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1. 概要(Summary)

Mid-infrared (mid-IR) integrated photonic circuits (PICs) have numerous applications in biochemical sensing. However, traditional silicon PICs suffer from strong optical absorption originating from waveguide and substrate materials in the fingerprint spectral region which spans from 8 μ m to 15 μ m. To overcome this limitation, we developed a novel germanium photonic integrated circuit. Specifically, we demonstrated the first mid-IR germanium photonic crystal cavity[1] and high-efficiency grating couplers[2] in this project. Our study is expected to play an important role in low-cost and portable sensing applications for molecular fingerprinting.

2. 実験(Experimental)

【利用した主な装置】

高速大面積電子線描画装置, 電子顕微鏡

【実験方法】

We designed and fabricated the devices based on a germanium-on-insulator (GOI) wafer in Takeda CR. We utilized electron beam lithography (F5112) to write the devices' patterns on a resist (ZEP-520A) and used a deep reactive ion etching machine to transfer the patterns from the resist to the GOI wafer. Then, the buried oxide below the devices was removed with hydrofluoric acid such that the devices were suspended in the air. After fabrication, we checked the structure of the fabricated devices by using a scanning electron microscope (SEM) (S-4700).

3. 結果と考察(Results and Discussion)

The SEM images of the fabricated germanium photonic integrated circuit are shown in Figure 1. A photonic crystal cavity, two photonic crystal waveguides, two cantilever waveguides, two suspended membrane waveguides, and two focusing subwavelength grating couplers were monolithically integrated on a single chip. At the wavelength range of 2.2-2.5 μ m, we demonstrated the germanium focusing subwavelength grating coupler with the peak efficiency of 11 dB and the germanium photonic crystal cavity with the Q factor of 200.

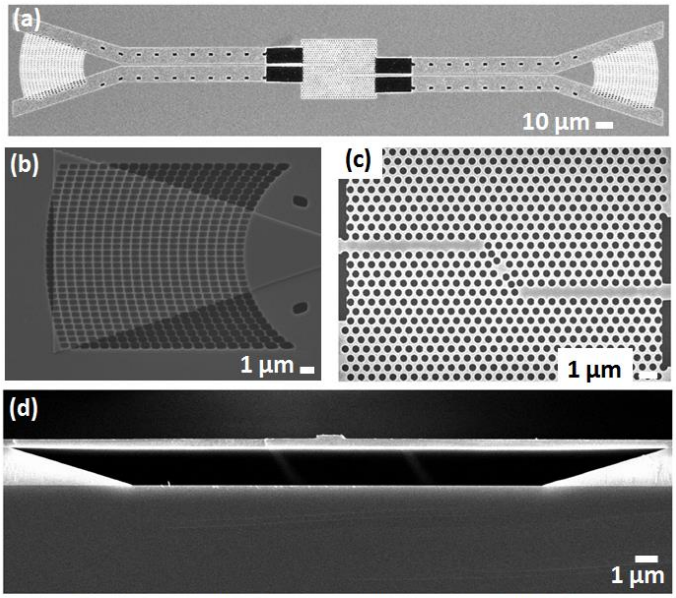

Figure 1. SEM image of the fabricated mid-IR germanium PIC. (a) Top-view of the PIC. (b) Top-view of the focusing subwavelength grating coupler. (c) Top-view of the photonic crystal waveguides and cavity (d) Cross-section of the suspended membrane waveguide.

4. その他・特記事項（Others）

なし

5. 論文・学会発表（Publication/Presentation）

(1) T. Xiao, Z. Zhao, W. Zhou, M. Takenaka, H. Tsang, Z. Cheng, and K. Goda, Optics Letters, Vol. 42 (2017) pp. 2882-2885

(2) J. Kang, Z. Cheng, W. Zhou, T. Xiao, K. Gopalakrisna, M. Takenaka, H. Tsang and K. Goda, Optics Letters, Vol. 42 (2017) pp. 2094-2097.

6. 関連特許（Patent）

なし