Repetitive Switching of Optical Gate Switch Using Phase-Change Material and Si Waveguide

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ABSTRACT

In this paper, we reported repetitive switching of two types of optical gate switch using phase-change material and Si waveguide; with a channel waveguide and with a rib waveguide. 1,000 times of repetitive switching was observed, and an average extinction ratio of channel waveguide and rib waveguide type switch was 9.7 dB and 15 dB, respectively.

Key word: Optical switch, Silicon photonics, Phase-change material

INTRODUCTION

Fast and low power consumption optical switches are required for photonic networks. For that purpose, we have proposed the optical gate switches using phase-change material (PCM) and silicon wire waveguide [1-6]. PCM has two different stable states of crystalline and amorphous at room temperature. We used the large difference in the imaginary part of the complex refractive index of these two states for the optical gate switches. This optical gate switch has three advantages; 1) small size, 2) fast switching, and 3) low power consumption. In this paper, we reported repetitive switching of two types of optical gate switch using PCM and Si waveguide.

STRUCTURE OF THE OPTICAL GATE SWITCH

Figure 1 shows the structure of the channel waveguide type switch. We used $Ge_2Sb_2Te_5$ (GST-225) as PCM. A GST-225 film with a thickness of 25 nm and a length of 5 μm was deposited on wire waveguide in a gate region. ZnS/SiO_2 with a thickness of 50 nm was deposited on GST-225 as a passivation layer. The core dimensions of the Si waveguide were 520 x 200 nm^2, but they were 410 x 180 nm^2 in a gate region.

Figure 2 shows a structure of the rib type switch. A GST-225 film with a thickness of 50 nm and a length of 1 μm was deposited on rib waveguide. A thickness of over cladding was about 2 μm.

EXPERIMENTAL

Figure 3 shows the experimental setup for laser pulse irradiation. A laser diode (LD) with a wavelength of 660 nm was used to irradiate the material. A light was guided by a single mode optical fiber and focused on to the sample. An object lens with a numerical aperture (NA) of 0.8 was used. The full-width at half-maximum (FWHM) of the focused spot size was about 1.2 μm.

Figure 4 shows the transmittance change of the channel waveguide type switch for 950 to 1,000 irradiation cycles. 1,000 times of repetitive switching with an average extinction ratio of 9.7 dB was observed. We used a laser pulse with a width of 400 ns and a peak power of 15 mW for crystallization, and a laser pulse with a width of 12 ns and a peak power of 70 mW for amorphization.

Figure 5 shows the transmittance change of the rib waveguide type switch for 950 to 1,000 irradiation cycles. 1,000 times of repetitive switching with an average extinction ratio of 15 dB was observed. We used a laser pulse with a width of 400 ns and a peak power of 25 mW for crystallization, and a laser pulse with a width of 12 ns and a peak power of 160 mW for amorphization.

CONCLUSION

In this paper, we have reported repetitive switching of two types of optical gate switch using phase-change material and Si waveguide; with a channel waveguide and with a rib waveguide. In a channel waveguide type switch, 1,000 times of repetitive switching with an average extinction ratio of 9.7 dB was observed. In a rib waveguide type switch, 1,000 times of repetitive switching with an average extinction ratio of 15 dB was observed.

ACKNOWLEDGEMENT

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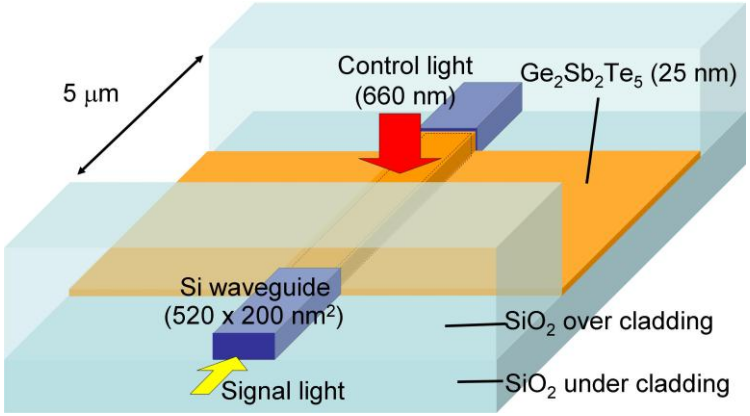

Fig. 1. Structure of the channel waveguide type switch

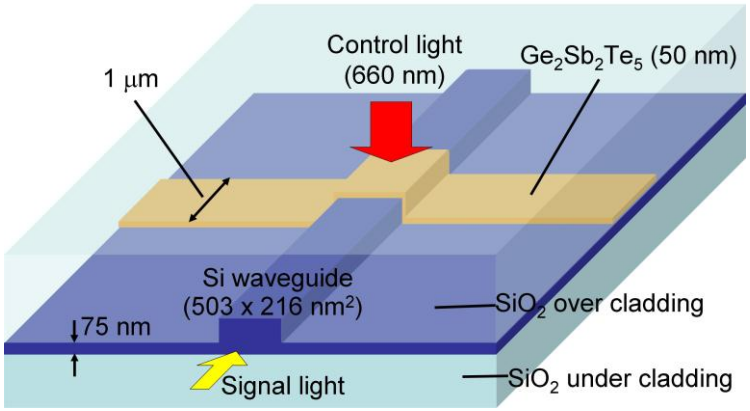

Fig. 2. Structure of the rib waveguide type switch

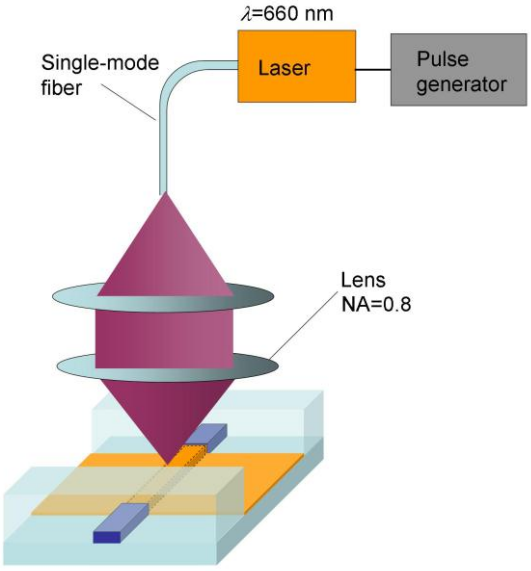

Fig. 3. Experimental setup for switching operation.

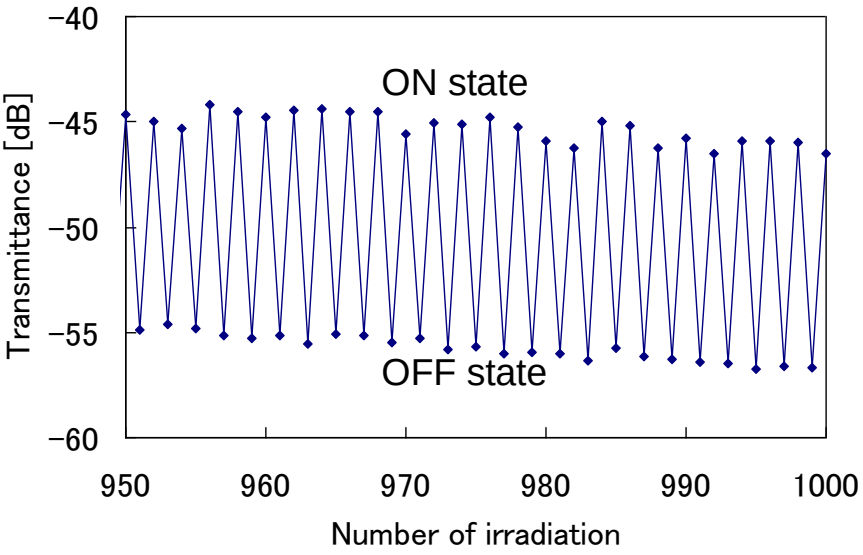

Fig. 4. Transmittance change with pulse irradiation for the channel waveguide type switch

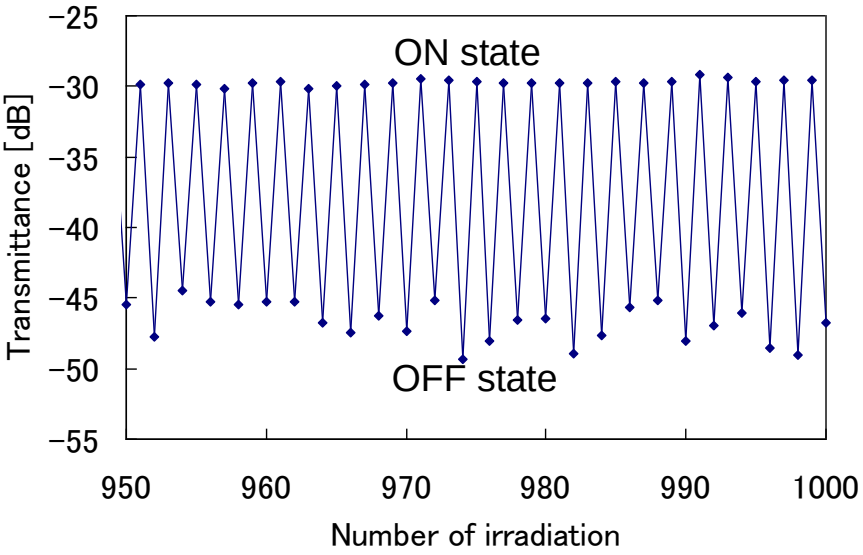

Fig. 5. Transmittance change with pulse irradiation for the rib waveguide type switch