Effects of hydrogen plasma exposure on amorphous carbon film surface, investigated with infrared spectroscopy

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Abstract

Effects of hydrogen plasma exposure on amorphous carbon film were investigated with infrared absorption spectroscopy in internal reflection geometry (MIR-IRAS). After the amorphous carbon films were deposited using acetylene plasma, the films were exposed to deuterium plasma. The data indicate that the deuterium radicals were adsorbed on the amorphous carbon film with exchange of the hydrogen.

Introduction

An amorphous carbon film is used in various fields, because the film has unique properties, such as chemical inertness, mechanical hardness, smooth surface, and so on. The film can be deposited at low temperatures using plasma enhanced chemical vapor deposition (PECVD) process. It is well known that hydrogen plays an important role in CVD process, including PECVD process. The details have not been adequately understood. Then, we investigate the hydrogen exposure effects on amorphous carbon films, by using “in-situ” “real-time” infrared absorption spectroscopy in multiple internal reflection geometry (MIR-IRAS) in this study. Deuterium plasma was used for distinguish the hydrogen exposure effects, since C-D and C-H vibration region are in different wavenumers.

Experiments

A stainless-steel chamber was used in this study. It was equipped with an IRAS monitoring system, a radio frequency (RF) plasma source, and a gas-delivery system, as is schematically illustrated in Fig. 1. After amorphous carbon films were deposited using acetylene plasma, the film was exposed to deuterium plasma. Deuterium plasma was generated using 20W-RF power at an acetylene pressure of 50 mTorr. The gas-flow rate was set at 1 sccm. To investigate deuterium radical effects, substrate bias was not

applied; on the other hand, to investigate the deuterium ion effects substrate bias of –150 V was applied.

Results and Discussions

Figure 1 shows the infrared spectra of deuterium radical exposure effects on the amorphous carbon film. Theses spectra also acquired using the spectrum of the as-deposited carbon film as the reference spectrum. Thereby, the changed portions can be deduced. The infrared spectra showed the decreases of intensity of the C-H vibration region located between 2800 and 3000 cm^{-1}, with the longer exposure to deuterium plasma; on the other hand, the spectra showed the increases of intensity of the C-D vibration region located between 2000 and 2700 cm^{-1}. Especially, the large sp-CD peak was observed. It indicates that the deuterium radicals were adsorbed on the amorphous carbon film with the abstraction of the hydrogen in the film.

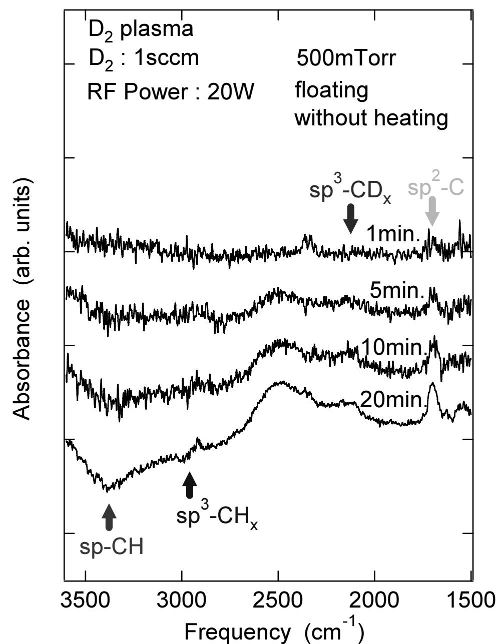

Fig. 1. IRAS spectra of hydrogen plasma exposure effects on an amorphous carbon film

Conclusions

We investigated the hydrogen plasma exposure effect on amorphous carbon film, using infrared spectroscopy in multiple internal reflection geometry (MIR-IRAS). The data shows that the intensity of the C-D peak was increased with the exposure; on the other hand, the intensity of the C-H peak was decreased. It indicates that hydrogen radicals were adsorbed on the amorphous carbon film.

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