Giant Enhancement in Signal Contrast Using Integrated All-Optical Nonlinear Thresholder

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Abstract: We experimentally demonstrate, for the first time, an all-optical nonlinear thresholder on a silicon photonic integrated circuit. This thresholder enhances signal amplitude contrast 40-fold and improves receiver sensitivity by 10 dB.

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1. Introduction

Thresholders are the heart of analog-to-digital converters, comparators and operational amplifiers. Thresholders based on simple, effective and integrable all-optical components can work well beyond the limit of electronic counterparts, particularly in terms of the operation speed. Therefore, all-optical thresholders have found their unique and indispensable role in a variety of applications which need fast signal processing [1–3]. In these applications, the all-optical thresholder eliminates the incomplete suppression of the zero-level signal and noise, thus essentially boosting the signal to noise ratio (SNR) of optical signals.

Substantial efforts have been taken to develop high performance all-optical thresholders by exploring different nonlinear effects and materials. However, most of these all-optical thresholders are constructed with bulky and discrete photonic devices, therefore lacking the abilities of massive integration. The rapid development of silicon on insulator the two arms of MZI. Meanwhile, the MZI bias can be independently tuned to provide an exact *p* phase shift to the signals on the two MZI arms.

Our all-optical thresholder sample has a silicon thickness of 220 nm and a width of 500 nm with fully etched waveguide, a 3 *m*m oxide passivation layer, a Ti/W heating filament layer, and an Al routing layer. The MRR on the MZI's arm has a relatively small radius of 5 *m*m and high coupling coefficient (gap = 100 nm), yielding a Q-factor

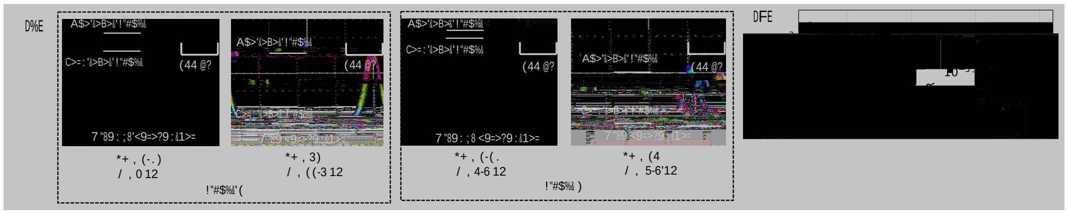

Fig. 3. (a) Eye diagrams (b) BER test of signals with and without the proposed all-optical thresholder

the optical power is completely shut off at one wavelength (see the dip of the resonance). In this case, the transmission spectrum reveals an asymmetric line shape with an on-off ratio of more than 45 dB.

Fig. 3(a) shows the performance of the all-optical thresholder using input optical signals with two different extinction ratios. Both input signals have extinction ratios closed to 1, resulting in a significantly degraded Q-factor, even though the received average power (0 dBm) is much higher than the sensitivity of our photodetector. After being processed by the thresholder, the lower power pulses in both signals are suppressed to a zero amplitude due to the perfect destructive interference. As a result, the signals after thresholding have a significant extinction ratio enhancement (40 times for signal 1, and 7.5 times for signal 2). The extinction ratio enhancement leads to Q factor improvement of 6.4 dB for signal 1 and 8 dB for signal 2. Our thresholder works well under low extinction ratios of close to 1, indicating that the thresholder has a steep "thresholding slope". Fig. 3(b) shows the results of bit error rate (BER) measurement of signal 1 using a BER tester (BERT). Assisted with the all-optical thresholder, the signal can achieve an error-free detection (BER = 10^{9}) at the signal power of -27.5 dBm due to its opened eye. Without processed by the thresholder, it is difficult for the BERT to idenity a threshold value. Therefore, at the same detection power (-27.5 dBm), the signal has a bit error rate more than 10^{4}. At the BER of 10^{7}, the receiver sensitivity with our thresholder is stresholding with a asouighe36reentcessedlo67ence.66(8)-33467evethe o58.112(o12.55nclu0 -3.-343(sho)25(ws)-50 -Miyoshi10 Td236