§33. Substrate Bias Dependence of Flux of Dusts Generated in Helicon Discharges

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Introduction

Dust particles generated due to plasma-surface interaction in fusion plasmas pose two potential problems: 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. Recently, we reported formation of large amount of carbon dust nano-particles due to interaction between hydrogen plasmas and carbon walls in LHD and in a helicon discharge chamber [1-3]. These reports motivate us to develop a method for reducing dusts in the LHD. In this report, we have evaluated a wall bias dependence of a dust flux using the helicon discharge chamber.

Experimental

Experiments were carried out with a helicon discharge chamber as shown in Fig. 1. Uniform magnetic field of 150 Gauss was applied along the center axis of the discharge tube with the four magnetic coils. Gas of pure H_2 was supplied to the helicon discharge chamber and the pressure was 8 mTorr. Hydrogen plasmas were generated by applying 1kW, 13.56MHz pulsed RF voltage to a helicon antenna. A discharging period was 0.25 s, and the interval was 1.0 s to avoid overheating the helicon discharge chamber. The total discharging period was 600 s. The ion density, electron temperature, and plasma potential V_s which were measured with a Langmuir probe located 20 mm from the graphite target, were $9.7x10^{11}cm^{-3}$, 10eV, and 30 V, respectively. Dust particles were collected on crystalline silicon substrates which are set on a bias holder, and are biased at V_{bias}=-50, 0, +15 and +50V simultaneously. In the helicon discharge chamber, dust particles were sampled at 111 mm below the target during helicon discharges. Then, size and shape of dust particles were obtained with Scanning Electron Microscope (SEM).

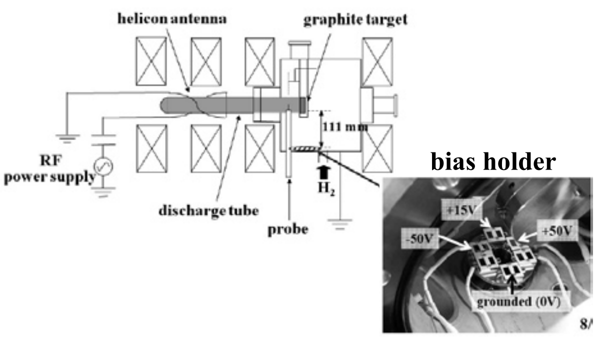

Fig. 1. Helicon discharge chamber and bias holder.

Results and discussion

Figure 2 shows SEM images of typical dust particles collected in the helicon discharge chamber. Dust particles can be classified into three kinds, that is, small dust particles, agglomerates and flake like dusts. Agglomerates are composed of small spherical primary particles around 10 nm in size.

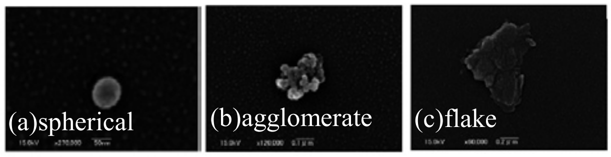

Fig. 2. SEM images of (a) spherical dust, (b) agglomerate, and (c) flake collected in the helicon discharge chamber.

Figure 3 shows dependence of dust flux on potential difference between the substrate bias and the plasma potential $\Delta V=V_{bias}-V_s$ for three types of dusts. For spherical dusts, the flux exponentially increases from $4.3x10^6$ $m^{-2}s^{-1}$ for ΔV=-80V to $3.6x10^9$ $m^{-2}s^{-1}$ for ΔV=20V while, for agglomerates and flakes, the fluxes are independent upon the ΔV. The flux of the agglomerates and flakes has large errors because the sample number is a quite low. The result for spherical dusts suggests that dusts generated in the discharges can be collected by substrate bias.

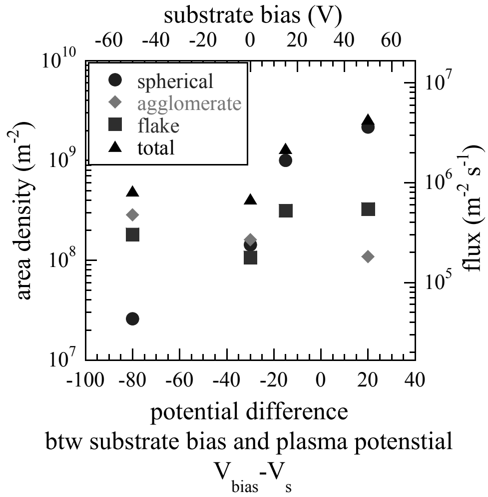

Fig. 3. Dependence of dust flux on potential difference between substrate bias and plasma potential for three types of dusts.

Conclusion

We have measured substrate bias dependence of the flux of dusts generated due to interaction between hydrogen plasma and a graphite wall. The flux of small spherical dusts exponentially increases with the bias. The result indicates dusts can be collected by substrate bias.

[1] K. Koga, R. Uehara, M. Shiratani, Y. Watanabe and A. Komori, IEEE Trans. Plasma Sci. **32** (2004) 405.

[2] K. Koga, S. Iwashita, S. Kiridoshi, M. Shiratani, N. Ashikawa, K. Nishimura, A. Sagara, A. Komori, and LHD Experimental Group, Plasma and Fusion Research **4** (2009) 34.

[3] S. Iwashita, H. Miyata, K. Koga, M. Shiratani, N. Ashikawa, K. Nishimura, A. Sagara, and LHD Experimental Group, J. Plasma Fusion Res. SERIES **8** (2009) 308.