Particle Growth Experiments (PAGE)

Particle growth and the behavior of particle clouds in hydrogen-methane capacitively-coupled rf plasmas are investigated. We determine the evolution of the particle number for several temperatures and gas compositions. Most of these particles are due to flakes of layers delaminated from electrode surfaces. If we introduce diamond seed particles in the apparatus, we observe nucleation of small new grains on the surfaces of the diamond particles.

The behavior of particle clouds and particle growth in reactive plasmas is studied in a capacitively coupled rf discharge. We use a three electrode assembly with the electrodes, 10 cm in diameter, being oriented horizontally. The rf power is applied to the upper electrode. To change the plasma conditions in the levitation region, a grided electrode is put between two rf electrodes. The particles are levitated between this grided and the lower electrode. To collect the particles directly from the particle clouds, we use a NFP (negatively charged fine particle) collector [1].

Particles generated in the plasma without introducing seed particles are mainly amorphous carbon. Most of the particles levitated are flakes, delaminated from the surface of the upper two electrodes. However we also find a few nano-diamond particles for the following growth condition, CH_4: 1sccm, H_2: 20sccm, temperature of electrodes: 800K. If we pour diamond seed particles (average size ~2.8 micron) into the apparatus, we observe nucleation of new particles on their surface as shown in Fig. 1 (size up to 100 nm after 8 hours plasma exposure at 800K). In order to increase the growth rate of diamonds and improve the quality, we have installed a tungsten hot filament between the gridded electrode and the lower electrode. To insert the W hot filament, three effects are expected. The first is to heat the particles more efficiently. The second is to produce more atomic hydrogen efficiently. The third is the decrease of the electron temperature [2]. The energetic electrons in plasma are absorbed to the filament instead of the electrons emitted from the filament because the hot filament system is electrically floating. The low electron-temperature electrons replace the high electron-temperature electrons in plasma. Figure 2 shows a picture of particles and the filament. In this case the temperature of the filament is 2300 K and the temperature of the particle levitation region is 1000K.

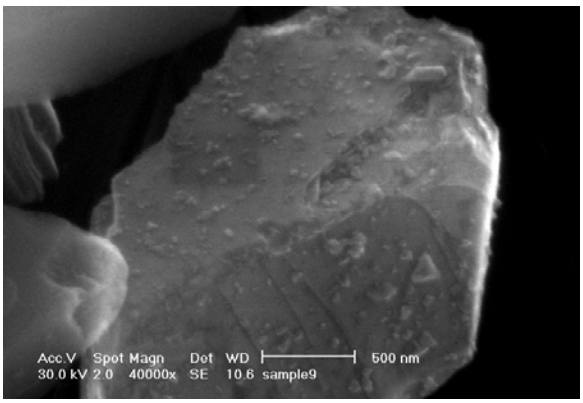

Fig.1: SEM image of diamond particle.

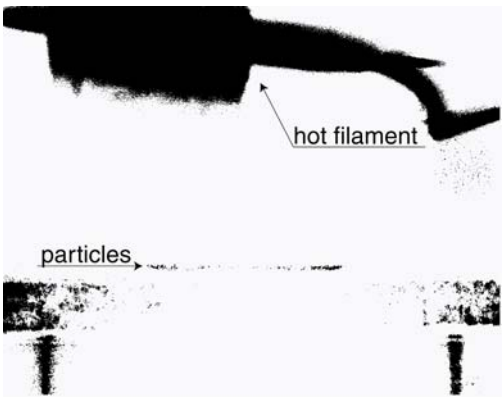

Fig.2: Particle-confinement with hot filament.

References:
• [1] G. Uchida, S. Iizuka, and N. Sato, *Proceedings of the 17th symposium on plasma processing*, 617(2000).
• [2] I. Alexeff and W. D. Jones, Appl. Phys. Lett., **9** (1966) 77.

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