N 型 Ge を用いた低損失中赤外導波路の検討

Investigation of Low-loss Mid-infrared Waveguide Using n-type Ge

○趙 子強 [1], 何 鐘培 [1], 高木 信一 [1], 竹中 充 [1] ([1]東大院工)

○Z. Zhao[1], C.-P. Ho[1], S. Takagi[1] and M. Takenaka[1] ([1]The University of Tokyo)
E-mail: zhaozq@mosfet.t.u-tokyo.ac.jp

Introduction: For decades, germanium (Ge) has been attracting tremendous attention from scientists and engineers for its superior properties in both electronic and photonic applications compared with silicon (Si) [1,2]. Ge smaller bandgap of Ge made it capable for an efficient photodetector in C-band, and also has good transmission properties in mid-infrared (MIR) range [2]. As a platform of electronic-photonic integrated circuits operating at MIR wavelengths, we have proposed the Ge CMOS photonics platform which uses a Ge-on-Insulator (GOI) wafer [3]. We have demonstrated Ge passive and active waveguide devices operating at a 2-µm wavelength on a GeOI wafer, while the propagation loss is still high probably due to the hole-induced free-carrier absorption (FCA) in Ge. In this we investigated the impact of n-type Ge on the propagation loss.

Experiments: An n-type Ge wafer (100) was pre-cleaned and covered by SiO_2. H^+ ion implantation was then performed for Smart-Cut. Followed by wafer bonding and splitting, the GeOI wafer was then treated by chemical mechanical polishing (CMP) and annealed in vacuum ambient for recovering crystal quality. Strip waveguides were fabricated by EB lithography and propagation loss was measured by the cut-back method through grating couplers.

Results & Conclusions: To investigation the impact of the waveguide width on the propagation loss, we fabricated Ge waveguides with varied waveguide widths of 0.6, 0.8, 1.0 and 2.0 µm as shown in Fig. 1. Figure 2 plots the waveguide width dependence of the propagation loss of Ge and Si waveguides with numerical fitting based on Payne and Lacey's theory [4]. When the waveguide width is less than 0.8 µm, the propagation loss of both Ge and Si waveguides increases rapidly due to the sidewall roughness. When the waveguide width is greater than 1 µm, the propagation loss of the n-type Ge waveguide is significantly smaller than that of the p-type Ge waveguide, and close to that of the Si waveguide. Thus, we have successfully demonstrated the feasibility of low-loss Ge waveguide using n-type Ge.

Acknowledgement: This work was partly commissioned by the New Energy and Industrial Technology Development Organization (NEDO) Integrated Photonics-Electronics Convergence System Technology (PECST) project and supported by JSPS KAKENHI Grant Number JP26220605.

References: [1] J. Michel et al., Nature Photonics, 2010, 4(8): 527-534. [2] R. Soref et al., Nature photonics, 2010, 4(8): 495-497. [3] J. Kang et al., Optics express, 2016, 24(11): 11855-11864. [4] F. P. Payne et al., Optical and Quantum Electronics, 1994, 26(10): 977-986.

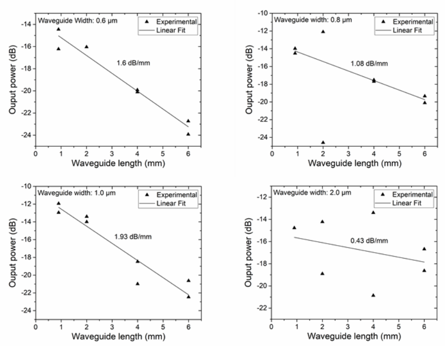

Fig. 1 Propagation loss of Ge waveguide with varied width (0.6, 0.8, 1.0 and 2.0 µm).

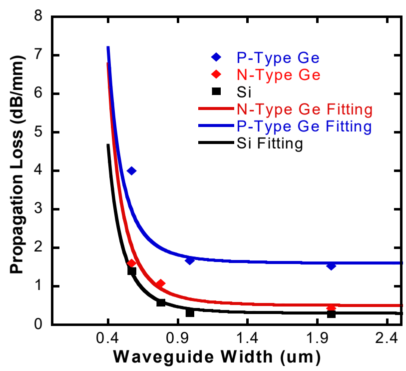

Fig. 2 Propagation loss of Ge and Si waveguides as a function of waveguide width.