# Heterogeneous integration of SiGe/Ge and III-Vs on Si for electronic-photonic integrated circuits

Univ. Tokyo [1], JST-CREST [2], ○Mitsuru Takenaka[1,2], Shinichi Takagi[1,2]
E-mail: takenaka@mosfet.t.u-tokyo.ac.jp

Heterogeneous integration of SiGe, Ge and III-V semiconductors on Si enables us to integrate photodetectors (PDs), modulators, and laser didoes (LDs) on Si photonics platform. Since SiGe/Ge and III-Vs have high hole and electron mobility, we are also able to integrate monolithically high-performance metal-oxide-semiconductor (MOS) transistors based on those semiconductors. Thus, the heterogeneous integration is a key enabler to realize high-performance and low-power electronic-photonic integrated circuits (EPICs) as shown in Fig. 1. We present our recent developments of EPICs based on SiGe/Ge and III-V integration on Si platform for near and mid-infrared photonics.

We have investigated SiGe-based optical modulators to enhance the modulation efficiency [1]. Strain SiGe is expected to exhibit greater free-carrier effects than Si owing to the light hole effective mass in SiGe. We have successfully demonstrated the enhanced free-carrier absorption and plasma dispersion effect in SiGe by making carrier-injection SiGe optical modulators [2,3].

Ge is an attractive material for mid-infrared photonics because of its transparency. We have proposed Ge CMOS photonics platform on a Ge-on-Insulator (GeOI) wafer [4]. A high-quality GeOI wafer fabricated by wafer bonding enables the first demonstration of Ge strip and rib waveguide on the GeOI for mid-infrared wavelengths. Ge passive components and carrier-injection VOAs have been successfully demonstrated [5].

We have proposed and investigated the III-V CMOS photonics platform [6]. By using a III-V-OI wafer, Si-photonic-like III-V photonic integrated circuits can be developed. We have demonstrated InP-based photonic-wire passive components [7,8], carrier-injection modulators [9], and InGaAs PDs [10] on the III-V-OI wafer.

In summary, the heterogeneous integration of SiGe/Ge and III-Vs can extend functionalities on Si photonics platform through electronic-photonic integration.

Acknowledgement
This work was supported by a Grant-in-Aid for Young Scientists (A) from MEXT, a Grant-in-Aid for Scientific Research (S) from MEXT, and NEDO “Integrated Photonics-Electronics Convergence System Technology (PECST)” project.

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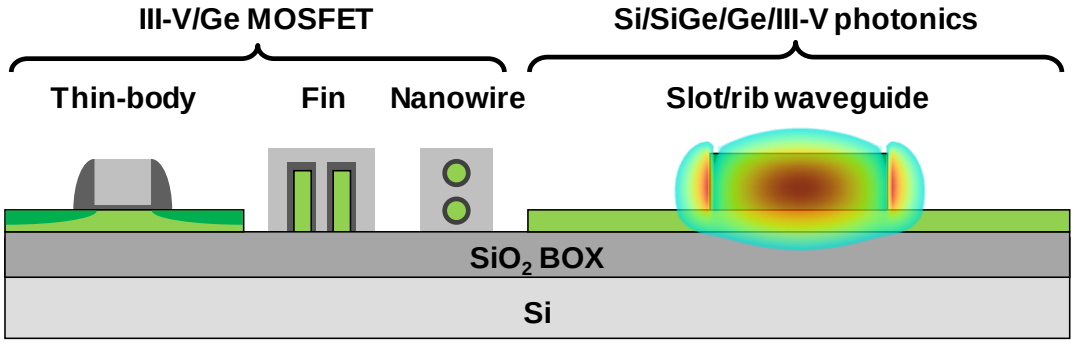


Fig. 1 Electronic-photonic integrated circuits by heterogeneous integration of SiGe/Ge and III-V semiconductors on Si.