Novel Scheme for Reducing the Pattern Effect in 40 Gbps SOA based All-optical Switch Utilizing Transparent CW Assist Light

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All-optical signal processing over 40 Gbps will be an essential technology in future all-optical networks. An ultrafast nonlinear interferometric (UNI) all-optical switch consisting of a semiconductor optical amplifier (SOA) is a promising candidate since it can be operated at a high speed of 80-100 Gbps [1,2]. However, reduction of a pattern effect of a UNI due to a slow recovery time of an SOA is one of the most important issues. We have already reported that a cw assist light at the wavelength transparent to an SOA could clamp the gain profile of the SOA without changing gain or loss for other control signals [3,4]. Here we propose to use a transparent assist light as a holding beam to reduce a pattern effect of an SOA-based all-optical switch. In this paper, we experimentally examined the proposed scheme in the UNI at 40 Gbps operation.

Figure 1 shows the gain recovery time of an InGaAsP/InP bulk type SOA with a gain peak at 1525 nm as a function of the input optical power of either the probe or the assist power measured using the experimental setup shown in the inset. The wavelengths of the cw probe light, the control pulse and the cw assist light were 1555 nm, 1545 nm and 1480 nm, respectively. Open and close circles indicate the data measured varying the probe light power without assist light and those measured varying the assist light power with a fixed probe light power of -10 dBm, respectively. The gain recovery time monotonically decreased with increasing either the probe or the assist light power with similar power dependence. Figure 2 shows the gain depletion of the SOA to the control pulse measured with the same setup. The meanings of the symbols are the same as those in Fig. 1. The gain depletion was only -1 dB when the assist light power was increased as large as 10 mW, whereas it was -5.5 dB when the probe power was increased to 4 mW without assist light. These results apparently proves the advantage of utilizing a transparent assist light as a holding beam because a large probe power as well as a large control power that is required to induce a refractive index change corresponding to π-phase shift are dispensable to reduce the gain recovery time.

The experimental setup for the UNI, which consists of two rutile crystals and the same SOA used in the former experiment, is shown in Fig. 3. Both the probe and control pulses were generated by 10 Gbps based optical multiplexing. The results of bit error rate (BER) measurement are shown in Fig. 4. As shown in the inset of Fig. 4, the signal impairment by the pattern effect on the mark level of switched signals was apparently suppressed due to the transparent assist light. The power penalty of 3.3 dB in case A (without assist light), which is defined at BER = 10^{-9} with reference to the back-to-back, was improved as small as 1 dB in case B (with assist light). In addition, no error floor was observed in case B, whereas slight error floor (BER=10^{-11}) was observed in case A. These results confirm that transparent assist light accelerates the gain recovery in the SOA, resulting in reducing the pattern effect of the UNI. On the other hand, increasing the probe power instead of using the assist light, the improvement in power penalty from that of the case A was only 0.3 dB at the optimum probe light power of +0 dBm because the required control pulse power increased.

We have successfully demonstrated the reduction of the pattern effect in the UNI at 40 Gbps by the transparent assist light while keeping the control pulse power as low as –3 dBm. The receiver sensitivity improvement of 2.3 dB was confirmed at BER = 10^{-9}. We conclude that our proposed scheme is an attractive method for a high-speed operation of an SOA based all-optical switch with a low signal power.

Reference:

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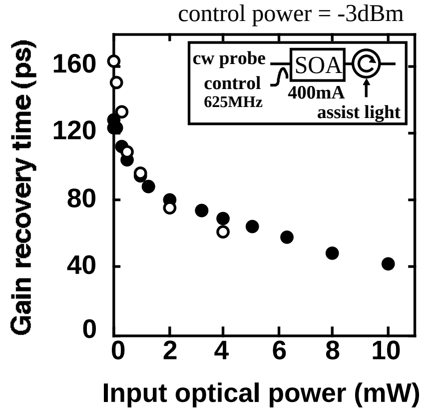
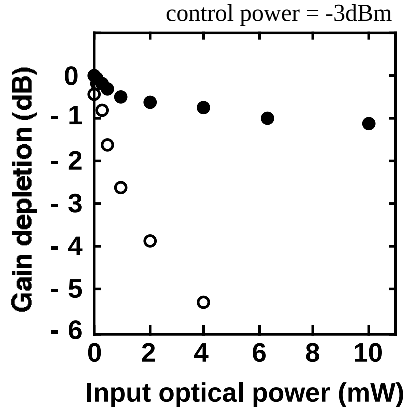


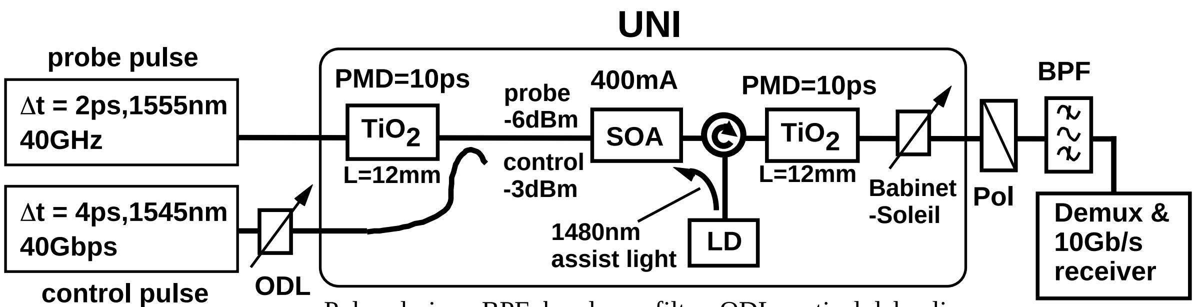


○ varying probe light without assist light
● varying assist light with probe power = -10 dBm

Fig. 1 Gain recovery time as a function of input power

○ varying probe light without assist light
● varying assist light with probe power = -10 dBm

Fig. 2 Gain depletion of control pulse as a function of input power



Pol: polarizer, BPF: band pass filter, ODL: optical delay line

Fig. 3 Experimental setup of 40 Gbps all-optical switch.

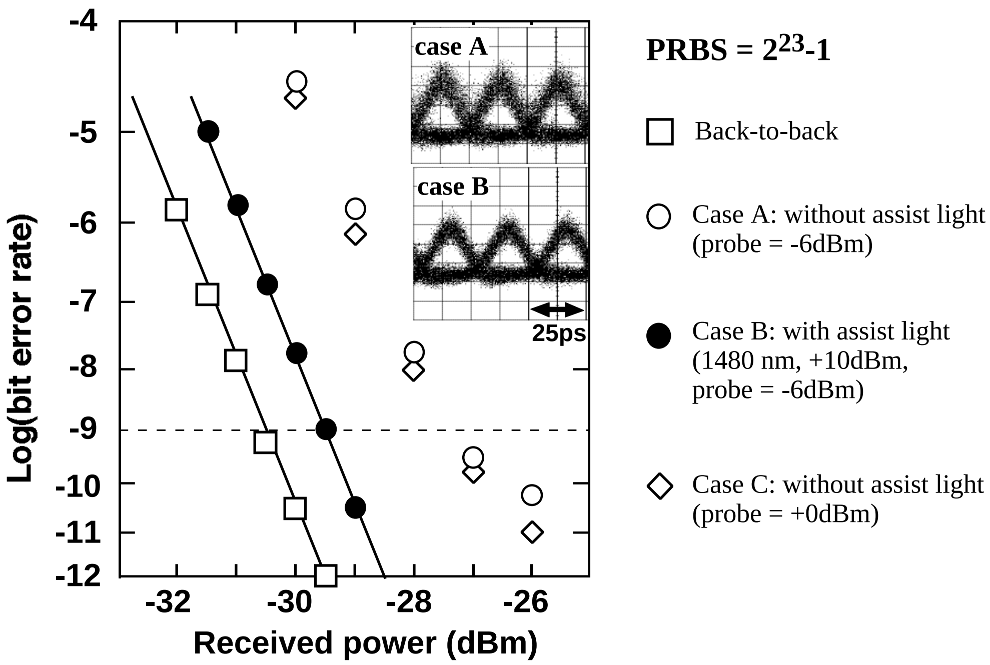


Fig. 4 BER result as a function of the received power