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Ordered Structure in the Thermal Oxide Layer on Silicon-on-Insulator Substrates

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Introduction

It is widly accepted that the thermal oxide layer on the Si surface has amorphous structure and some crystalline oxides exist just close to the interface, although several structural models are still inconsistent with each other. Recent studies using high-resolution transmission electron microscope basically support the structural model, in which any crystalline oxides are not observed in the region far from the interface [1].

However, we have been proposing that the thermal oxide layer are not simple amorphous, but has a kind of ordered structure not only close to the interface but also throughout the oxide layer, having an epitaxial relation with the Si substrate [2]. This structural model is based on the results of the x-ray diffraction experiments. In this report we show the experimental result for the thermal oxide layer on silicon-on-insulator (SOI) substrates.

Experimental

The SOI layer of 100 nm thickness is oxidized at 950 °C in dry O_2. The thickness of the oxide layer is 25 nm. X-ray diffraction experiments using synchrotron radiation were performed on BL4C of Photon Factory (KEK) by employing a four-circle diffractometer with an Si(111) crystal analyzer. The wavelength was chosen to be 0.154 nm.

Results

The ordered structure was found in the thermal oxide layer on the SOI layer. Because of the existence of an unintentional misorientation between the SOI layer and the Si substrate, we can observe x-rays diffracted by the SOI layer separately from that by the substrate. In Fig. 1 the intensity distribution of the CTR scattering around the 111 Bragg point of the SOI layer is shown. We see that the intensity distribution of the CTR scattering itself has the thickness fringe related to the thickness of the SOI layer. The extra peak of the ordered oxide is observed at 1 1 0.47 as in the case of the oxide layer on the bulk wafer. The inset of Fig. 1 shows the enlargement around the extra peak. We see the Laue-function-like oscillation pattern of which period corresponds to the inverse of the oxide thickness, together with the fringe for the SOI layer. This result is additional evidence indicating the existence of the ordered oxide having the epitaxial relation with the parent Si crystal.

References

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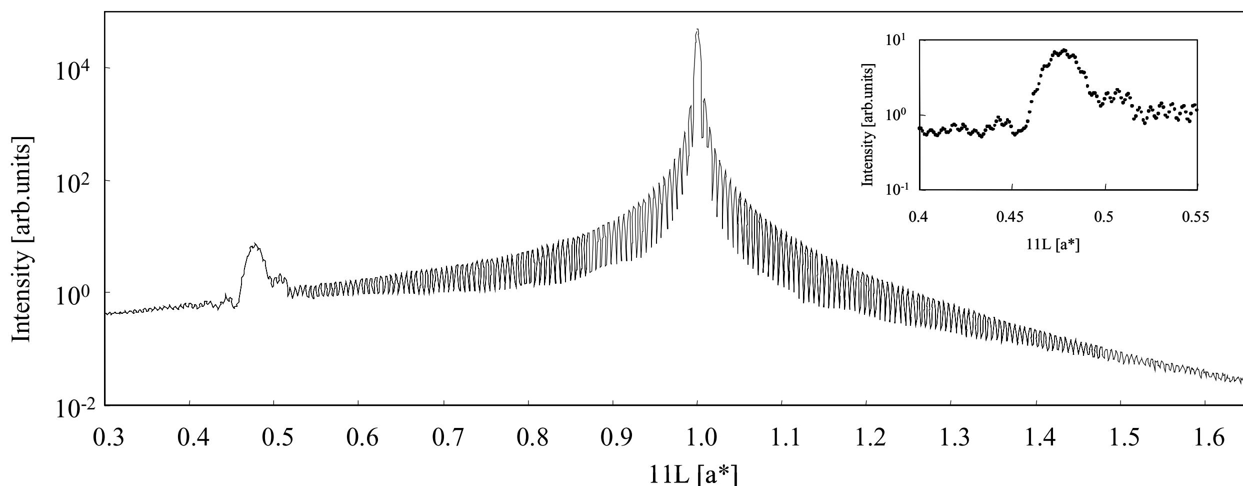

Fig. 1 Intensity distribution of the CTR scattering around the 111 Bragg point from the bonded SOI layer with the thermal oxide layer of 25 nm thickness. Inset shows the enlargement around the extra peak.