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表面波プラズマによる電気伝導性炭素膜の高速及び大面積堆積
High speed and wide area conductive carbon film deposition by surface-wave plasma

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1. Introduction

Plasma-enhenced chemical depositon (PECVD) is widely used to deposit various types of carbon films from diamond-like to graphite. Graphite films have been given attention as conductive coating film to protect metal surface from corrosion. However, deposition rate of the graphite film is rather low (<1 nm/s)[1] and higher deposition rate are required for its industrial application.

In this study, conductive carbon film deposition at high deposition rate is investigated using high-density microwave plasma, *i.e.*, surface wave plasma (SWP), and high negative bias voltage to the depositing film. Film properties such as electrical doncuctivity and hydrogen content are measured as a function of the bias voltage.

2. Experimental Setup

A vacuum chamber (width 50 cm, height 26cm, depth 16 cm) is equipped with a slotted waveguide and a quartz plate, and is evacuated (<0.1 Pa) by a dry pump. N-doped (100) silicon (15 cm width, 10 cm height) is placed on a water-cooled stage facing to the quartz plate. High voltage negative pulse (<2 kV) is applied to the stage. Argon and benzene gases are introduced to the vessel through mass flow controllers at a total pressure of ~ 13 Pa. The SWP is produced by microwave power (2.45 GHz, 1.3 kW). The substrate is pre-sputtered with argon plasma in order to remove native oxide layer of the silicon substrate before the deposition. Carbon film is deposited with different negative bias voltages. Carbon film thickness (~400 nm) is measured by a surface profiler. From the film thickness and deposition time, deposition rate was obtained and high deposition rate (~6 nm/s) was obtained. Conductivity of the film is measured by four terminal method. Hydrogen (H) content of the deposited film is evaluated by infrared absorption spectroscopy from C-H stretching mode absorption at ~3000 cm^{-1}.

3. Results and Discussion

Electrical conductivity was measured varying the bias voltage and increase of the electrical conductivity up to ~250 $\Omega^{-1}cm^{-1}$ was observed at higher bias voltages. Spatial uniformity of the electrical conductivity within 20 cm was also confirmed. Figure 1 shows H content as a function of the bias voltage. The H content monotonically decreases with the bias voltage and is less than $0.4x10^{22}$ cm^{-3} at a bias voltage of 1.95 kV. It is known that sp^2 structure critically influences electrical property and impingement of high energy ions increases sp^2 structure with breaking C-H bonds.[2] The result shows reduction of C-H bonds and suggests increase of sp^2 bonds in the film.

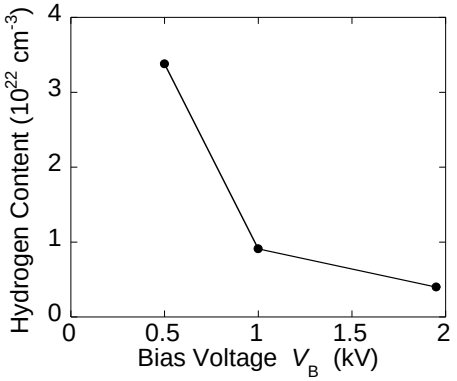

Fig. 1. Bias voltage dependence of H content.

4. Summary

Using the SWP and high negative bias voltage, high conductive carbon film was successfully deposited with high deposition rate. The conductivity increase was promoted presumably due to the sp^2 bond increase and the H content decrease.

References

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