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高気圧Ar+CH_4ナノ秒放電を用いた薄膜堆積とナノ粒子生成
Thin Film Deposition and Nanoparticle Generation using High Pressure Ar+CH_4 Nanosecond Discharge

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Formation kinetics of nanoparticles in low pressure nonthermal plasmas and high pressure thermal plasmas has been extensively studied [1, 2] because nanoparticles play central role in nanotechnologies due to their size-related properties that differ significantly from those observed in bulk materials. Formation kinetics of nanoparticles in *high pressure nonthermal plasmas* has been attracted relatively little attention. Here we report generation of nanoparticles and deposition of thin films using high pressure CH_4+Ar nanosecond discharge plasmas.

Nonthermal glow discharges were generated in a 0.2 mm gap between a cathode and a grounded anode of 15mm in diameter by applying pulsed voltage to the cathode as shown in Fig. 1. The concentration of CH_4 was 5 %. The total gas flow rate and total pressure were 100 sccm and 6300 Pa, respectively. The peak voltage was -700 V. The discharges were sustained for 200 ns. The repetition frequency of the discharges was 5 kHz. The discharge duration was 30 min.

Figure 2 shows images of cathode and anode after the deposition. Carbon films are deposited on both of the electrodes. The deposition rate is evaluated from the film thickness near the center of the electrodes measured with a scanning electron microscope. The deposition rate at the cathode is 7.0 times as high as that at the anode. The deposition rate unbalance might be attributed to an ion assisted deposition at cathode and/or asymmetry of spatial profile of radical density.

Particles were deposited on the both electrodes. Particles deposited on the anode were mainly accumulated on the outer rim. We collected nanoparticles by the vacuum collection method and observed them with a scanning electron microscope. The collected nanoparticles are classified into three kinds: spherical particles, agglomerates and flakes. Spherical particles are below 200 nm in size. The shapes of spherical particles and agglomerates suggest that they are generated in the gas phase, whereas flakes are generated by peeling off the deposited films.

[1] M. Shiratani, et al., J. Phys. D **44** (2011) 174038.

[2] J. Gonzalez-Aguilar, et al., J. Phys. D **40** (2007) 2361.

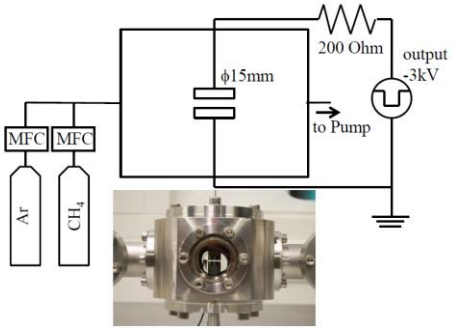

Fig. 1. Experimental setup.

Fig. 2. Carbon films deposited on cathode and anode.

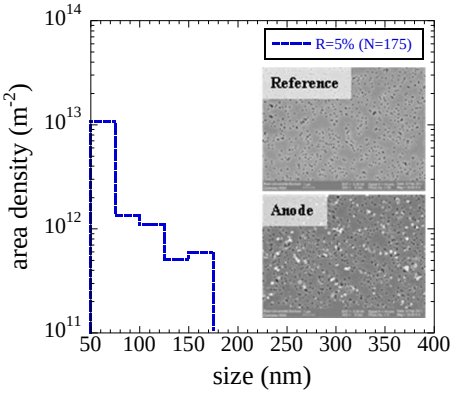

Fig. 3. Size distribution of particles collected on the anode with vacuum collection method.