Substrate Bias Effect on Deposition Process of Amorphous Carbon Films

Takanori Inayoshi[1], Hiroki Kawazoe[1], Masanori Shinohara[2]*
Yoshinobu Matsuda[2], Hiroshi Fujiyama[1], Yuki Nitta[3] and Tatsuyuki Nakatani[3]
[1]*Graduate School of Science and Technology, Nagasaki University*
[2]*Department of Electrical and Electronic Engineering, Nagasaki University*
1-14 Bunkyo-machi, Nagasaki 852-8521, Japan
[3]*Toyo Advanced Technologies Co., Ltd.,*
5-3-38 Ujina-higashi Ninami-ku Hiroshima, 734-8501, Japan.
*E-mail: sinohara@nagasaki-u.ac.jp

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 sp^3-CH_X (X=1～3) species was decreased in amorphous carbon films with substrate bias.

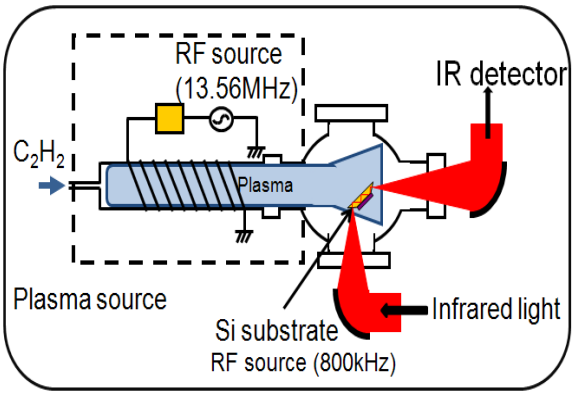
Keywords:
Acetylene plasma, Amorphous carbon film, Deposition process, Infrared spectroscopy, Substrate bias

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 (C_2H_2) 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 inportant 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 sp^3-CH_X 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 sp^3-CH_X 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 sp^3-CH_X 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.

Acknowledgements

This research was partially supported by a Grant-in-Aid for Young Scientists (A), No. 20684027 (2008-2011) from the Ministry of Education, Culture, Sports, Science and Technology (MEXT) of Japan