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Comparison of Strained SiGe-on-SOI and Condensed SGOI p-MOSFET with Various Ge Concentrations

Seung-Hyun Song, Du-Young Lee, Tae-Hyun Kim,
Tae-Hun Shim, and Jea-Gun Park*

Advanced Semiconductor Materials and Devices
Development Center, Department of Electronics and
Communication Engineering, Hanyang University, Seoul
133-791, Korea

As a Si thickness in thin-body silicon-on-insulator (SOI) structure decreases below 20 nm for scaling, resulting in decreased carrier mobility [1], novel fabrication technologies or channel materials become necessary. Germanium has been attracted great attention as a promising channel material because of its high bulk electron mobility of 3900 $cm^2V^{-1}s^{-1}$ and hole mobility of 1900 $cm^2V^{-1}s^{-1}$. For n-type metal-oxide-semiconductor field-effect-transistors (n-MOSFETs), however, the actual electron mobility of Ge n-MOSFET was much worse than that of Si n-MOSFET applications. On the other hand, for p-type MOSFETs (p-MOSFETs), SiGe-on-SOI or SiGe-on-insulator (SGOI) structures with high Ge content and large compressive strain are promising channel for p-MOSFET future sub-10 nm technology.

In this research, we investigated the electrical characteristics of p-MOSFETs with various Ge concentrations fabricated by compressively-strained SiGe channel growing on SOI structure and condensed SGOI structure. For a condensed SGOI substrate, 10-nm-thick capping Si and 80-nm-thick strained $Si_{0.7}Ge_{0.3}$ layer were grown on 20-nm-SOI substrates at 550 ^oC by ultrahigh-vacuum chemical-vapor-deposition and were followed by the annealing process in N_2 ambient. Then the SGOI substrates were oxidized at the dry O_2 ambient by utilizing multi-steps [2]. Figure 1 shows cross-sectional transmission electron microscopy (TEM) image for compressively-strained SiGe-on-SOI with Ge concentration of 32 and 43 at% and condensed SGOI substrates with Ge concentration of 34 and 47 at%.

P-MOFET was fabricated on compressively-strained SiGe-on-SOI and condensed SGOI substrates. The 10-nm Al_2O_3 gate oxide was grown by Atomic Layer Deposition (ALD) and doped poly-silicon with a 100-nm thickness was deposited. After that, the source and drain were formed by boron ion implantation, rapid thermal anneal (RTA) was performed at 1,000 ^oC with 3 sec for dopant activation, and forming the gas anneal with H_2 and N_2 ambient was performed at 450 ^oC for 30 min to improve the interface characteristics.

Figure 2 shows effective hole mobility of each structure. For compressively-strained SiGe-on-SOI p-MOSFET with a Ge concentration of 43 at%, effective hole mobility was increased 2.33 times at effective field of 0.1 MV/cm compare to that of control SOI p-MOSFET. For condensed SGOI p-MOSFET with a Ge concentration of 47 at%, effective hole mobility was increased 2.11 times at effective field of 0.1 MV/cm compare to that of control SOI p-MOSFET.

These mobility enhancements can be explained by strain values of each structure. It is expected that strain value increase with increasing Ge concentration of compressively-strained SiGe-on-SOI. However, for condensed SGOI, SiGe layer could be fully relaxed when Ge concentration is higher than specific concentration. Figure 3 shows Raman shift for the condensed SGOI with Ge concentration of 23, 34, 47, 54, 63, 89 and 97 at%. In our presentation, we report the relation between effective hole mobility and Ge concentration of condensed SGOI p-MOSFET and electrical properties in detail.

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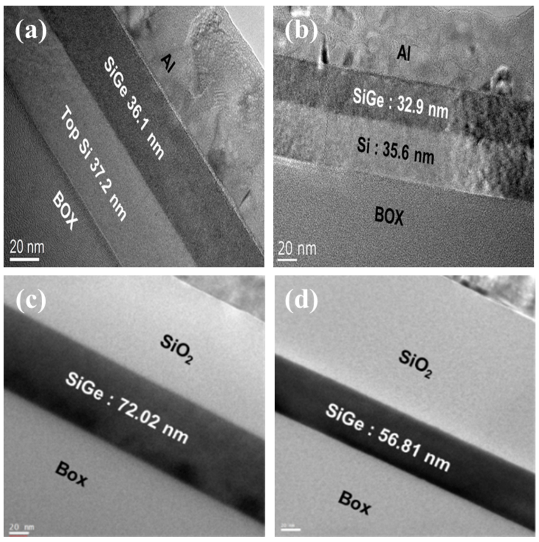

Fig. 1. Cross-sectional TEM images of compressively-strained SiGe-on-SOI structure with (a) 32 and (b) 43 at % Ge concentration, condensed SGOI structure with (c) 34 and (d) 47 at% Ge concentration.

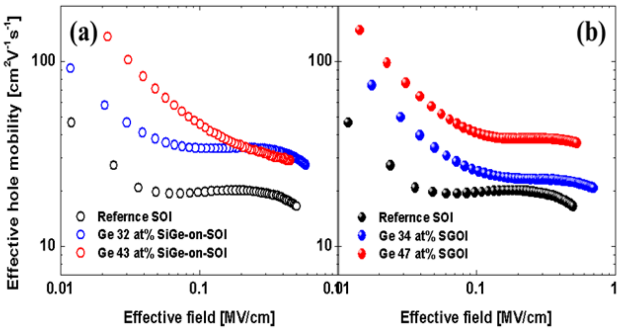

Fig. 2. Effective hole mobility of (a) compressively-strained SiGe-on-SOI structure and (b) condensed SGOI structure.

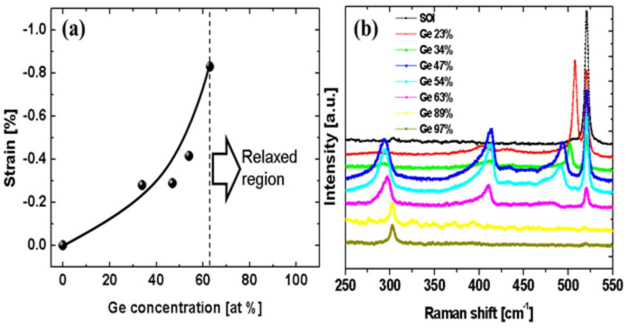

Fig. 3. (a) Compressively-strain value of condensed SGOI substrate as a function of Ge concentration and (b) Raman shift of condensed SGOI substrate.

Reference

[1] S. Takagi, J. Koga and A. Toriumi, *Jpn. J. Appl. Phys.* **37**, 1289 (1998).

[2] Tae-Hyun Kim and Jea-Gun Park, *J. Korean Phys. Soc.* **62**, 531 (2013) .