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Residual order in thermal oxide of fully strained SiGe alloy on Si

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Introduction

Oxidation of SiGe alloy has been a target of research for both fundamental and technological reasons, as in the case of Si oxidation. It has been expected as the fabrication process for the gate oxide of SiGe channel metal oxide semiconductor field effect transistors (MOSFETs), which allows higher carrier mobility than that of Si channel MOSFETs [1]. In recent years, it has also been employed in the fabrication of SiGe-on-insulator and Ge-on-insulator substrates [2]. These substrates are employed to realize high-speed MOSFETs with channel materials of strained Si, SiGe, and Ge.

However, the oxidation mechanism of SiGe alloy is still open to question, due to the complexity caused by lattice strain and diffusion of Ge atoms. The most characteristic phenomenon of SiGe oxidation is that Ge atoms are ejected from the interface between the surface oxide and the SiGe layer without the incorporation of Ge atoms into the oxide layer. Ge atoms accumulate at the SiO_2/SiGe interface and diffuse into the SiGe layer [1,2]. In the case of a strained SiGe layer epitaxially grown on a Si substrate, the effects of strain relaxation and defect generation during the oxidation process must be taken into account.

It is important to investigate the atomic structure of the thermally oxidized layer, because it allows us to understand what really happens at the oxidized interface. In the case of the thermally oxidized layer of Si, the Si atoms in the oxide layer still maintain order, which originates from the diamond structure of the parent Si crystal, although the structure appears to be amorphous at a glance. This provides an actual picture of the oxidation process and explains the almost perfect properties obtained by electric measurements of the SiO_2/Si interface. In this study, the residual order in the thermal oxide layer on a fully strained SiGe alloy was investigated.

Experimental

$Si_{1-x}Ge_x$ (x=0.08, 0.13 and 0.21) layers were epitaxially grown on Si(001) substrates by chemical vapor deposition. The thickness of the SiGe layers was approximately 100 nm. The SiGe layers were fully strained, so that the lateral lattice spacing of the SiGe layers was exactly the same as that of the Si substrate. These samples were oxidized in dry O_2 in the temperature range from 850 to 1000°C.

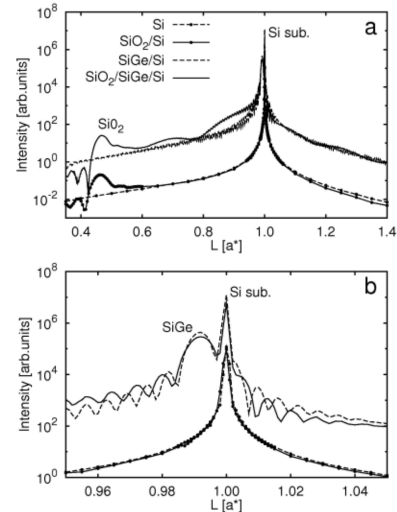

Fig. 1. Intensity distributions of CTR scatterings elongated from the 111 Bragg point of SiGe/Si and Si substrates. Enlargement around the 111 Bragg point of (a) is shown in (b).

Results

Figure 1 shows the intensity distributions along the CTR scatterings elongated from the 111 Bragg points for the $Si_{1-x}Ge_x$/Si (x=0.13) and Si substrates. Solid lines show the distributions for the samples oxidized at 850°C for 1 h. Figure 1(b) shows an enlargement around the 111 Bragg point. The diffraction peaks of the SiGe layer are observed close to those of the Si substrate, and the position did not change during the oxidation, while the period of the intensity oscillation became larger, indicating that the thickness of the SiGe layer became smaller with oxidation while maintaining the original lattice strain.

Diffraction peaks of the residual order in the oxide layers are also clearly observed around L=0.45 for the oxidized samples. The intensity and the position of the peaks are almost the same for both samples. This indicates that the residual order in the oxide layers of both samples has the same crystallinity.

References

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