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

Masanobu Miyao1*, Ryo Matsumura1, Masashi Kurosawa1, 2, Kaoru Toko1, and Taizoh Sadoh1

1Department of Electronics, Kyushu University; 744 Motooka, Fukuoka 819-0395, Japan
Phone: +81-92-802-3736, Fax: +81-92-802-3724
2JSPS Research Fellow
Corresponding authors: miyao@ed.kyushu-u.ac.jp

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 cm²/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.
(5) Future application to multi-functional LSI and flexible-electronics.

Acknowledgements
A part of this work was supported by a Grant-in-Aid for Scientific Research from the Ministry of Education, Culture, Sport, Science and Technology in Japan. M.K wishes to thank JSPS research program for young scientists.
Reference


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.

Present address
M. Kurosawa: Graduate School of Engineering, Nagoya University, Nagoya 464-8603, Japan
K. Toko: Institute of Applied Physics, University of Tsukuba, Tsukuba 305-8573, Japan