Extended Abstracts of the 2010 International Conference on Solid State Devices and Materials, Tokyo, 2010, pp23-24

Defect-Free GOI (Ge on Insulator) by SiGe Mixing-Triggered Liquid-Phase Epitaxy

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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 in a 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 Si substrates [2-4]. 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 Ge-on-insulator (GOI) structures becomes essential.

In line with this, we have been developing SiGe mixing triggered liquid-phase epitaxy (LPE) [5]. This achieves defect-free Ge single crystals on insulating substrates [6]. The present paper reviews our recent progress in this novel growth technique [5-9]. Main subjects to be discussed in this conference are as follows:

(1) Basic idea for SiGe mixing-triggered Ge-LPE on insulating substrates.
(2) Advanced Ge-LPE combined with Al-induced crystallization.
(3) Giant Ge lateral growth (~1 cm length) with (100) orientations.
(4) Defect-free GOI with high carrier mobility (~ 1200 cm^2/Vs).
(5) Possible application to 3D-LSI, thin film transistors (TFT), and spin-transistors.

Acknowledgements

This work was partially supported by Semiconductor Technology Academic Research Center (STARC).

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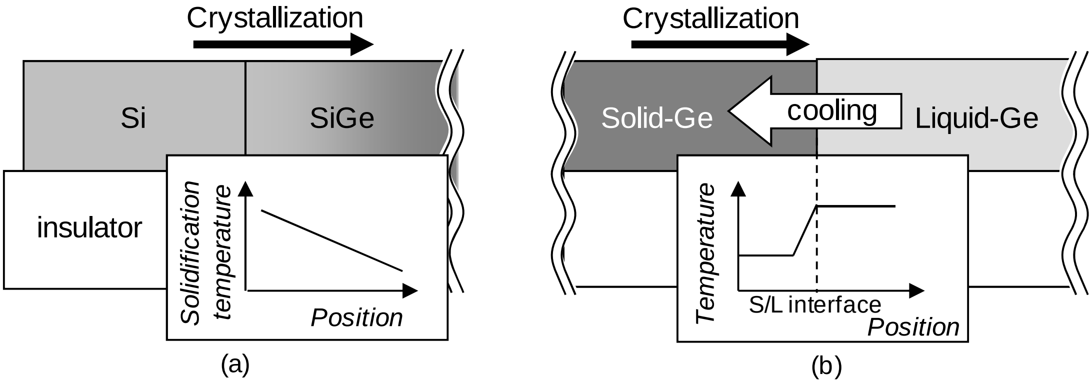
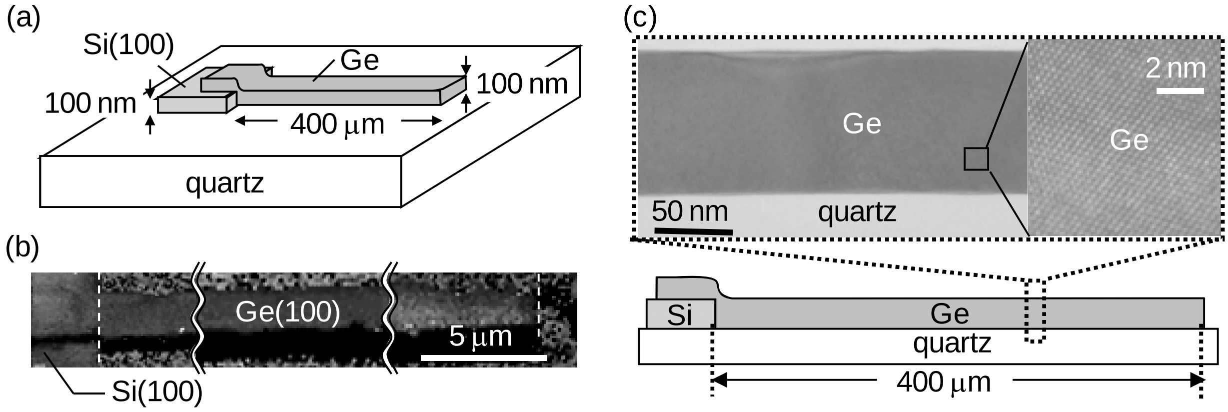
(1) Growth mechanism of SiGe mixing-triggered liquid-phase epitaxy



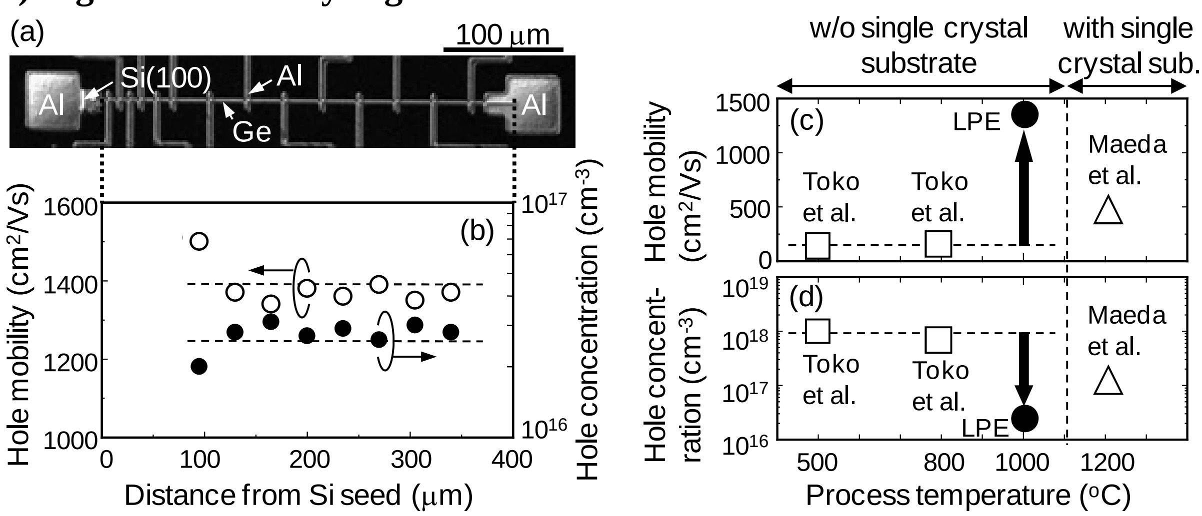
(a) Growth mechanism of GOI near and (b) far beyond seeding area.

(2) Formation of defect-free Ge (100) stripes on quartz substrates



(a) Sample structure of Ge stripe with Si (100) seed on quartz, (b) EBSD image of Ge stripe after RTA (1000°C, 3 sec), and (c) cross-sectional TEM image.

(3) High-hole-mobility in grown GOI



(a) Nomarski optical micrograph of Ge stripe with Al-pads, (b) electrical properties as a function of the distance from Si seed, where open circles show hole mobilities and closed circles show hole concentration, (c) comparison of hole mobility and (d) hole concentration of Ge films obtained by LPE with Si(100) seed, SPC [K. Toko et al., Solid State Electron. 53, 1159 (2009)], and oxidation-induced Ge condensation [T. Maeda et al., Thin Solid Films 508, 346 (2006)].