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Bias Dependent Reactions of a Si(110) Substrate on Irradiation of Hydrogen Plasma

水素プラズマ照射によるシリコン(110)基板相互反応のバイアス依存性

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It has been investigated hydrogen exposure process on Si(110) surface, with infrared absorption spectroscopy in multiple internal reflection geometry (MIR-IRAS). Infrared absorption spectra showed that inserting hydrogen in Si(110) result in the formation of amorphous layer. The kinds of the generated hydride components were changed with the exposure. The SiH was formed in the initial stage and the SiH_2 was formed in the latter stage.

1. Introduction

Silicon is indispensable in semiconducting materials and is used for a solar cell, LSI and so on. Hydrogen plasma is well known to modify the morphology, structure and properties of silicon materials. The interaction of hydrogen with c-Si surfaces gives rise to a large variety of phenomena, such as etching, vacancy-generation and so on. It is considered that the interaction is affected to several factors like substrate bias and temperature. Nevertheless, it is not fully understood how hydrogen plasma-induced reactions on Si crystal surfaces. In order to know the details of the plasma-surface interaction, we need to understand how hydrogen is inserted in Si surface and bulk Si. In this study, therefore, we used in situ and real time infrared reflection absorption spectroscopy (IRAS) in multiple internal reflection (MIR) geometry to investigate the interaction of hydrogen plasma and Si(110) surface with substrate bias.

2. Experiment

The system that we used in this study was a chamber equipped with an MIR-IRAS monitoring system, an inductively coupled plasma (ICP) source, and a gas delivery system, as is schematically illustrated in Fig.1. The Si prism used here was made of n-type Si(110) wafers. The prisms had a dimension of 0.5 × 10 × 40 mm, with mirror-polished 45° bevels on each of the short edges. RF plasma was generated by applying 13.56MHz RF power to a coil wrapped around a glass tube. Hydrogen plasma was generated by using 30W RF power at a hydrogen pressure of 50mtorr. The RF bias during plasma exposure was given by the high-frequency power source of 800 KHz. The silicon surface covered with a chemical oxide layer was used as the reference spectrum of all spectra in order to recognize the changed portion. The chemical oxide layer was produced in a boiled H_2O_2/H_2SO_4 solution.

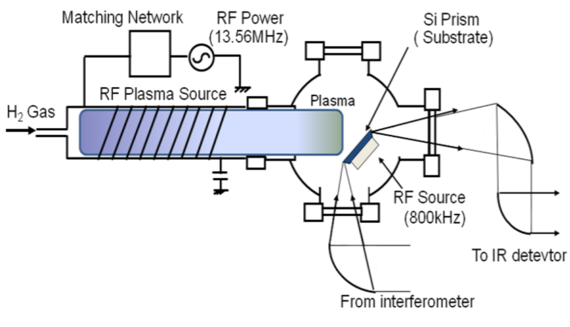

Fig.1 Experimental set up

3. Experimental results and discussion

Figure 2 shows infrared absorption spectra of Si(110) exposed hydrogen plasma with substrate bias, -200V. Each figure indicated the exposure time. These spectra showed that the peak intensity was increased with the exposure times, indicating that the hydride components were generated by the hydrogen plasma exposure. The peak located at

2030cm^{-1} was observed at low exposure reagion. The peak at 2100cm^{-1} was observed at the high exposure region. The peak position was changed with the plasma exposure. It means that the kinds of hydride components were changed with the hydrogen exposure. According to the previous reports, the peak at 2030cm^{-1} is assigned to a monohidride (SiH) component in amorphous silicon phase, that at 2100cm^{-1} is assigned to silicon dihidride (SiH_2) component in amorphous silicon phase. Then we can consider as follows: the silicon cyrstal was changed to amorphous layer to form SiH components in the Si by hydrogen plasma exposure with the substrate bias of -200V. The SiH components were hydrogenated to SiH_2 components by further exposure to the hydrogen plasma.

Figure 3 shows infrared absorption spectra of Si(110) exposed hydrogen plasma with substrate bias, which is respectively -50V, -100V, -150V and -200V. Because peak intensity is strong with increasing bias, hydrogen is easily introduced in Si(110) with substrate bias. In case of Si(110) applying substrate bias -50V and none, the reaction of Si(110) surface is the main, as the main peak is SiH. In case of -100V, -150V and -200V, the main peak is bulk-SiH_2. Therefore, the main reaction is the amorphous form.

4. Conclusion

We investigated the interaction of hydrogen plasma with Si(110), especially the effect of the applied substrate bias with infrared spectroscopy in multiple internal reflection geometry (MIR-IRAS). Infrared absorption spectra showed that inserting hydrogen in Si(110) result in the formation of amorphous layer. The kinds of the generated hydride components were changed with the exposure. The SiH was formed in the initial stage and the SiH_2 was formed in the latter stage.

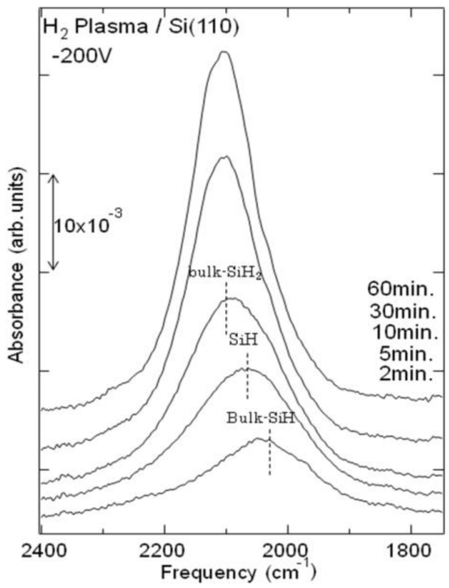

Fig.2 Infrared spectra of Si(110) surface exposed to hydrogen plasma with the substrate bias of -200V.

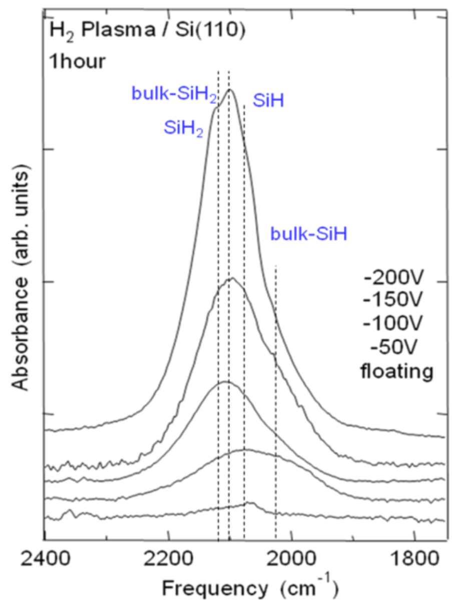

Fig.3 Infrared spectra of Si(110) surface exposed to hydrogen plasma with the substrate bias of floating, -50V, -100V, and -200V.

Acknowledgments

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