Modulators

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Silicon microphotonics has drawn great interest for use in high-capacity data transfer using lightwave based technology. The Giga bit-per-second capacity data transfer in planar structures enables solutions for interconnects delay in computers. The wavelengths used in silicon microphotonics of 1.3 and 1.55µm enable the telecommunication applications such as Local Area Networks (LANs) and fiber-to-the-Home (FTTH). Compatibility with existing complementary metal-oxide-semiconductor (CMOS) technology provides processing capability and enables the integration between microphotonics and silicon-based microelectronics.

Silicon-based optical modulators are crucial components that manipulate optical signals in the integrated microphotonics. At present, carrier related effect limits the speed of silicon-based modulators to only Gigahertz. High-speed application (>10GHz) requires modulation based on field effect. In this work, we study the field-effect based absorption modulation in pure germanium and germanium-rich silicon-germanium epitaxial films. Using spectral responsivity measurement, we relate the material absorption coefficients to spectral responsivity.

We observed the electro-absorption effect in germanium p-i-n diodes. For the energy lower than the bandgap (0.79 eV), the spectral responsivity is enhanced by the applied field. Above the bandgap, we observed the Franz-Keldysh oscillation in spectral responsivity. This oscillation is due to band structure perturbation from the electric field. In Ge-rich, SiGe p-i-n diodes, we observed decreasing material absorption between direct and indirect band edges under the applied field using spectral responsivity by a laser source. The cause of this effect is being investigated. These materials are potential candidates for using as field-effect-based optical modulators in silicon microphotonics.

Figure 1: Spectral responsivity from Ge p-i-n diodes under 0 kV/cm and 30kV/cm.

Figure 2: Differences in Ge-rich SiGe absorption coefficients under the applied fields.