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Suppression of nanoparticle growth in TEOS plasma by amplitude modulation discharge method

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1.Introduction

Today, semiconductors are used in a wide variety of applications and have become an integral part of our daily lives. With the growing demand for IoT (Internet of Things), the semiconductor market will grow steadily in the future [1]. Such growth requires advances in plasma processes for semiconductor fabrication. There is, for instance, a strong demand for plasma CVD of good film quality with a high deposition rate. Nanoparticle formation in CVD plasmas is one major obstacle fulfil the demand.

TEOS (tetraethyl orthosilicate) [2] is often used as a material gas for semiconductor SiO_2 insulating films. Insulating films formed with TEOS have excellent electrical properties [3] and good step coverage [4].

The AM modulated discharge method has been shown to suppress growth of nanoparticles in SiH_4 CVD plasmas [5]. There are few reports on effects of AM modulated discharge on nanoparticle formation in TEOS plasmas. Here we investigated the effects and relationship between nanoparticle growth and TEOS plasmas.

2.Experimental

Experiments were performed using a capacitively coupled reactor [5,6]. An RF 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.

2DLLS (two dimensional laser light scattering) method [7,8] 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 1000 fps). 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 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

Figure 1 shows AM modulation level dependence of the LLS intensity interelectrode profile. Under all conditions, there is a strong peak near the RF 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 direction between the electrodes, and the larger the AM modulation level, the larger the oscillation width. The details will be presented at the conference.

Acknowledgements

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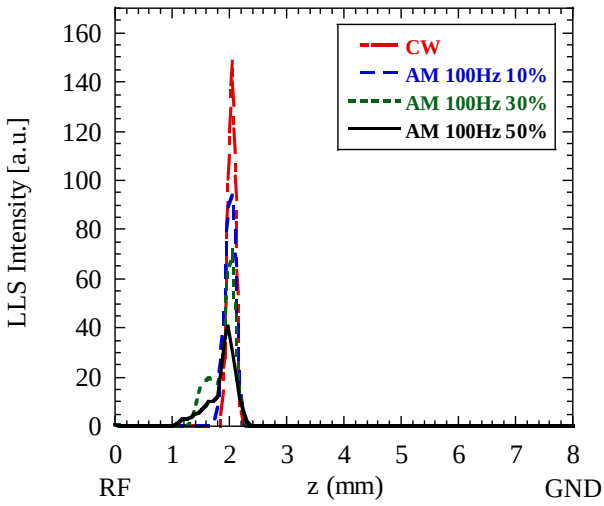

Fig.1 Amplitude modulation level dependence of the LLS intensity interelectrode profile.