Substrate Bias Effect on Deposition Process of Amorphous Carbon Films

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Abstract
Substrate bias effects on the deposition process of amorphous carbon films were investigated by using infrared spectroscopy in multiple internal reflection geometry (MIR-IRAS). The density of the sp-CH species was increased in amorphous carbon films with substrate bias; on the other hand, the density of the sp³-CHX (X=1~3) species was decreased in amorphous carbon films with substrate bias.

Keywords:
Acetylene plasma, Amorphous carbon film, Deposition process, Infrared spectroscopy, Substrate bias

Introduction
An amorphous carbon film has been one of promising materials because it has unique properties such as mechanical hardness, chemical inertness, bio-compatibility, and changeable electrical property. Additionally, it can be synthesized at low temperature by plasma process. So, it is widely used in the industry. Now, it is often deposited by using acetylene (C₂H₂) gas as a source gas. To obtain the desirable film properties, it is important to control the film deposition process. Then, the deposition process has to be understood. In fact, the detailed deposition has not been understood, because there are a lot of parameters in this process. One of important process parameters is substrate bias. We have investigated the substrate bias effect on deposition process of amorphous carbon films by using infrared spectroscopy in multiple internal reflection geometry (MIR-IRAS).
Experiments
We observed deposition process of amorphous carbon films by using “in-situ” and “real time” infrared spectroscopy in multiple internal reflection geometry (MIR-IRAS). The film thickness during deposition was estimated from the deposition rate. The film deposition rate was calculated from the deposition time and the thickness after the deposition measured with the profilemeter. Plasma was generated by 13.56 MHz RF power. The substrate bias was fed by 800kHz RF power.

Results and Discussions
Compared the substrate bias of 0V with that of –200V, we observe a similar spectra when the film thickness is 1nm. As the film grows thicker, the deference grew larger. At the substrate bias of 0V, the intensity of the peak around 2900cm⁻¹, which corresponds with the sp³-CHₓ species, was increased more than that of the peak located around 3360cm⁻¹, which corresponds with the sp-CH species. On the other hand, at the bias of –200V, the peak intensity of the sp-CH and that of the sp³-CHₓ grew at almost the same rate.

This phenomenon is considered as follows: at the bias of 0V, the sp-CH deposited on the film reacts with H species in plasma. Then, the density of the sp³-CHₓ species was increased. On the other hand, at the bias of –200V, in addition of this effect, the effect of drawing the sp-CH species into the film grew also larger.

Conclusions
Substrate bias effects on the deposition process of amorphous carbon films have been investigated by using infrared spectroscopy in multiple internal reflection geometry (MIR-IRAS). Owing to the substrate bias, the density of the sp-CH species was increased in amorphous carbon films.

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