ECR プラズマを用いた高伝導性カーボン薄膜成膜

High conductive carbon film deposition by electron cyclotron resonance (ECR) plasma

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1. Introduction

High conductive carbon film is attractive material because of its characteristics, such as high electrical conductivity, high thermal conductivity, protection of corrosion and so on. So far, various conductive carbon film deposition techniques have been reported such as physical vapor deposition (PVD), chemical vapor deposition (CVD) or plasma-enhanced chemical vapor deposition (PECVD). Among them, PECVD has achieved the highest deposition rate, but its value is less than 1 nm/s [1]. To enhance the deposition rate, high-density plasma source is required. In our previous work, high speed deposition of conductive carbon film is introduced with microwave-excited surface-wave plasma (SWP) [2].

In this study, electron cyclotron resonance (ECR) plasma which can produce higher plasma densities of ~1x10^{18}/m^3 is introduced for carbon film deposition.

2. Experimental setup

A vacuum chamber (50×26×16 cm^3) equipped with a slotted waveguide and a quartz plate is evacuated by a dry pump less than 0.1 Pa. Argon (65 sccm) and benzene (50 sccm) are introduced at a working pressure of 13 Pa. Magnets (surface magnetic flux: ~570 mT) are located on the backside of the quartz plate. Electron cyclotron resonance (ECR) plasma is generated on ECR zone (87.5 mT) near quartz surface by applying microwave power (2.45 GHz, 1.3 kW) to the waveguide. N-doped silicon (100) substrates those are cleaned by an ultrasonic cleaner with acetone are placed on a stage surface. Negative pulse bias voltage (0 ~ 1.75 kV) is applied to the stage. Deposition rate and electrical conductivity of deposited carbon film are investigated by a step profiler, and four-terminal sensing, respectively.

3. Result and discussion

Carbon films are deposited at negative bias voltages (V_B) from 0 to 1.75 kV. Fig. 1. shows comparison of sheet resistance of deposited films between the SWP plasma and the ECR plasma. The sheet resistance decreases with increasing the bias voltage. Surface resistance of carbon film by the SWP decreases at $V_B \geqq 1.2$ kV. On the other hands, surface resistance of the film deposited by the ECR plasma decreases at $V_B \geqq 0.8$ kV. Sheet resistance is related to sp^2 content in the carbon film. The result suggests that the carbon film deposited by the ECR plasma has higher sp^2 content ratio compared with the case of the SWP at the same bias voltage.

Different bias voltage dependence of the film resistivity between the SWP and the ECR plasma cases is presumably due to the difference of the plasma characteristics. Temporal bahavior of the emission intensity and plasma density are measured by optical emission spectroscopy and Langmuir probe. In the presentation, detailed measurement of the plasma density and influence of the pulse bias application to the plasma density will be discussed.

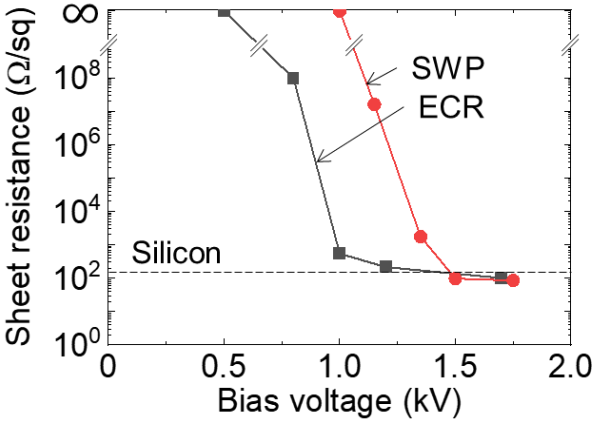

Fig.1. Bias voltage dependences of the film sheet resistance for SWP and ECR plasma depositions.

Reference

[1] Golap Kalita et al., RSC Adv, **2**, 3225 (2012).
[2] Hansin Bae et al., The 68th JSAP Spring Meeting 2021, 18a-Z17-5.