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ナノ粒子成長に対するプラズマ摂動周波数の効果
Effects of Plasma Fluctuation Frequency on Nanoparticle Growth

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In plasma processing in a nanometer size range, size and properties of the nanoproducts are fluctuated due to fluctuation of interactions between plasmas and nano-materials. To study such interaction fluctuation, we have employed nanoparticles grown in reactive plasmas. We have found the conditions of the transition from CVD growth to agglomeration growth of nanoparticles [1]. For the CVD growth, nanoparticles of high density can exchange information through radicals. We have theoretically predicted coupling between radicals and nanoparticle growth [2]. Here we study effects of plasma fluctuation on nanoparticle growth using a capacitively coupled discharges with amplitude modulation (AM).

Experiments were carried out using a capacitively-coupled discharge reactor equipped with a two-demensional laser light scattering (LLS) system described elsewhere [3]. We 1employed a high speed camera equipped with an interference filter of a center wavelength of 532 nm. Spatiotemporal profile of LLS intensity was measured at a frame rate of 1000 fps.

The LLS intensity from nanoparticles is detected from 3.5 s after discharge ignition at the plasma/sheath boundary around 2mm above the powered electrode. The result indicates that radicals and nanoparticles are mainly generated at the plasma/sheath boundary near the powered electrode. After 3.5 s, nanoparticles are observed in the plasma region between the powered electrode and the grounded electrode. The LLS intensity is varied with the AM frequency. Figure 1 shows axial profile of the power spectrum of the LLS intensity at the center of electrode for AM frequency of 50 Hz and 100 Hz. There exists a peak at 3/5 of the AM frequency. Our previous theoretical study has revealed a kind of coupling among growth rates of nanoparticles thourgh radicals is described by

$$\Gamma \propto \pi/6\, d_p^{\,2}\, n_p^{\,5/3}\, L^3$$

where d_p and n_p are particle size and density, respectively. L is a characteristic reactor size. The peak at 3/5 of the AM frequency corresponds to this coupling.

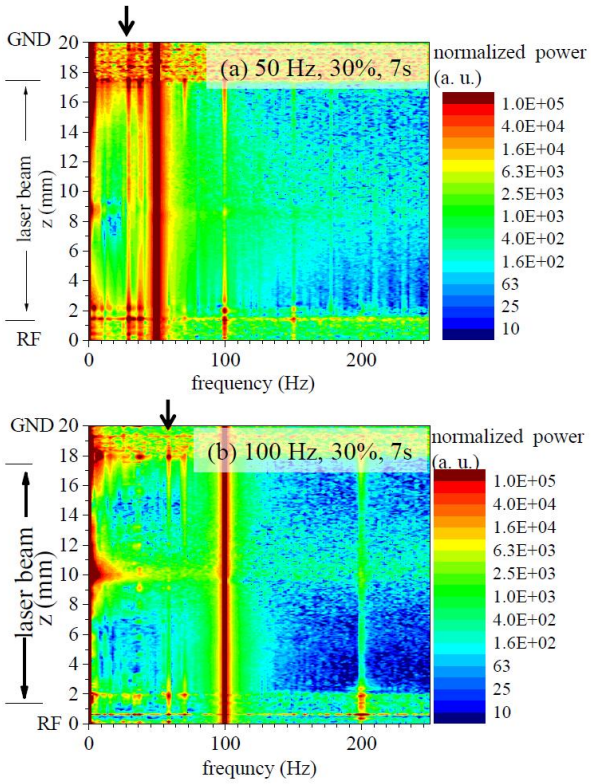

Fig. 1. Spatial profile of power spectrum of LLS intensity at 7s after discharge ignition for (a) AM frequency of 50 Hz and (b) 100 Hz. Arrow shows 3/5 frequency of the fundamental frequency.

Acknowledgements

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