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Impact of Amplitude Modulation of RF Discharge Voltage on the Spatial Profile of Nanoparticle Characteristics in Reactive Plasma

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1. Introduction

Plasma process technology plays a vital role in the applications of nanotechnology in numerous industrial and engineering areas such as 3D nanodevice fabrication [1]. For faster development of ultra-precision nano-fabrication methods, effects of plasma fluctuations in reactive plasma must be taken into account, since plasma fluctuations affect the growth of nanostructures [1, 2]. In our previous research [3], we clarify the spatial structure of density fluctuation of nanoparticles, as nanostructures formed in reactive plasmas, using an envelope analysis, an amplitude modulation (AM) method together with a two-dimensional laser-light scattering (2DLLS) method [4].

In this paper, we report the relationship between the spatial profile of density fluctuation of nanoparticle and the nano-particle size and density in order to clarify the impact of the plasma fluctuation on the spatial structure of nanoparticle characteristics in reactive plasma.

2. Experimental

Experiments were performed using a capacitively-coupled rf discharge reactor with a 2DLLS system. A powered disc electrode with a diameter of 60 mm and a thickness of 1mm was set 20 mm below an upper grounded electrode with a diameter of 60 mm as shown in figure 1(a). $Si(CH_3)_2(OCH_3)_2$ gas was supplied to the reactor at a flow rate of 0.2 sccm, diluted with Ar at a flow rate of 40 sccm. Total gas pressure was 166Pa. The rf discharge power was 30W and rf frequency was 60 MHz for a discharge period of T = 8s.

The spatial profile of the size and density of nanoparticles was measured using the 2DLLS method combined with a simple method for deducing their size and density form their thermal coagulation after the discharge was turn off [4,5]. The LLS intensity is proportional to nanoparticle density n_p and the sixth power of size d_p ($n_p d_p^6$).

3. Results and Discussion

Figure 1(a) shows spatial profiles of intensity of LLS fluctuation of 100 Hz components at T = 4 s after discharge was turn on. Strong fluctuations of LLS intensity of 100Hz components appear around the edge of rf electrode mainly during the discharge. Figures 1(b) and (c) show the density of nanoparticle with AM (f_{AM}=100 Hz, AM level=30%) and without AM at T = 8 s. These results show the spatial density profile tends to be uniform with AM. Especially, the density near the edge region of electrode increase with AM. The spatial LLS fluctuations of 100 Hz components have influence on the spatial profiles of nanoparticle nucleation and growth.

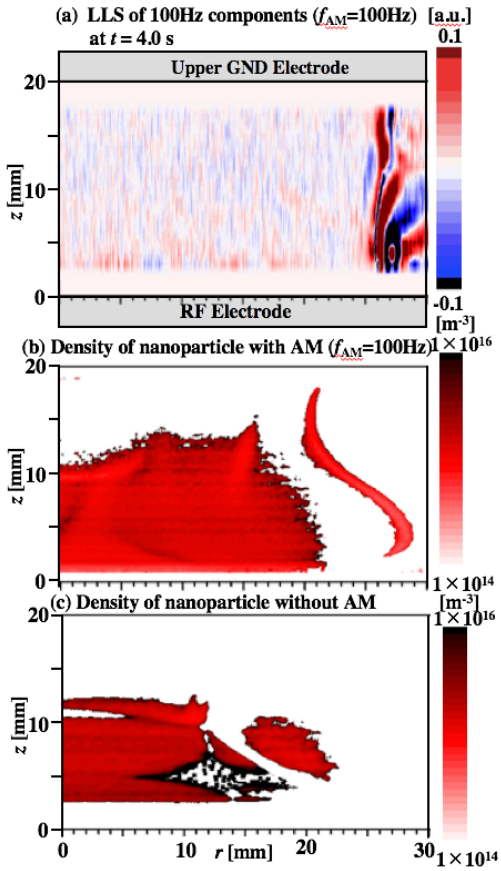

Figure 1 Spatial profiles of (a) intensity of LLS fluctuation of 100 Hz components at T = 4 s after discharge was turn on, (b) density of nanoparticle with AM(f_{AM}=100 Hz, AM level=30%) and (c) without AM at T = 8 s.

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