Observation of Sub-bandgap Photodetection at 2 μm wavelengths in a Germanium Lateral PIN Photodetector

°Ziqiang Zhao[1], Chongpei Ho[1], Qiang Li, Kasidit Toprasertpong[1], Shinichi Takagi[1] and Mitsuru Takenaka[1] ([1]The University of Tokyo)
E-mail: zhaozq@mosfet.t.u-tokyo.ac.jp

Introduction: Being boosted by the crying needs for high-speed and broad-band data communication, silicon (Si) photonics has attracted people's attention not only in the near-infrared region but also in the mid-infrared (MIR) wavelengths [1]. Moreover, with the evolution of low-loss hollow-core optical fibers and thulium/holmium optical amplifiers, developments of photonic building blocks for MIR have been promoted [2]. Particularly, monolithic Si photodetectors (PDs) operating at sub-bandgap wavelengths, i.e. 2 μm, through defects mediation have been reported [3]. In this work, we reported sub-bandgap photodetection in Germanium (Ge) lateral PIN PDs on Ge-on-insulator (GeOI) wafer operating at 2 μm wavelengths for the first time.

Methods: The GeOI wafer was fabricated by following the process flow reported in [4]. Grating couplers and rib waveguides were patterned by electron-beam lithography and defined through dry etching with CF_4. After that, SiO_2 hard mask was deposited for boron ion implantation to form the p^+-region of Ge PIN junction. Spin-on-glass doping with phosphorus was performed on the Ge PIN junction for high quality n^+-region formation. Nickle (Ni) and Aluminum (Al) were sputtered and succeeded by lift-off process to make electrodes. Figure 1 illustrated the schematic of the Ge lateral PIN PD and plan-view optical microscopy of a Ge PD with junction length of 500 μm.

Results & Conclusions: To evaluate the generated photocurrent under illumination of lights, an amplified spontaneous emission (ASE) source at 2 μm wavelengths was coupled into the Ge rib waveguide by grating coupler. Dark current and photocurrent were measured respectively using a 500-μm-long Ge PD with reversed bias voltage from 0 V to -5 V as shown in Fig. 2. Noted that the coupled-in light was centered at 1960 nm. Considering the coupling loss after grating coupler and Ge waveguide propagation loss, an estimated photo responsivity of 0.25 A/W at -5V bias voltage can be obtained with quantum efficiency of approximately 16%. In conclusion, we successfully observed photodetection at 2 μm wavelengths using Ge PIN waveguide formed on a GeOI platform that is attributable to defects-mediation mechanism, enabling a bunch of promising applications on GeOI platform at/beyond 2 μm wavelengths.

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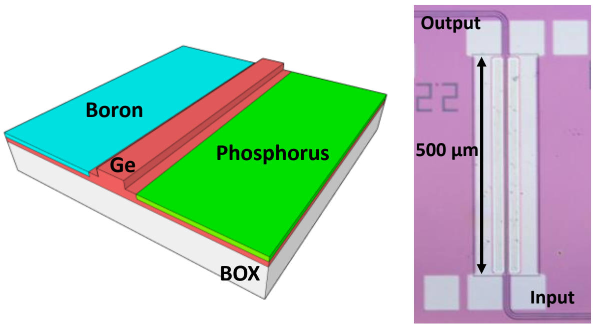

Fig. 1 Schematic of the Ge lateral PIN PD and plan-view optical microscopy of a 500-μm-long Ge PD.

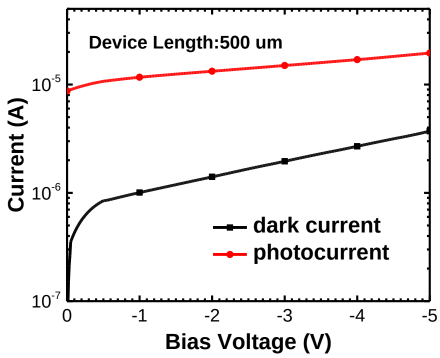

Fig. 2 I-V curve of a 500-μm-long Ge lateral PIN PD with reversed bias voltage from 0 V to -5 V (center wavelength is at 1960 nm).