Thickness Dependent Growth Kinetics in Ni-Mediated Crystallization of a-SiGe on Insulator

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INTRODUCTION

Low-temperature (≤550°C) formation of high quality poly-SiGe on insulator is essential to realize advanced thin-film transistors. Low-temperature (≤550°C) solid-phase crystallization of a-Si was realized by using the catalytic effect of metals (1,2). This metal-induced lateral crystallization (MILC) has achieved poly-Si with large grains (~10μm) on insulating films. However, the MILC process of a-SiGe on SiO_2 has not been established.

It is expected that the crystallization kinetics for a-SiGe depend on various parameters of the starting amorphous films, such as the Ge fraction and the thickness. In order to establish the MILC process of a-SiGe, a systematical understanding of the kinetics is necessary. We previously reported the effect of the Ge fraction on MILC for a-$Si_{1-x}Ge_x$ ($0 \leq x \leq 1$) on SiO_2, and showed that the growth velocity and the morphology of the grown area strongly depended on the Ge fraction (3). In the present study, we have investigated the effect of the film thickness on MILC of a-SiGe on SiO_2.

EXPERIMENTAL PROCEDURE

In the experiment, a-$Si_{1-x}Ge_x$ (x: 0-1.0) layers (thickness: 10-100nm) were deposited on SiO_2 by using a solid-source MBE system. Subsequently, 5 nm-thick Ni films were deposited, and patterned by using lithography. The samples were annealed at 550°C in a N_2 ambient. The morphology of poly-crystals was evaluated by Nomarski optical microscopy and scanning electron microscopy (SEM).

RESULTS AND DISCUSSION

A typical photograph and its schematic drawing of the sample (x: 0.4, thickness: 50nm) after annealing (550°C, 10h) are shown in Figs.1(a) and 1(b), respectively. A large (~70μm) crystallized region was observed after annealing. The crystallized region consisted of a plane region, which uniformly extended from the front of the Ni pattern, and a dendrite region. In addition, it was found that the plane and dendrite growth velocities became maximum at x=~0.4 for a-$Si_{1-x}Ge_x$ ($0 \leq x \leq 1$) films (thickness: 50nm). Thus, we will report our results by focusing on the samples with x=0.4.

The characteristics of the plane growth (550°C) for the samples with thickness of 10-100nm are shown in Fig.2(a). It is found that the growth velocity becomes faster after annealing for 10h, and the growth length does not saturate after annealing over 20h. The growth characteristics of the dendrite region are shown in Fig.2(b). The dendrite growth velocity is very fast in the short-time annealing (≤5h), while the growth velocity slows down and the growth length saturates after long-time annealing (≥5h).

These results clearly indicate that both velocities for plane and dendrite growth increase with increasing thickness of the starting amorphous films. In the MILC process, Ni atoms diffuse through the crystallized SiGe regions and induce crystallization of a-SiGe at the growth front, i.e., the grown c-SiGe regions act as the Ni channel. Since the c-SiGe/SiO_2 interfaces and the surfaces of the c-SiGe regions act as the gettering sites of Ni atoms, the effective thickness of Ni channel in the c-SiGe regions decreases with decreasing thickness of the starting amorphous films. Thus, the MILC of a-SiGe on SiO_2 is enhanced with increasing thickness. The electrical characteristics of the grown layer are now under investigation.

CONCLUSION

The thickness dependent growth kinetics in MILC of a-SiGe on SiO_2 has been investigated. The crystallized area consisted of plane and dendrite regions. The growth velocities of both regions increased with increasing thickness of the starting amorphous films. This dependence could be explained on the basis of the narrowing of the effective Ni channel in the grown c-SiGe regions with thinning deposited SiGe films. The control of the film thickness is important for optimization of MILC process of a-SiGe to realize high quality thin-film transistors.

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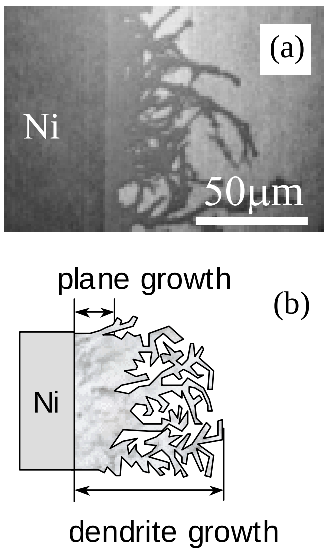

Fig.1 Nomarski optical micrograph (a) and its schematics (b) of a-$Si_{0.6}Ge_{0.4}$ (thickness: 50nm) on SiO_2 after annealing (550°C, 10h).

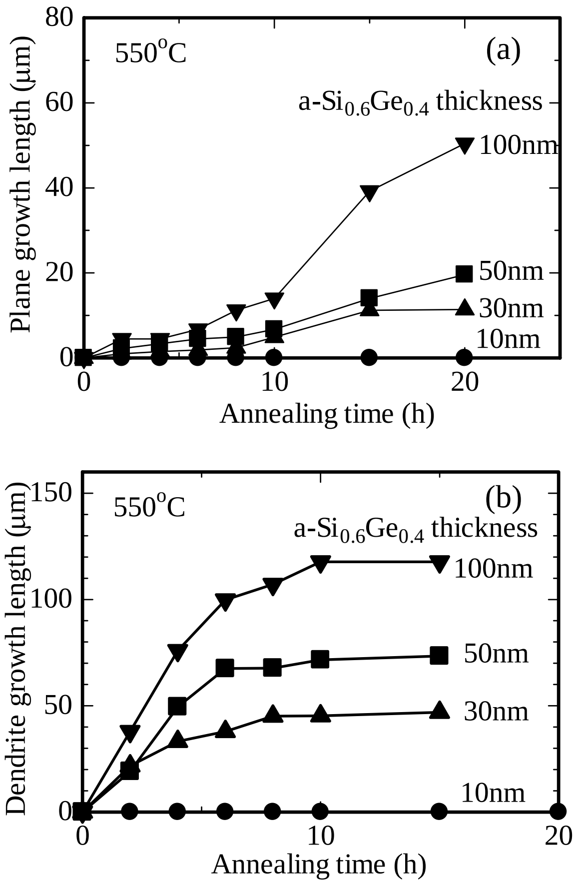

Fig.2 Growth characteristics (550°C) of plane (a) and dendrite regions (b).