§26. Effects of Wall Potential on Flux of Dusts Impinging to LHD First Wall

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Recently, nanoparticles formed in fusion devices have been attracted a growing interest as one of critical issues in next-step fusion devices. Nanoparticles generated due to plasma-surface interactions pose two potential problems in fusion plasmas: those remained in a fusion device are dangerous, as they can contain a large amount of tritium and can explode violently; they may lead to deterioration of plasma confinement. We have found large amount of carbon nanoparticles due to interactions between H_2 plasmas and carbon walls in an ECR discharge reactor,[1)] in LHD,[2)] and in a helicon discharge reactor.[3)] Here we describe experimental results of in-situ collection of nanoparticles in a helicon discharge reactor.[4)]

Experiments were carried out with a helicon discharge reactor. Gas of H_2 was supplied to the helicon discharge reactor. The gas pressure was 5 mTorr. H_2 plasmas were generated by applying 1 kW, 13.56 MHz pulsed RF voltage to a helicon antenna. The discharging period was 0.25 s, and the interval between discharges was 1.0 s. The total discharging period t_{total} was 600 s. A graphite target was located at the one end of the discharges. Carbon nanoparticles were formed due to interactions between H_2 plasmas and the target.

Nanoparticles were collected on crystalline silicon substrates which were set on a holder located at 111 mm below the target, and were biased at V_{bias} = -50, 0, +15, and +50V. Then, size and shape of nanoparticles were obtained with SEM. Nanoparticles are classified into three kinds: small spherical nanoparticles below 1 μm in size, large flakes above 1 μm in size, and agglomerates, suggesting three formation mechanisms: CVD growth, peeling from wall, and agglomeration. These features are similar to those of nanoparticles collected in LHD. Figure 1 shows substrate bias voltage dependence of size distribution of dust particles. The area density for the spherical nanoparticles exponentially increases with V_{bias}, while the area densities of agglomerates and flakes are almost constant. There are two candidate mechanisms bringing about the results. The first candidate is that transport of spherical particles is modified by the spatial potential deference due to their small inertia, whereas the agglomerates and flakes are not due to their large inertia. The other candidate is that kinetic of H^+ impinging to the substrate increases with decreasing V_{bias}, which increases an etching rate of small spherical carbon nanoparticles.

1) K. Koga, et al., IEEE Trans. Plasma Sci., **32,** 405 (2004).
2) K. Koga, et al., Plasma Fusion Res., **4,** 34 (2009).
3) S. Iwashita, et al., J. Plasma Fusion Res. SERIES, **8,** 308 (2009).
4) H. Miyata, et al., Proc. 63rd Annual Gaseous Electronics Conference and 7th International Conference on Reactive Plasmas, (2010) CTP.00114.

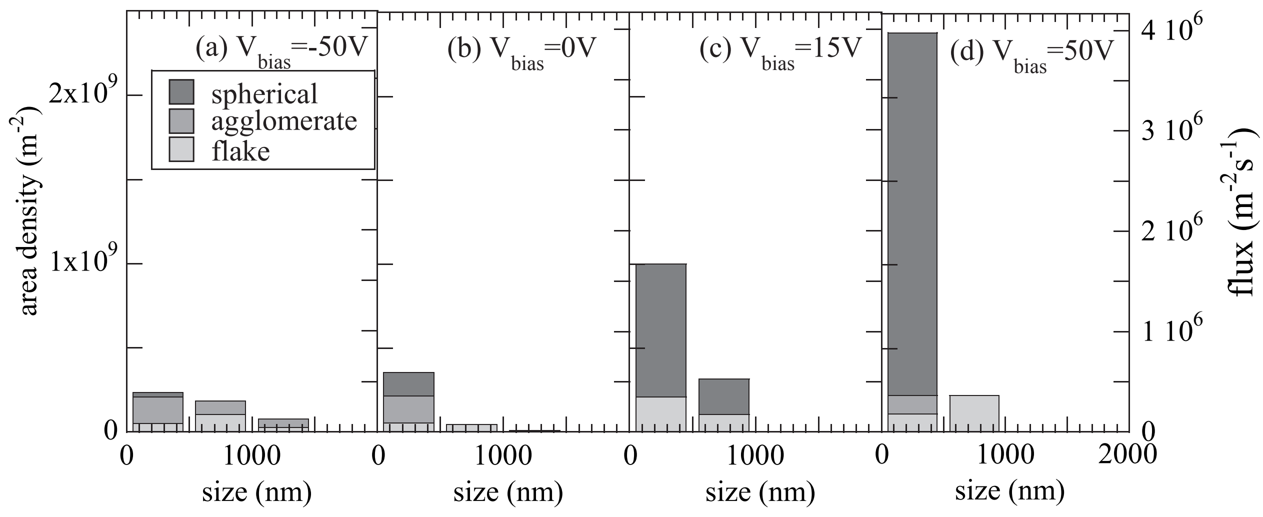

Fig. 1. Substrate bias voltage dependence of size distribution of dust particles.