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Hybrid-Formation of Single-Crystalline Ge(Si, Sn)-on-Insulator Structures by Self-Organized Melting-Growth

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Research and development for new semiconductor devices which enable ultrahigh speed operation, ultralow power dissipation, and/or multi-functional operation are strongly required to overcome a scaling limit of the complementary metal-oxide-semiconductor (CMOS) performance. Thus, Si-based heterostructure technologies have been widely developed over the last quarter century [1]. The hetero-epitaxial growth of III-V semiconductors and ferromagnetic Heusler alloys is the typical example, which achieves optical emission and spin injection on SiGe substrates [2-6]. In order to create multi-functional large scale integrated circuits (LSI), such new materials should be stacked on the group-IV semiconductor platform with high carrier mobilities. Consequently, development of high quality SiGe-on-insulator (SGOI) structures becomes essential.

In line with this, we have been developing self-organized rapid-melting growth [7-8]. Melt-back process achieves defect-free SiGe, Ge, and GeSn single crystals on insulating substrates. This also forms the laterally-graded SiGe, GeSn, and dopant profiles, where lateral-profiles are modulated by controlling the growth-velocity. Network-structures and three-dimensionally stacked-structures of SGOI are also demonstrated. In addition, the *artificial* GOI single-crystals with hybrid-orientation are achieved on (100) Si platform by using Si micro-seed techniques.

The present paper reviews our recent progress in such melt-back-growth techniques [7-21]. Possibility of self-organized zone-melting-growth is also presented. Main subjects to be discussed in this conference are as follows:

(1) Defect-free and chip-sized GOI (~1 cm length) with high carrier mobility (~ 1200 cm^2/Vs) and its Fermi-level control.
(2) Growth-velocity-modulated laterally-graded SiGe and GeSn profiles on insulating substrate.
(3) Network and/or three-dimensionally-stacked SGOI structures and hybrid-orientation GOI on (100) Si platform.
(4) Physics and application of self-organized melt-back-growth and zone-melting-growth.
(5) Future application to multi-functional LSI and flexible-electronics.

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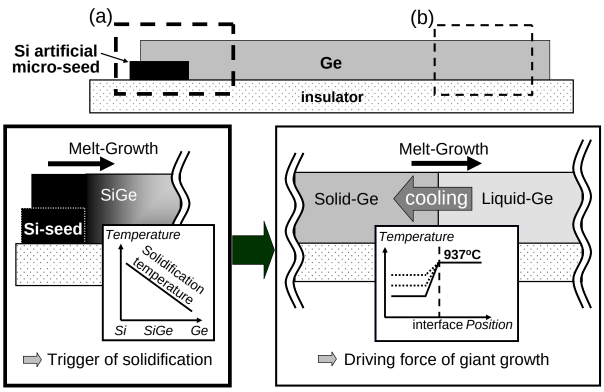

Fig.1 Basic idea for SiGe mixing-triggered rapid melting growth.

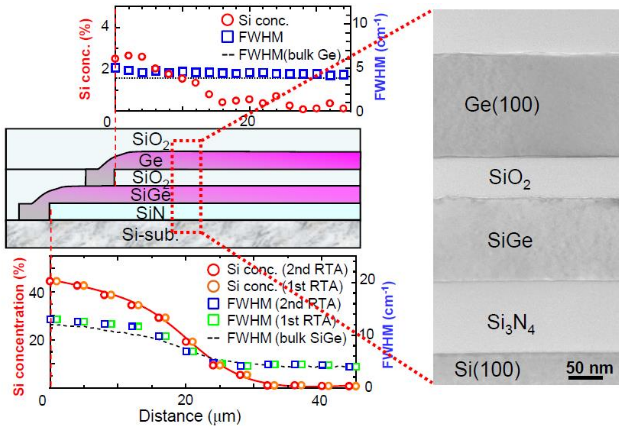

Fig.2 Multiply stacked SiGe-on-insulator structures.

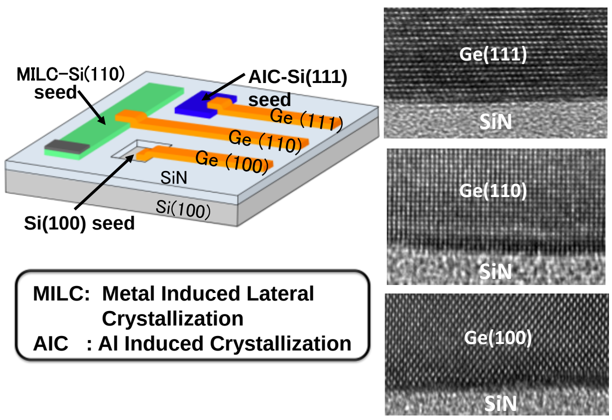

Fig.3 Hybrid-orientation GOI structures on (100) Si platform.

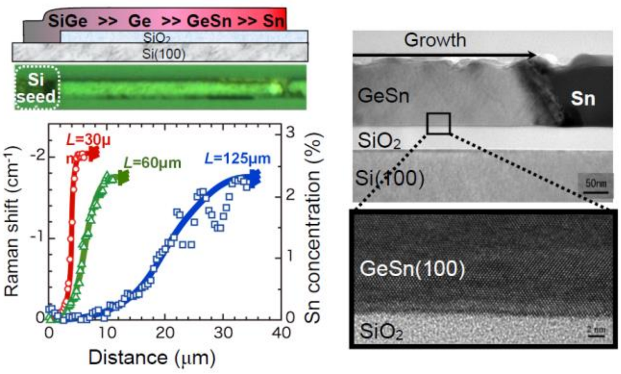

Fig.4 Laterally graded GeSn-on-insulator structures.