Ultra-wide-band high-speed wavelength selector using a hybrid integrated gate module: a 4-channel SS-SOA gate array on PLC platform

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Abstract

A 4-channel semiconductor optical amplifier gate array whose both facets are assembled on PLC platform has been developed. An ultra-wide-band (1530-1600 nm) and high-speed (< 1 ns) wavelength selector is also demonstrated.

Introduction

Optical networks in the near future will require a number of optical gate elements for both routing and buffering operations [1]-[2]. The multi-channel semiconductor optical amplifier (SOA) gate [3]-[8] is one of the most promising candidates for such a gate element because it provides fiber-to-fiber loss-less operation and a high extinction ratio over a wide wavelength range. An effective method for developing SOA gates arrays into efficient and functional optical components for wavelength division multiplexing (WDM) is the hybrid integration of the arrays with a silica-based planar lightwave circuit (PLC) [9]-[10]. The monolithic integration of spot-size converters (SS) at both the input and output ports of the SOA gate array is indispensable. Previously we reported a 4-channel polarization-insensitive SOA gate array integrated with SS using a butt-joint structure in order to optimize the bulk active layer and SS region [8]. In this paper we describe for the first time a 4-channel SS-SOA gate array whose both facets are assembled on a PLC platform. The SOA gate array module has an extinction ratio higher than 35 dB, and it operates at less than 50 mA throughout an ultra-wide-band of 1530-1600 nm. A high speed wavelength selector is also demonstrated using the SOA gate array module and PLC-arrayed-waveguide grating (AWG) [11] wavelength multiplexer.

Device structure

The SS-SOA gate chip [8] consists of a 600-μm bulk active region for 1.55 μm and two 300-μm SS tapered bulk passive regions (band gap wavelength = 1.3 μm at the facet) [12]. The thickness of the active region is 0.4 μm, while the thickness of the SS layer changes gradually from 0.4 μm at the butt-joint interface to 0.2 μm at the facet. The 0.6 μm-wide mesa stripe was formed by CH_4/H_2 dry-etching and was buried by the buffer-inserted buried

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hetero-structure method [13]. After anti-reflection coating, the SS-SOA gate array was bonded with AuSn solder on a PLC platform using passive alignment, as shown in Fig. 1. Single-mode fibers arrays were butted for the both facets of 4-channel silica waveguides. The total loss between SOA gates and fiber, which includes the coupling loss between the SOA gates and the PLC, was 5 dB.

Experimental results

Figure 2 shows the fiber-to-fiber gain versus driving current of the 4-channel SS-SOA gate array module at a wavelength of 1550 nm. The optical input power was -10 dBm. The gain characteristics of each channel were very similar. Fiber-to-fiber loss-less was obtained at 33 mA for all the channel. Detailed gain characteristics of the 4 channels are shown in Fig. 3. A high extinction ratio of nearly 40 dB, defined as the optical power loss at the 0 mA, was achieved in all the channels. The polarization dependence was less than 1 dB. Figure 4 shows the wavelength dependence of the extinction ratio and the loss-less current. The extinction ratio was more than 35 dB and the fiber-to-fiber loss-less current was less than 50 mA over a wide wavelength range from 1530 to 1600 nm. The minimum loss-less current was 25 mA for 1580 nm.

Figure 5 demonstrates the high-speed wavelength selector using the 4-channel SOA gate module and 8x8 PLC-AWG. The input signals at 4 wavelengths of 1532.0, 1553.5, 1554.3 and 1600.0 nm were demultiplexed by the PLC-AWG and were selected by the SOA gates. Note that the wavelength selector operated at an ultra-wide band of 1532 to 1600 nm. Wavelength separation can be set at 0.8 nm, as shown as the separation between channel-2 and -3. Both rise- and fall-time were less than 1 ns, which is suitable for high-speed optical packet switching, including photonic ATM [1]-[2]. We also checked electrical and optical interference between channel by using bit error rate (BER) measurement. The BER of channel-3 was measured. Though the other channel were randomly driven, no power penalty was observed. The interference between the channel is therefore negligible.

Conclusion

We have demonstrated for the first time a hybrid integrated gate module: a 4-channel SS-SOA gate array whose both facets are assembled on the PLC platform. The SOA gate array module has an extinction ratio higher than 35 dB throughout an ultra-wide-band of 1530-600 nm, with good uniformity between the 4 channel. A high-speed (< 1 ns) wavelength selector was also demonstrated. Both rise- and fall-time were less than 1 ns, which is suitable for high-speed optical packet routing and buffering operations.

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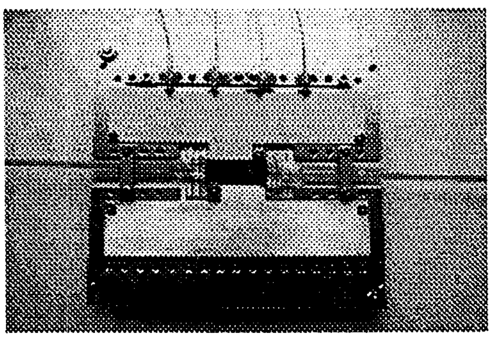

Figure 1. Photograph of gate module: a 4-channel SS-SOA on PLC platform

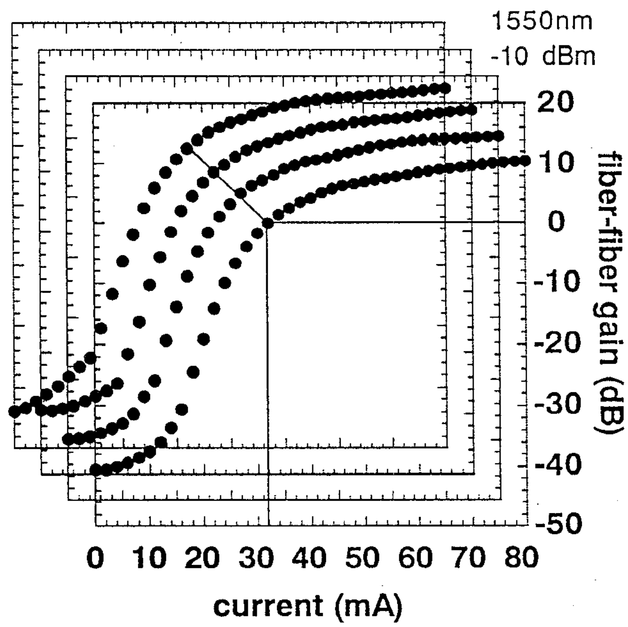

Figure 2. Gain characteristics of a 4-channel gate module

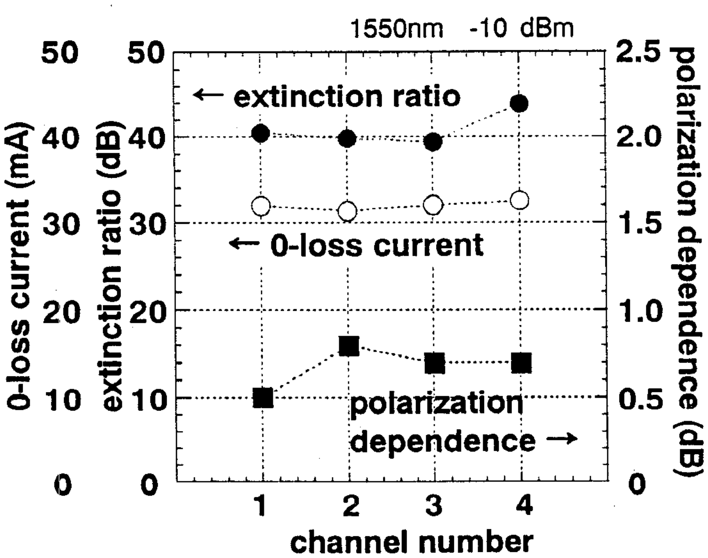

Figure 3. 0-loss current, extinction ratio and polarization dependence of a 4-channel gate module

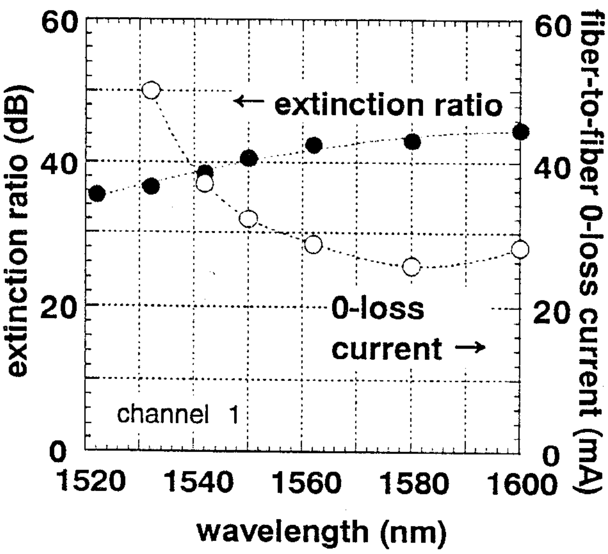

Figure 4. Wavelength dependence of extinction ratio and 0-loss current

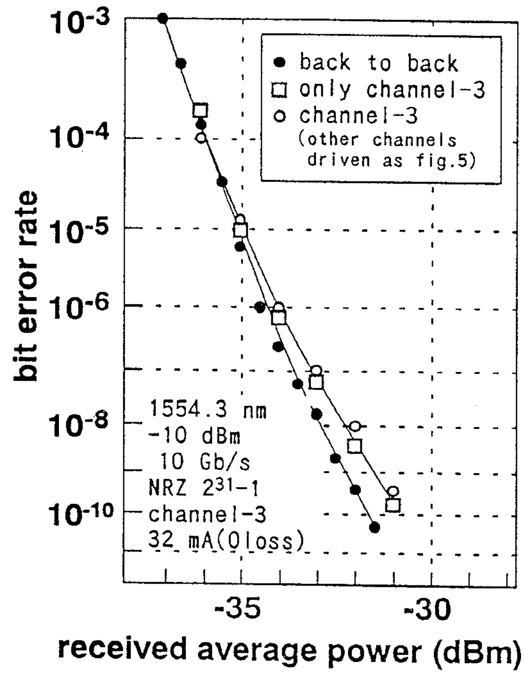

Figure 6. Bit error rate of an ultra-wide band wavelength selector using a 4-channel gate module and 8x8 PLC-AWG

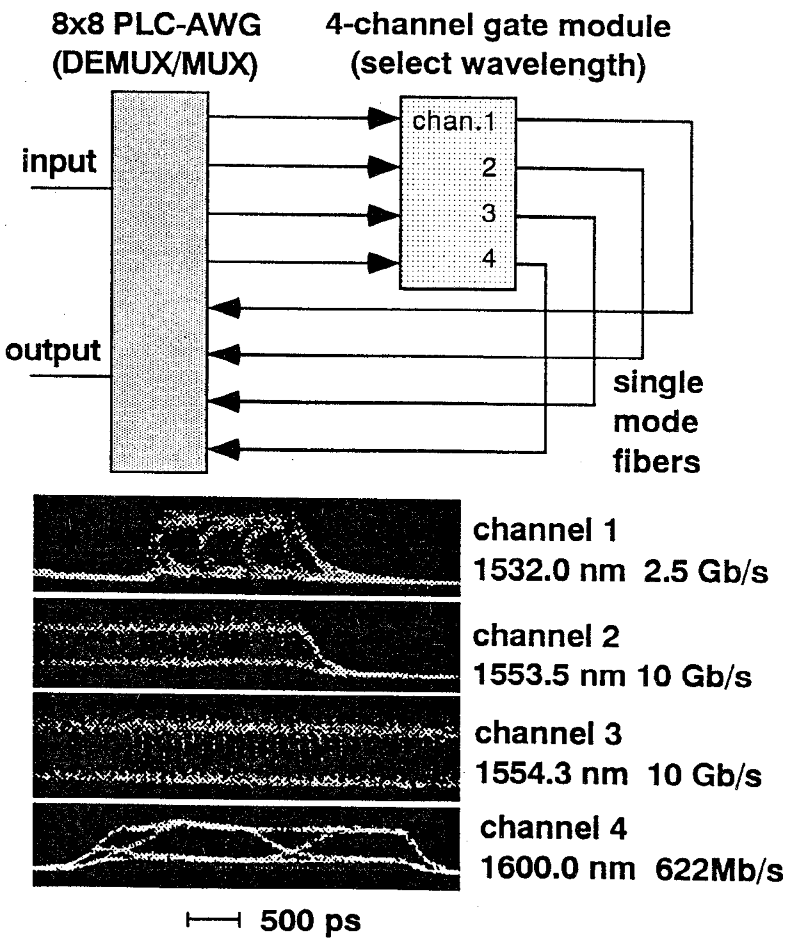

Figure 5. Dynamic response of an ultra-wide band wavelength selector using a 4-channel gate module and 8x8 PLC-AWG