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Spatial-Structure of Density Fluctuation of Nanoparticles in Amplitude Modulated Capactively Coupled Plasma

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1. Introduction

Plasma processing is the main technology driver of "3D power scaling" for semiconductor devices [1]. Interaction fluctuations between reactive plasma and nanostructures have a great influence on such 3D nanodevice fabrication. With the increase of the number of stacked layers of 3D nanodevices, it is very important to understand and control the interaction fluctuations [2]. In this research, we analyze the spatial structure of density fluctuation of nanoparticles in reactive plasmas.

2. Experimental

We employed a capacitvely coupled plasma CVD reactor. DM-DMOS ($Si(OCH_3)_2(CH_3)_2$) and Ar gas were supplied into the reactor at a flow rate of 0.2 sccm and 40 sccm. Respectively, the total pressure was 1.25 Torr. The RF discharge frequency and power were 60MHz and 30W. The discharge voltage was modulated at a frequency of 100Hz and the modulation level of 30% to perturb the plasma [3]. Nanoparticles were detected using a two-dimensional laser light scattering (2DLLS) system employed with a high-speed camera [3]. The discharging period was 8 s.

3. Results and discussion

In our previous study [4], we applied envelop analysis to extract interaction fluctuation between plasmas and nanoparticles from the 2DLLS intensity fluctuation. Figure 1 shows spatial profiles of LLS fluctuations of (a) 100 Hz, and (b) 300 Hz components at 3.0 s after the discharge ignition. There are strong interaction fluctuations at *r* from -30 mm to -20 mm, where corresponds to the edge of RF electrode. We measure the wavelength of the LLS fluctuation of 100, 200, 300, and 400 Hz components around z = 13, 10, and 7mm at these areas, as shown in the figure 1. The relationship between the frequency and the wavelength is shown in Fig. 2.

With increasing the frequency, the wavelength tends to decrease, or the wavenumber tends to increase. The results suggest the density fluctuations are governed by the same dispersion relation.

References

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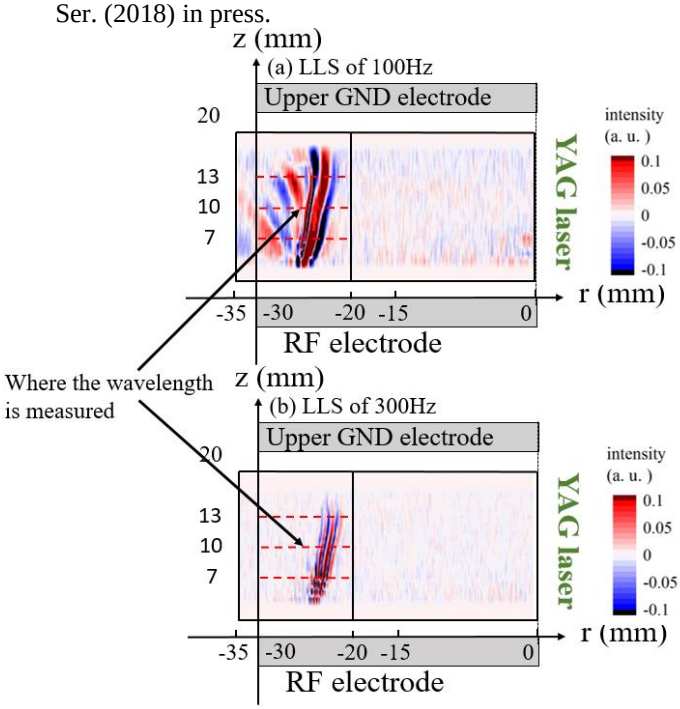

Figure 1. Spatial profiles (*r* from -35 mm to 0 mm) at 3.0 s after discharge of LLS fluctuations of (a) 100 Hz components, and (b) 300 Hz components.

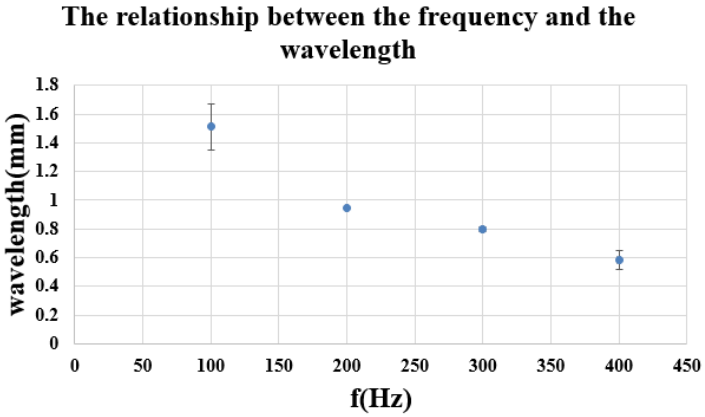

Figure 2. The relationship between the frequency and the wavelength of density fluctuation of nanoparticles.