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Observation of SOI wafers by X-ray topography

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Introduction

Silicon-on-insulator (SOI) wafers have been extensively studied as the key technology for the promising substrate material of low-power and high-speed devices. In these studies the quality of the SOI material such as the crystalline quality of the top Si layer, the morphology of its interfaces, and the buried oxide integrity has been characterized by several techniques. The crystalline quality of the top Si layer has generally been characterized by transmission electron microscopy (TEM) and chemical etching methods followed by optical observations, which are sensitive to dislocations and stacking faults. Atomic force microscopy (AFM) observations after chemical etching of overlayers show the morphology of the interfaces. The integrity of the buried oxide layer can be evaluated by electrical methods.

X-ray topography is one of the powerful tools to characterize crystalline quality, which provides us the distribution of dislocations and micro defects. But it has not been employed for the characterization of SOI wafers, because the SOI layer is much thinner than the extinction distance of x-rays. It causes drastic reduction of the contrast of the image of the defects. But it is possible to observe structural irregularity of the SOI layer in the framework of the kinematical diffraction theory. Therefore, we tried to observe the diffraction images of the SOI layers.

Experimental

A bonded SOI wafer was prepared for this study. The thicknesses of the top Si and buried oxide (BOX) layers are about 2000 and 50 nm, respectively. The top Si layer was rotated 5 degree around [001] axis for the Si substrate in the bonding process. Two samples of 15x20-mm^2 rectangle were cut out from the wafer. The SOI layer of one of the samples was etched off to 240 nm by KOH solution.

X-ray topographs were taken by using 220 Bragg reflection in Laue geometry. The energy of the x-rays was selected to be 17.4 keV.

Results

X-ray topographs from the SOI layers are shown in Fig.1, in which a) and b) show the images from the SOI layers of thickness of 2000 and 240 nm, respectively. The images represent the 2x2-mm^2 area. We see the rugged images in both topographs, although the thickness of the SOI layers is much less than the extinction distance of 35000 nm. Therefore, this contrast can be understood in the kinematical diffraction theory.

As the results of further investigation, the lattice of the SOI layers undulated in more than ten arc seconds. Typical special interval is about dozens of micrometers.

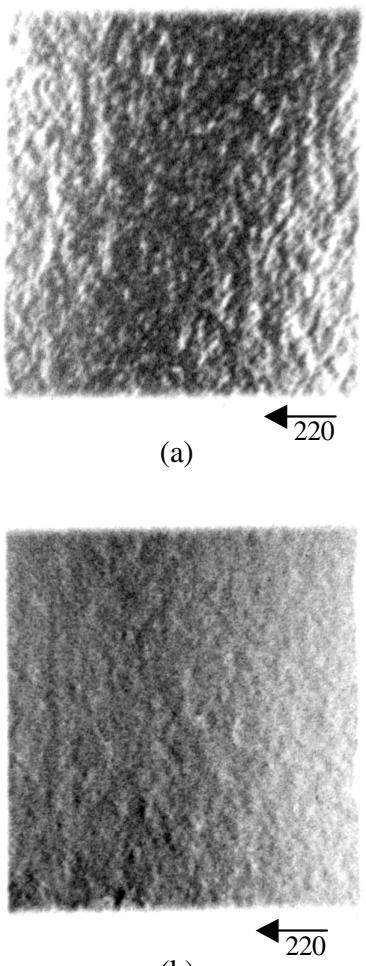

Fig.1 X-ray topographs of SOI layers. Thicknesses of the SOI layers are 2000 nm and 240 nm for a) and b), respectively. The size of the images correspond to 2x2 mm^2.

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