Demonstration of Ge Waveguide on Ge-on-Insulator Substrate for Mid-Infrared Photonics

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Introduction

Mid-infrared (MIR) photonics is of considerable interest in the fields of sensing and ultrafast optical communications [1]. However, conventional discrete MIR devices are bulky and expensive, which severely limit their practical applications. To provide a solution, we previously proposed Ge CMOS photonics platform with Ge-on-Insulator (GOI) structure, and further improved the GOI qualities by performing a proper thermal annealing [2, 3]. In this work, we demonstrate the Ge waveguides on the fabricated GOI substrate for MIR photonics.

Fabrication procedure

The fabrication process of Ge waveguides on the GOI substrate is shown in Fig. 1. First, the Ge layer was thinned to 400 nm by RIE dry etching using CF_4 gas. Then, waveguide patterns were defined and formed by EB lithography and RIE etching. The Ge layer thickness in rib waveguide core and slab regions are 400 and 100 nm, respectively, as shown in the inset of Fig. 2. After isolating the Ge waveguides, 300-nm-thick SiO_2 layer was deposited on the waveguide surface by PECVD for passivation.

Results and discussion

To study the transmission property of Ge waveguide in MIR wavelength, we used an amplified spontaneous emission (ASE) light source at the 2-µm wavelength band, which was coupled to the cleaved end of Ge waveguides through a lensed fiber. Then, the output light was again coupled to another lensed fiber, which was connected with an optical spectrum analyzer (OSA) to monitor its power and spectrum.

Figure 2 shows the propagation loss of 2-µm-wide straight Ge waveguides measured by the cut-back method. A waveguide loss of approximately 1.4 dB/mm was obtained.

We further studied the transmission property in the waveguide bends. After compensating the propagation loss in straight waveguide part, the bend loss per 90 degree turn was obtained as a function of bend radius, as shown in Fig. 3. The SEM image of a series of 5-µm-radius bends is also shown in the inset. The Ge waveguide shows a bend loss of approximately -0.2 dB at each turn and bend loss shows no dependence on radius from 5 to 30 µm, suggesting a strong optical confinement was achieved in the Ge rib waveguide.

These results suggest that the Ge CMOS photonics platform is very promising for MIR photonics.

Acknowledgement

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References

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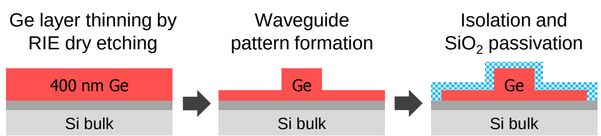

Fig. 1 Fabrication process of Ge rib waveguide on the GOI substrate.

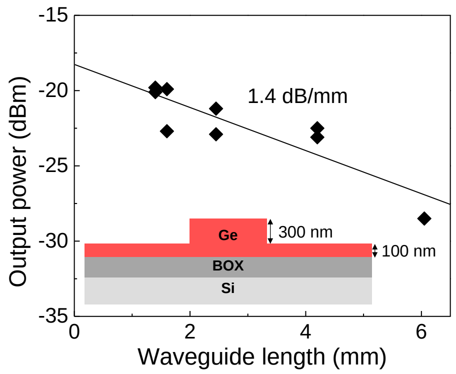

Fig. 2 Propagation loss of Ge straight rib waveguides at 1.9-2 um measured by cut-back method.

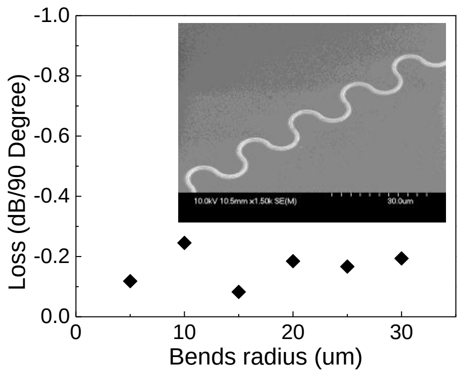

Fig. 3 Bends loss of Ge rib waveguide as a function of bends radius.