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Infrared Spectroscopic Study on Effects of Substrate Temperatures on Oxidation of Amorphous Carbon Films

酸素プラズマによるアモルファス炭素薄膜の酸化過程における基板温度依存性

Yuya TAKAKI[1], Kojiro HARA[2], Yoshiki TAKAMI[1]
Masanori SHINOHARA[1], Yoshinobu MATSUDA[1] and Hiroshi FUJIYAMA[1]
高木雄也[1]，原 幸治郎[2]，高見佳生[1]，篠原正典[1]，松田良信[1]，藤山 寛[1]

Graduate School of Engineering, Nagasaki Univ.[1], Graduate School of Sci. and Technol., Nagasaki Univ.[2]
1-14, Bunkyo-machi, Nagasaki 852-8521, Japan[1,2]
長崎大院工[1]，長崎大院生産[2]　〒852-8521　長崎市文教町1-14

Oxidation process of the amorphous carbon film deposition has been investigated, using infrared absorption spectroscopy in multiple internal reflection geometry (MIR-IRAS). Amorphous carbon film was oxidized by the exposure to oxygen molecules and oxygen plasma. We observed the decreases of the density of CH_X species, and the increases of those of OH species, with longer exposure to oxygen molecules. It means that the CH bonds were decomposed to form OH species. We also observed the temporal evolution of the OH peak due to oxygen plasma exposure. The results indicated that the carbon film was oxidized, and moreover the film was also evaporated with the longer exposure.

1. Introduction

An amorphous carbon film has frequently used in various fields because the films have a lot of useful properties: chemical inertness, mechanical hardness, smooth surface, and bio-compatibility. Moreover, the addition of other kinds of atoms induces the different film property. The film shows hydrophilic property if the oxygen atoms were inserted into the film, as a result, the films show hydrophilic property. Plasma oxidation is one of the effective oxidation methods. But there were not many reports on oxidation of amorphous carbon that relationship of substrate temperature related oxidation process and hydrophilic property. Furthermore, the detailed oxidation process of amorphous carbon was not sufficiently understood. We have investigated the oxidation process of amorphous carbon films due to oxygen plasma, with “in-situ” and “real time” infrared absorption spectroscopy in multiple internal reflection geometry (MIR-IRAS). In this paper, we report the effect of the substrate temperature on the plasma oxidation of the amorphous carbon films.

2. Experiments

Figure 1 shows the experiment system. The PECVD chamber was equipped with an MIR-IRAS monitoring system. The substrate was heated with resistive heater. The Si prisms were made of n-type Si (100) wafers. The prisms had a dimension of 0.5×10×40mm, with mirror-polished 45° bevels on each of the short edges. Amorphous film was deposited with methane plasma. Oxidation of the film was performed with oxygen plasma. All spectra were recorded at 4cm^{-1} resolution. The reflection spectrum of the as-deposited film was used as the reference spectrum of all spectra, in order to recognize the changed portion due to the oxygen plasma exposure.

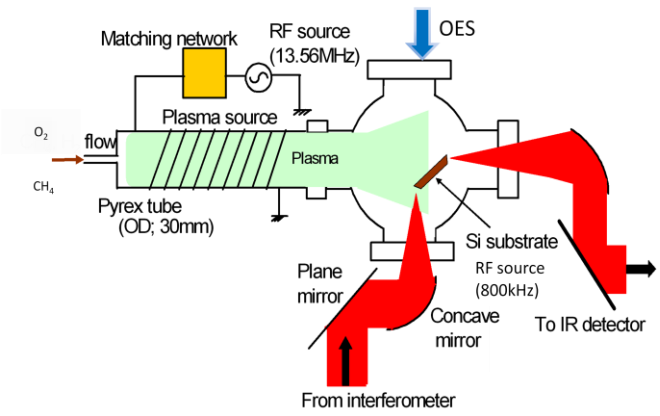

Fig. 1 Experiment System

3. Results and Discussions

Figure 2 shows the initial oxidation process of the amorphous carbon film due to the exposure to oxygen plasma. The carbon film was polymer-like structure, because the film was deposited using acetylene plasma without substrate bias. The flow rate of oxygen molecules was 2sccm, and the gas pressure was 6.7 Pa.

In this graph, each spectrum was deduced by using the spectrum of the as-deposited amorphous carbon film as a reference spectrum. Thereby, the changed portions due to oxidation can be deduced from the as-deposited amorphous carbon film. The infrared spectra have several broad peaks. In this research, we pay attention to two peaks: one is located between 2,800 and 3,000cm^{-1}, the other is located between 3,000 and 3,400cm^{-1}. The former is assigned to C-H mode, and the latter is assigned to O-H mode. The results showed that the quantity of OH-group in the amorphous carbon film was decreased, on the contrary to the increases of the substrate temperatures.

Moreover, Table 1 shows the contact angle of the substrate which was measured using a stylus step height meter. From the result, it is found that the substrate at room temperature is maintained hydrophilic property. The contact angle was increased with the substrate temperature. These results indicate that changes in OH-group have a close relationship with hydrophilic functionality.

4. Conclusion

We investigated the effects of substrate temperature on the oxidation of an amorphous carbon film, with the infrared spectroscopy in multiple internal reflection geometry (MIR-IRAS). The infrared spectra indicate that the quantity of OH group in the film was decreased, on the contrary to the increases in substrate temperatures.

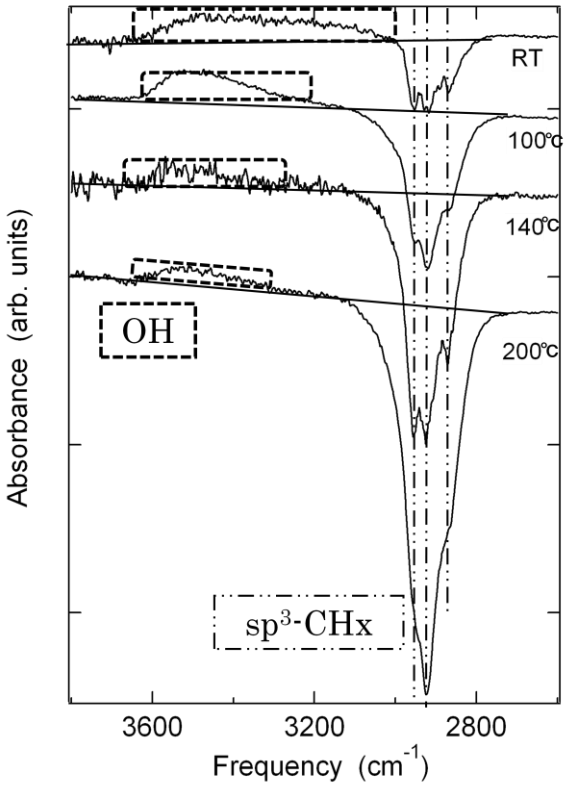

Fig.2 IRAS spectra of oxidation of an amorphous carbon film at different temperatures.

Table.1.Contact angle of the substrate

Temperature(℃)	RT	100	140	200
Contact Angle(°)	7.0	13.2	35.1	47.2

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