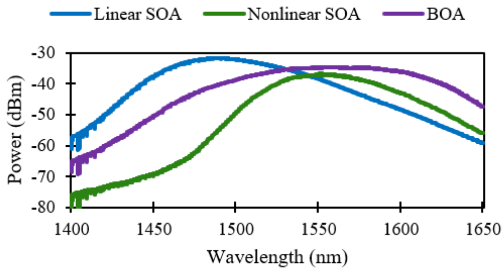

Fig. 2. The ASE generation for all types of SOA.

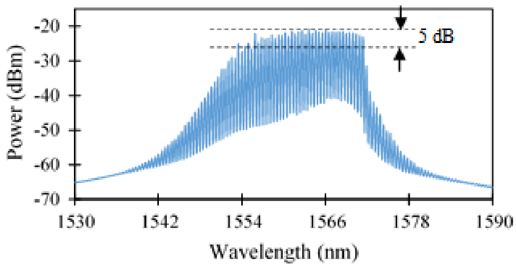

Fig. 3. The multiwavelength laser spectrum using linear SOA.

Fig. 4 illustrates the multiwavelength spectrum based for non-linear SOA. The peak power is −39.1 dBm, while the number of lasing lines is 19. The measured ER has increased slightly to 25 dB. Non-linear SOA has high polarization sensitivity, making it difficult to produce flat wavelength across wider spectrum.

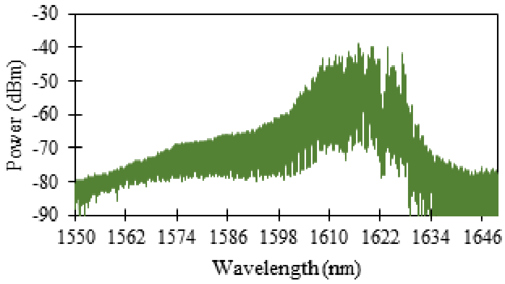

Fig. 4. The multiwavelength laser spectrum using nonlinear SOA.

Subsequently, Fig. 5 shows the output spectrum of MWFL with BOA. The ER is the highest at 52 dB, with high peak power of −13.2 dBm. However, the number of lasing lines is not as competitive as linear SOA, as only 25 lines are generated within 5 dB bandwidth.

Summary of the laser performance in conjunction with a Lyot filter is shown in Table I. Since the lasing output bandwidth follows the ASE spectrum of SOA, it is believed that the lasing output spectrum can be determined by the ASE of SOA used. The best laser performance is the one with BOA result, where it has high ER, high peak power, and wide, flat spectrum. The BOA is a special type of optical amplifier with

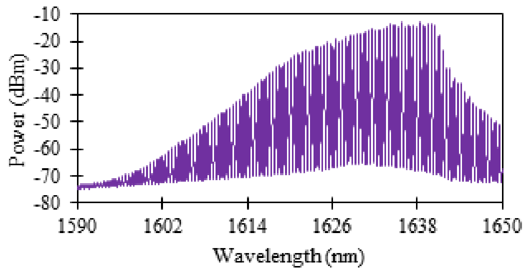

Fig. 5. The multiwavelength laser spectrum using BOA.

satisfying results on high ER property when compared with other linear and nonlinear SOA types.

TABLE I
MULTIWAVELENGTH LASER PERFORMANCE

Type of SOA	Laser performance			
	Wavelength Bandwidth (nm)	Highest Peak Power (dBm)	Number of Lasing Lines	ER (dB)
Linear	1542-1578	-20.7	35	20
Non-linear	1600-1630	-39.1	19	25
BOA	1614-1650	-13.2	25	52

IV. CONCLUSION

The multiwavelength fiber laser performance utilizing different types of SOA with Lyot filter as the comb filter was investigated. The setup using BOA had shown the best performance with 52 dB extinction ratio and −13.2 dBm peak power. Meanwhile, the linear SOA produces the highest number of lasing outputs at 35 lasing lines within 5 dB bandwidth. Since the lasing output follows the ASE bandwidth of SOA, it is possible to produce the multiwavelength fiber laser at any wavelength band by carefully selecting the right SOA.

ACKNOWLEDGMENT

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