6th Asia-Pacific Conference on Plasma Physics, 9-14 Oct, 2022, Remote e-conference

Control of Growth of Nano-particles and Properties of SiO2 Films with Amplitude Modulated Discharge in TEOS-PECVD

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1. Introduction

As the global semiconductor market expands, the demand for technology in plasma processing of semiconductor is increasing. In recent years, TEOS (Tetraethyl orthosilicate) is often used as a material gas for fabrication of SiO_2 insulating film [1]. The insulating film formed by TEOS plasma enhanced CVD has excellent electrical characteristics [2] and has good step coverage [3]. The AM modulation discharge method has been confirmed to suppress nanoparticle growth [4]. However, there are few reports of the effect of AM-modulated discharge on the growth of nanoparticles in TEOS plasma. In this study, we investigated the effect of AM-modulated discharge on nanoparticle growth and the relationship between nanoparticle growth and plasma.

2.Experimental

Experiments were performed using a capacitively coupled reactor [4, 5]. A powered electrode with a diameter of 60 mm was installed at the top, and a ground electrode with a diameter of 60 mm was installed at the bottom, and the distance between the electrodes was 6 mm. TEOS, O_2, and Ar were used as the gas, the flow rates were 50 sccm, 200 sccm, and 225 sccm, and the pressure was 6 Torr. The RF power was 30 W, and the RF frequency was 13.56 MHz. For AM discharges, the discharge voltage V_{pp} was modulated with a sine waveform having a modulation frequency f_{AM} of 10 Hz.

The 2DLLS (two dimensional laser light scattering) method [4-7] was used to obtain nanoparticle information. In this method, a sheet-shaped laser beam having a wavelength of 532 nm is irradiated between the electrodes, and scattered light of nanoparticles is observed with a high-speed camera (Photron 1000fps). The LLS intensity, which is nanoparticle scattered light, is proportional to the nanoparticle density n_p and size d_p to the sixth power ($\sim n_p d_p^6$) in the Rayleigh scattering regime. In this study, in order to clarify the relationship between nanoparticle growth and plasma, LLS (532 nm) intensity and ArI (750.4 nm) emission intensity were measured simultaneously using two high-speed cameras.

3.Results and Discussion

Fig. 1 shows the AM modulation level dependence of the LLS intensity profiles. This result shows LLS intensity decreases as AM level increases and there is a strong peak near the RF powered electrode. This indicates that nanoparticles are generated near the RF powered electrode. Under the conditions of AM modulation level of 30% and 50%, the width of the LLS intensity distribution widens toward the RF powered electrode. This suggests that the generated nanoparticles oscillate in the z-direction between the electrodes, and the larger the AM modulation level, the larger the oscillation length. The details will be presented at the conference.

Acknowledgements

This work was partly supported by JSPS KAKENHI (Grant No. JP20H00142) and JSPS Core-to-Core Program (Grant No. JPJSCCA2019002).

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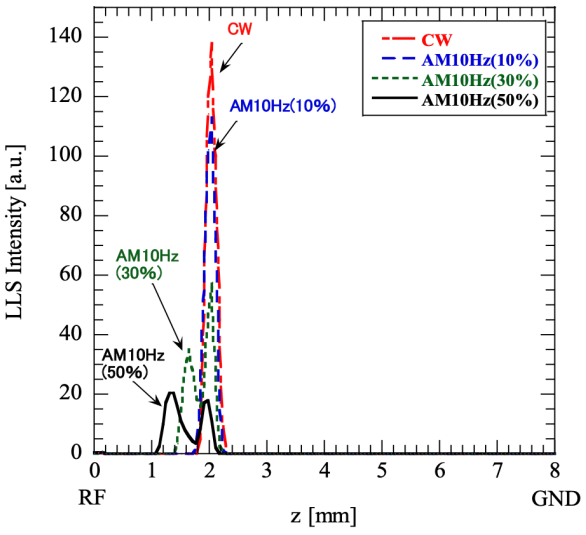

Fig.1 Amplitude modulation level dependence of z profile of the LLS intensity.