Monitoring of Chemical Vapor Deposition Process of Hydrocarbon Thin Films by Optical Reflectance Interferometry

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Abstract

Optical reflectance interference has been investigated during the deposition processes of hydrocarbon thin films. A clear oscillation in the laser power reflected from the substrate has been observed during the deposition. From the instantaneous oscillation amplitude, temporal change in the refractive index was evaluated.

Introduction

The chemical vapor deposition (CVD) of hydrocarbon thin films including DLC films have been well established and widely used in many variety of industry so far. [1] It will be useful to establish an inexpensive and handy in-situ monitoring method. For the purpose, we have focused attention on the optical reflectance interference [2] using a small power cw laser. In this paper, experimental results of measurement of reflectance interference signal during CVD processes of hydrocarbon thin films are presented. In addition, possibility of in-situ monitoring of deposition rate and refractive index are discussed.

Experimental

A single turn coil antenna with a diameter of 100 mm was arranged in the middle of the chamber to excite the inductive RF discharge. After the chamber was evacuated down to a pressure less than 3×10^{-6} Torr, working gases were introduced by mass flow controllers at the total flow rate of 10 sccm and the total working pressure was set at 5 mTorr. For the chemical vapor deposition of hydrocarbon thin films, mixed gas of 50 % argon and 50 % methane was used in 13.56MHz inductively coupled plasma.

To monitor the reflectance interference, 1 mW He-Ne laser beam was incident onto a polished surface of Si (001) substrate attached on a substrate holder located 5 cm behind the ICP center. The geometry was approximated to vertical incidence. Reflected beam was focused by a lens on the sensing area of a photodiode. Temporal change of the photodiode output was displayed and recorded on a PC.

Results and Discussion

Figure 1 shows the temporal variation of photodiode output during hydrocarbon film deposition by Ar/CH_4-ICP. The exact, integrated deposition time was 1866*s*. The film thickness after the deposition was measured by a stylus profiler. As a result, film thickness was found 2.8μm. In addition, the averaged refractive index of the deposited thin films was calculated as 1.7. This value is lower than the reported refractive indices for DLC films (1.8-2.4) which are usually fabricated with high substrate bias more than 100V, but corresponds to the values of hydrogenated carbon films fabricated under low substrate bias.

Here, we will make analysis by assuming the deposition rate is constant. By comparing the experimental instantaneous values read over each oscillation period, we can obtain the instantaneous refractive index at each different local minimum point. In addition, the experimental increment of optical path length over the oscillation period Δ was read at each different local minimum point. Evaluated n_1 and Δ are plotted in Fig. 2. Figure.2 shows the instantaneous refractive index decreased from 2.0 to 1.3 during deposition. It is noted the calculated $2n_1\ \Delta$ is close to the laser wavelength λ=632.8 nm over the entire deposition time.

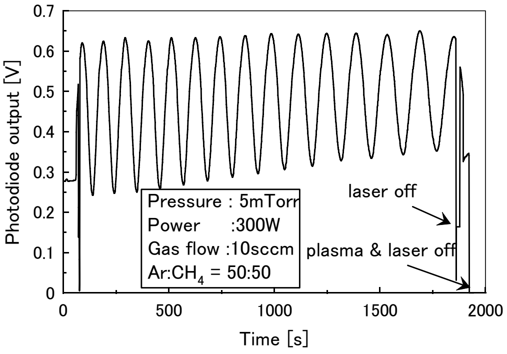

Fig. 1 Temporal variation of photodiode output during hydrocarbon film deposition

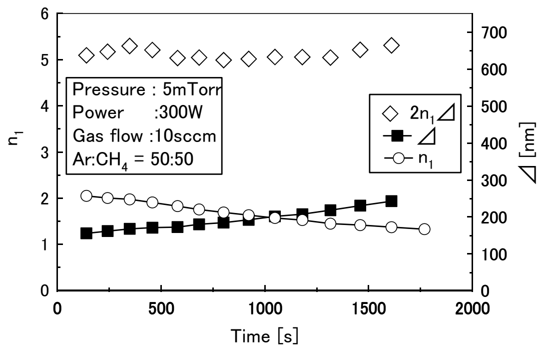

Fig. 2 Temporal variations of refractive index and the instantaneous increment

Conclusions

Deposition process of hydrocarbon films was investigated by optical reflectance interference. By using several assumptions, temporal change in refractive index during deposition was obtained. It has to be cross-checked, but this technique has a potential for a simple process monitor.

References

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