초기 플라즈마 방전에 미치는 RF 방전전압 변조의 영향

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Effect of Amplitude Modulation on Initial RF Plasma Discharge

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1. Introduction

Silicon clusters in silane discharges are mainly responsible for degradation of amorphous silicon thin films. In a RF glow discharge in SiH_4 there are many chemical and physical processes that may affect the deposited film quality. High energy electrons accelerated by the electric field cause initial ionization and dissociation of SiH_4, whereas low energy electrons may attach to neutral species that are trapped in the plasma potential. These reactive species form stable higher order silane that eventually agglomerates into silicon clusters or particles. Most of the silicon particles suspended in the plasma collect negative charge in the discharge and thus are trapped there. However, statistical charge fluctuations will neutralize some of them, and they escape from the discharge and deposit onto the growing film. In the present paper, we report the effects of sine-wave AM especially on initial phase of silane discharge using optical emission spectroscopy (OES).

2. Experimental details

The multi-hollow CVD reactor is consists of stainless steel chamber with optical ports for spectroscopic observations, and contains three multi-hollow electrodes (43 holes, 5mm diameter); one powered electrode is sandwiched between two grounded electrode as described in elsewhere. Plasma was generated by an excitation frequency of 60 MHz. Discharge voltage was modulated to 10 kHz. Silane gas was introduced into the vacuum chamber through gas inlet line located above power electrode. The working pressures in vacuum chamber are 0.5 Torr at a silane flow rate of 30 sccm. Details of the instrumentation on multi-hollow plasma discharge CVD described in elsewhere. Optical emission spectroscopy was carried out to obtain information on initial discharge. The measurements were made from a view-port installed upper side of the deposition reactor.

3. Results and discussion

Time evolution of optical emission intensities Si* and SiH* for AM level 0-30%. Time-resolved Si* intensities for AM 0% is almost constant, whereas SiH* intensities gradually increase during 50 s and saturate. However, when AM level is 10-30%, Si* and SiH* intensities increase rapidly for initial 20s and then decreases until 70s. These results indicate that generated species are changed in initial phase of discharge due to AM.

Time evolution of intensity ratio of I_{Si*}/I_{SiH*} provides information on the slope of high energy tail of electron energy distribution function (EEDF) in the plasmas. Namely, the higher intensity ratio of I_{Si*}/I_{SiH*} means longer high energy tail of EEDF corresponding to “high electron temperature”. I_{Si*}/I_{SiH*} gradually decreases with the discharge time. Time evolution of I_{Si*}/I_{SiH*} for AM level 0-30% shows almost similar trends. These results suggest that amplitude modulation affects more generation rate of radicals than electron temperature.

4. Summary

We have investigated effects of AM on initial phase of rf discharge plasmas. Amplitude modulation significantly affects on initial rf discharge plasmas.

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