First demonstration of 40 Gbps wavelength conversion with no pattern effect utilizing cross-phase modulation in an electroabsorption waveguide

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All-optical wavelength conversion will be an essential technology to enhance flexibility and scalability in future all-optical communication networks. An intensive research has been reported on the wavelength converters utilizing cross-phase modulation (XPM) in semiconductor optical amplifiers (SOAs), which can be operated over 40 Gbps by means of differential operation of a Mach-Zehnder interferometer (MZI) [1-5]. In terms of pattern effect, however, it is hard for the SOA-based devices to overcome the limitation that is forced by a rather long gain recovery time around 100 ps. The potential advantage expected by utilizing XPM in an electroabsorption waveguide (EA-WG) is that a short absorption recovery time of less than 20 ps can be easily obtained since photogenerated carriers are immediately swept away by a high external electric field [6]. In this report, we demonstrate wavelength conversion utilizing XPM in an EA-WG at 40 Gbps for the first time. An error-free operation of the wavelength converter with no pattern effect is presented.

We employed delayed-interference configuration [2,3,7], which consists of only one XPM modulator and hence the structure is very simple, to demonstrate our proposed scheme of wavelength conversion. The experimental setup is shown in Fig. 1. An EA-WG with 200 μm-long bulk InGaAsP absorption layer with the bandgap wavelength of 1472 nm, which was designed as an external intensity modulator, was used as an XPM modulator with reverse-bias at -2.0 V. An EDFA was used to compensate the loss of the EA-WG, which was 10 dB with 0 V bias at the probe light wavelength of 1565 nm. The bit-error-rates (BERs) of the original control pulse and the converted probe pulse were measured with various pattern lengths of pseudorandom bit-sequence (PRBS).

In Fig. 2 (a), the BERs are plotted as functions of the received power for the control and the converted pulses with various PRBS pattern lengths. An error-free conversion was verified for each pattern length. A relatively large power penalty for the converted pulse can be attributed to the deterioration in optical signal-to-noise ratio because of a large insertion loss of the EA-WG as well as the noises from the EDFA that was used for loss compensation. However, the loss of the EA-WG can be reduced by optimizing the device parameters since the EA-WG used in the present study was not designed for such a usage. For the control pulse, the error floors and the slight power penalties induced by the increase of the pattern lengths were observed, which were caused by the EA modulator used for demultiplexing. The power penalty between the converted and the control pulses is the same for each pattern length within the measurement error. Consequently, the pattern effect in the EA-WG based wavelength converter is confirmed to be negligible owing to the short absorption recovery time of the EA-WG. Figs. 2 (b) and (c) show the respective eye diagrams of the control and the converted pulses with the PRBS pattern lengths of 2^{31}-1. The clear eye opening of the converted pulse, which is comparable to that of the control pulse, proves no significant impairment on signal quality occurred during the wavelength conversion. We can expect further improvement in loss and conversion efficiency of the wavelength converter by optimizing the device parameters of the EA-WG such as the bandgap wavelength and the device length. Therefore, it is concluded that the proposed scheme of wavelength conversion has a high potential for a high bit-rate operation.

References

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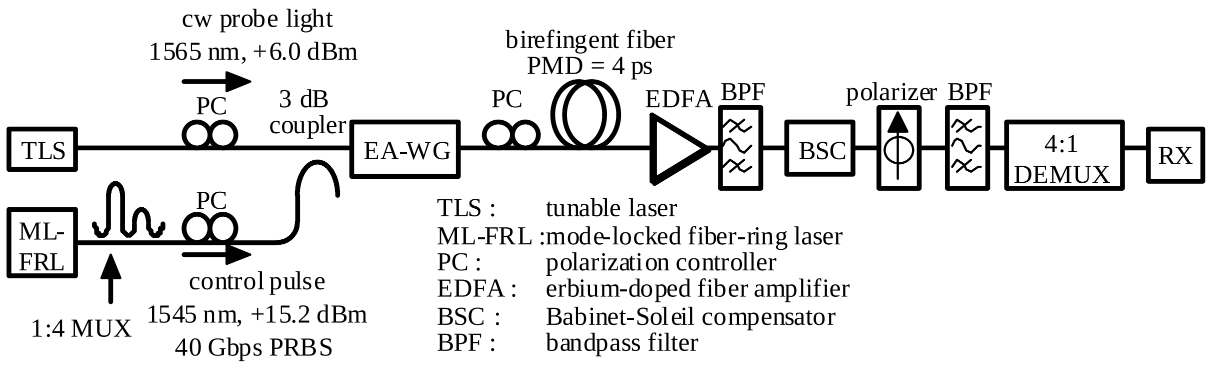

Fig. 1. Experimental setup for 40 Gbps wavelength conversion utilizing XPM in an EA-WG.

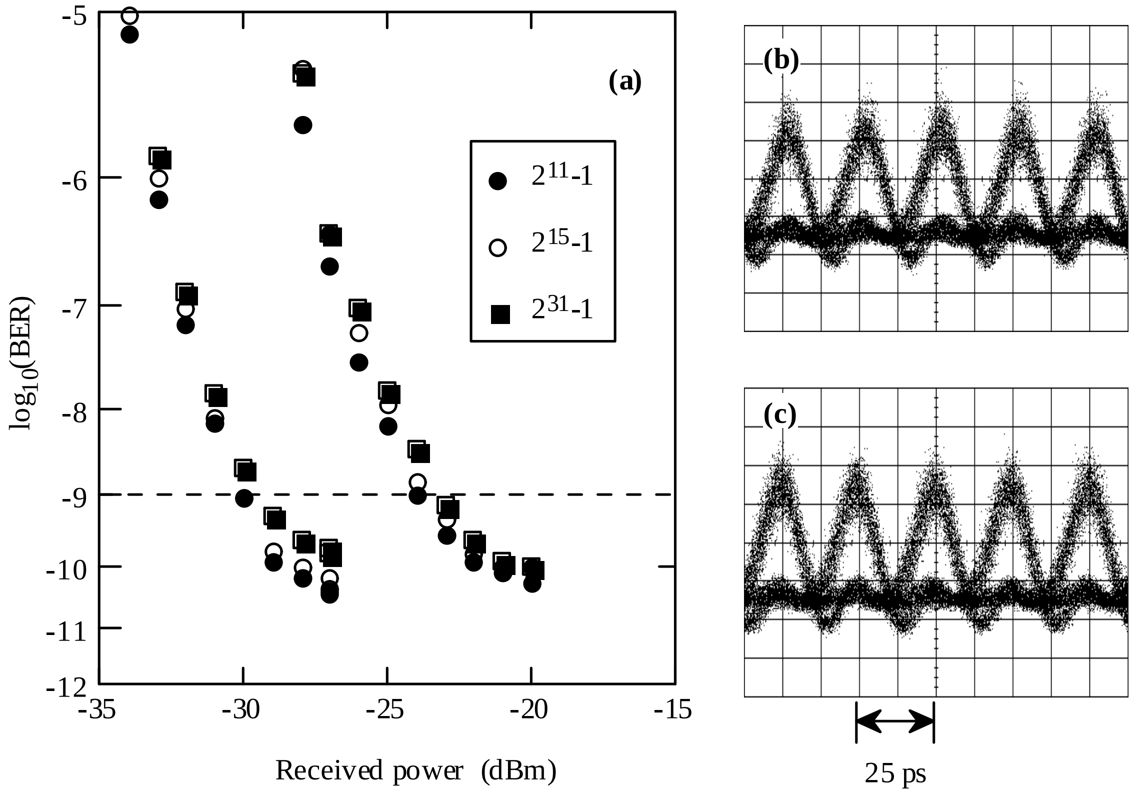

Fig. 2. Results of wavelength conversion. (a) BERs plotted as functions of received power for the control and the converted pulses with various PRBS pattern lengths. (b) and (c) The respective eye-diagrams of control and converted pulses with PRBS length of 2^{31}-1.