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Yamamoto, Y. / Nishimura, T. / Aoki, Y. / Kashiwagi, T. / Hatakeyama, Y.

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ION BEAM INDUCED INTERFACIAL AMORPHIZATION IN SiGe

T. Kashiwagi[#], Y. Aoki[**], Y. Hatakeyama[**],
Y. Yamamoto[**], and T. Nishimura[***]
[#]Graduate school of science and engineering Hosei University,
[**]Faculty of science and engineering Hosei University,
[***]Research center of Ion Beam Technology, Hosei University

Abstract

The surface region of SiGe/Si containing 10% Ge with a thickness of 400nm was amorphized to the depth of 230 nm by Ge ion bomardment to a fluence of 1.0×10^{15} ions/cm^2 at the energy of 200 KeV at room temperature. Some samples were annealed in a N_2 atomosphere at 300℃ for 10 min. Then the samples were bombarded with Ge ions at the energy of 3.9 MeV to fluences of 4×10^{14}, 7×10^{14}, 9×10^{14} ions/cm^2 at room temperature. Rutherford backscattering spectrometry (RBS) measurements revealed that as the fluence increased the interface between amorphous and crystal proceeded toward internal of the sample, indicating a layer-by-layer movement of the interface. The thickness of amorphous layer of the sample without annealing increased as 7.79 nm per 1×10^{14} ions/cm^2 in contrast to the sample with annealing 4.82 nm, representing more rapid a/c interface movement in the sample without annealing than that with annealing.

I. Introduction

Ion beam induced epitaxial crystallization (IBIEC) and ion beam induced interfacial amorphization (IBIIA) are well known as the crystallization/amorphiza-tion processes using ion beam techniques at low temperatures. IBIEC and IBIIA are extensively studied on Si[2,3,6,7] but there were few studies on SiGe in spite of its usefulness such as high frequency devices[1]. Although IBIEC is widely studied[2-5], IBIIA is less studied than IBIEC, which the is reverse process IBIEC, where a/c interface moves toward the single crystalline substrate with the increase of amorphous layer. As far as we know, study on IBIEC in SiGe[4,5] existed but not on IBIIA in SiGe.

In this paper, we investigate IBIIA in SiGe, focusing on the effect of annealing before high energy irradiation for IBIIA.

[#] email : toshihide.kashiwagi.4z@stu.hosei.ac.jp

II. Experimental

Samples used were epitaxially grown (100) single crystalline SiGe on Si substrates containing 10% Ge with a thickness of 400 nm. The surface region of SiGe were amorphized by Ge ion bomardment to a fluence of 1×10^{15} ions/cm^2 at the energy of 200 KeV at room temperature. The bombarded sample was divided into two pieces: one was annealed in a N_2 ambient at 300℃ for 10 min and the other was not. Then the both samples were bombarded with Ge ions of the energy at 3.9 MeV at room temperature to fluences of 4×10^{14}, 7×10^{14}, 9×10^{14} ions/cm^2.

The crystallinity was analyzed by 1.5 MeV He^+ Rutherford back scattering (RBS) with channeling techniques. In order to detect the slight movement of a/c interface, the scattering angle was chosen as 120° to increase depth resolution.

III. Results & discussion

Figure 1 shows random and aligned RBS spectra from SiGe/Si samples with and without annealing in a N_2 ambient at 300℃ for 10 min after 200 keV Ge irradiation to a fluence of 1×10^{15} ions/cm^2. As shown in Fig. 1 the samples with and without annealing were amorphized to the depth of 230 nm. After annealing the a/c interface becomes sharper than before annealing. Figures 2 and 3 show random and aligned RBS spectra from the samples with and without annealing, respectively. These samples were irradiated to fluences of 4×10^{14}, 7×10^{14}, 9×10^{14} ions/cm^2 with Ge ions at the energy at 3.9 MeV at room temperature.

In these figures, aligned spectra did not reach to the random spectra corresponding to the amorphous region. The reason for the discrepancy was considered to be the geometry of the detector and the sample for the random spectrum measurement.

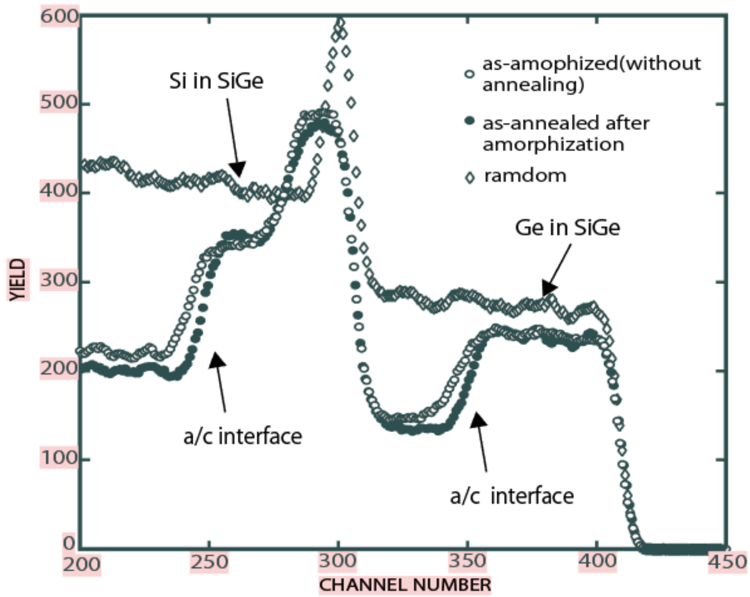

Fig. 1 Random and aligned RBS spectra from SiGe/Si samples amorphized by Ge irradiation with 200 keV to a fluence of 1 × 10^{15} ions/cm^2 at room temperature with and without post-annealing in a N_2 ambient at 300°C for 10 min.

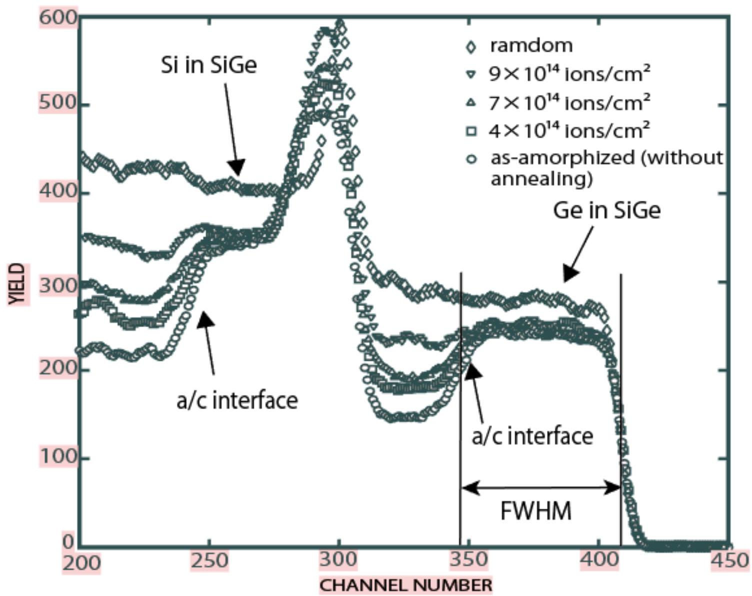

Fig. 2 Random and aligned RBS spectra from SiGe/Si samples without annealing before irradiation with 3.9 MeV Ge ions to fluences of 4 × 10^{14}, 7 × 10^{14}, 9 × 10^{14} ions/cm^2 at room temperature. Amorphous region width is evaluated from FWHM between leading and back edges of the aligned spectra corresponding to the amorphous region.

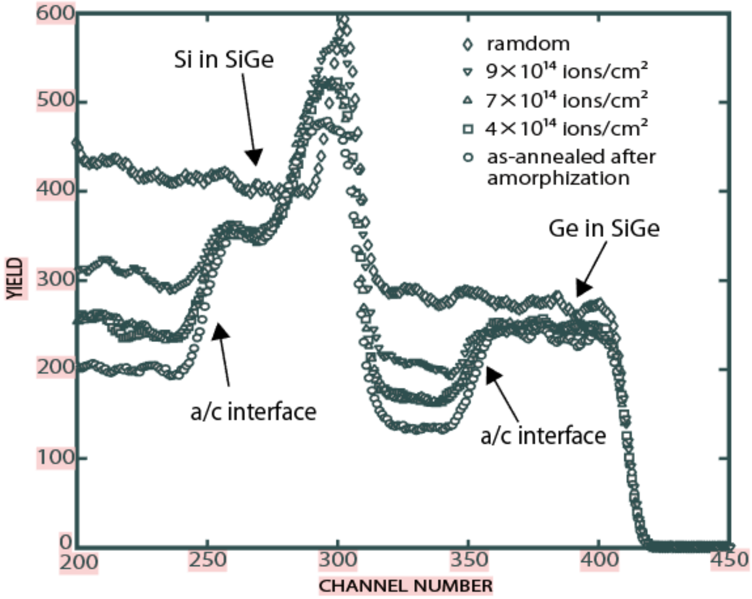

Fig. 3 Random and aligned RBS spectra from SiGe/Si samples with annealing before irradiation with 3.9 MeV Ge ions to fluences of 4×10^{14}, 7×10^{14}, 9×10^{14} ions/cm^2 at room temperature.

As shown in Fig. 2, the a/c interface moved towards lower channel numbers with increasing fluence, indicating that IBIIA occurred. As shown in Fig. 3, although the a/c interface similarly moved towards lower channel numbers, which indicated the occurrence of IBIIA, the movement was small compared to that found in the sample without annealing.

Figure 3 shows the amorphous region width of the samples with and without annealing as a function of Ge fluence. The width of the amorphous region is evaluated from the full width at half maximum (FWHM) between leading and back edges of the aligned spectra corresponding to the amorphous region.

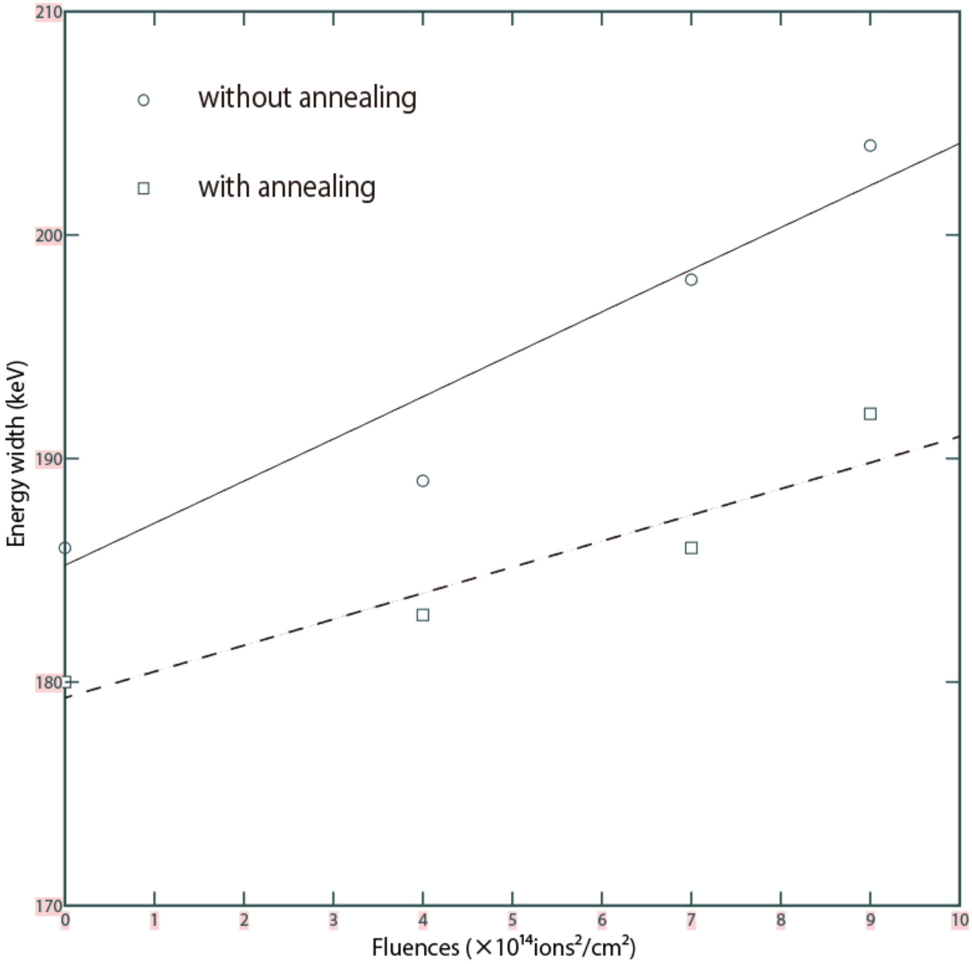

Fig. 4 The energy width of amorphous region evaluated from FWHM between edges corresponding to the surface and a/c interface as a function of Ge fluence. The solid line indicates the regression line of plots without annealing. The dashed line indicates the regression line of plots with annealing.

As shown in Fig. 4, linearity was seen in the both samples with and without annealing. The deviation in the sample without annealing at a fluence of 4×10^{14} ions/cm^2 was considered to be within the statistical fluctuation. The energy width of the amorphous region of the sample without annealing increased as 6.3 keV per 1×10^{14} ions/cm^2 and that of the sample with annealing 3.9 keV per 1×10^{14} ions/cm^2, which corresponded to 7.79 nm and 4.82 nm, respectively. From these result, pre-annealing made the increase of amorphous layer slow.

As previously shown the interface became flat by pre-annealing, therefore the change of roughness had effect on IBIIA. In other words, the roughness of the interface without annealing enhanced IBIIA.

IV. Conclusion

Ion beam induced interfacial amorphization (IBIIA) was observed in SiGe/Si samples which were bombarded with Ge ions to fluences of 4×10^{14}, 7×10^{14}, 9×10^{14} ions/cm^2 of the energy at 3.9 MeV at room temperature, with and without annealing in a N_2 ambient at 300℃ for 10 min after amorphization to the depth of 230 nm by Ge ion bomardment to a fluence of 1×10^{15} ions/cm^2 of the energy at 200 KeV at room temperature. RBS with channeling technique revealed that the a/c interface became flat after annealing, and also revealed that the movement of the interface of the sample with annealing was slower than that of sample without annealing. The thickness of amorphous layer of the sample without annealing increased as 7.79 nm per 1×10^{14} ions/cm^2 and that of the sample with annealing 4.82 nm. That is to say, the roughness of the interface without annealing enhanced IBIIA.

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