

## §18. Short- and Long-term Dust Collection in LHD with Dc-biased Substrates

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Dust accumulation is of critical issue in fusion devices because of their chemical activity, tritium retention, radioactive content and explosiveness. They may lead to operational issues such as deterioration of plasma confinement.<sup>1)</sup> It is indispensable to reduce dust accumulation in the vessel to realize the long term operation. So far we have revealed that large amount of dust particles in a nanometer size range exist in the large helical device (LHD).<sup>2)</sup> We also have carried out short-term dust collection during main discharges in the 15th campaign using dc-biased substrates and found that positive local potential can be useful for removing carbon and metal dust particles below 50 nm in size and negative local potential can be useful for suppressing accumulation of dust particles.<sup>3)</sup> Here we report on short-term dust collection from the 15th campaign to the 17th campaign as well as long-term dust collection during the entire period of 17th campaign.

For the short-term dust collections, dc-biased Si substrates located at the bottom of the first wall at the 4.5L port during main discharges. The collections in the 17th campaign were conducted 2 times on 11th – 12th Jan. 2013, and 17th – 18th Jan. 2013. The bias voltage ( $V_{\text{bias}}$ ) was set from -200 V to +150 V. The substrates were exposed by main discharges of 1488 s and 862 s, respectively. The size and shape of the deposited dust particles were measured by scanning electron microscopy (SEM). The dust flux on the substrates was obtained from the discharge period and the area density of the number of the particles between 50 nm to 1  $\mu\text{m}$  in size. For the long-term dust collection, grounded and negatively biased Si substrates were set on 7O port. The substrates were exposed to both main and glow discharges during the entire period of 17th campaign. We analyzed the deposition on the Si substrates using SEM equipped with energy dispersive X-ray (EDX) analysis.

Collected dust particles can be classified into two kinds: spherical particles and flakes. Figure 1 shows bias voltage dependence of the dust flux. The flux of spherical dust increases exponentially with increasing the bias voltage from -70 to +90 V then the flux decreases with further increasing the bias voltage. For flakes, the highest flux is obtained for the voltage of +30 V. These results suggest that bias voltages from -70 V to +90 V is better for dust transport control for dust particles between 50 nm and 1  $\mu\text{m}$  in size. Further study is required to reveal the difference between the bias dependence of spherical dust and that of flakes.

For the long-term dust collection, deposition layer are formed on the substrates. Major composition of the layer is

carbon, which is primary component of divertor plates in LHD. Figure 2 shows cross sectional SEM images of the deposited films. The thickness for  $V_{\text{bias}} = -70$  V is 317.9 nm, being larger than 233.0 nm for  $V_{\text{bias}} = 0$  V. Bright spots below 50 nm in size are observed in the layer for  $V_{\text{bias}} = -70$  V while a few such spots exist for  $V_{\text{bias}} = 0$  V. In addition, some voids exist at the interface between the carbon films and the substrates. The size and number of voids for  $V_{\text{bias}} = -70$  V are larger than that for  $V_{\text{bias}} = 0$  V.

For the short-term collections, the flux of dust particles for  $V_{\text{bias}} = -70$  V is much smaller than that for  $V_{\text{bias}} = 0$  V, whereas the film thickness for  $V_{\text{bias}} = -70$  V is larger than that for  $V_{\text{bias}} = 0$  V. The deposition of positively charged dust particles during the glow discharges and/or flux of ions impinging to film surface may lead to the difference.

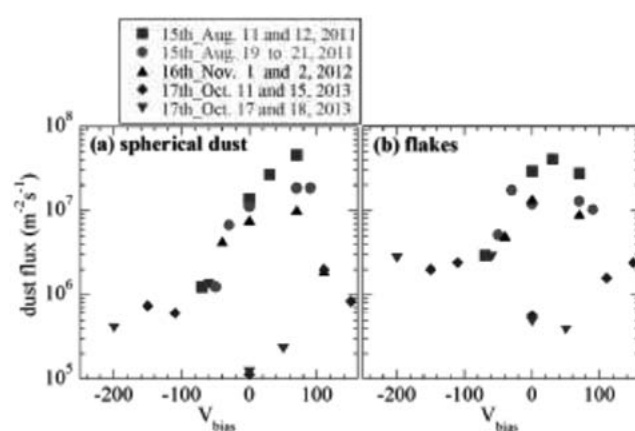


Fig. 1. Bias voltage dependence of dust flux toward Si substrates for the short-term dust collection. (a) spherical dust, (b) flakes. These flux was obtained from the area density of the particles between 50 nm to 1  $\mu\text{m}$  in size and the discharge period.

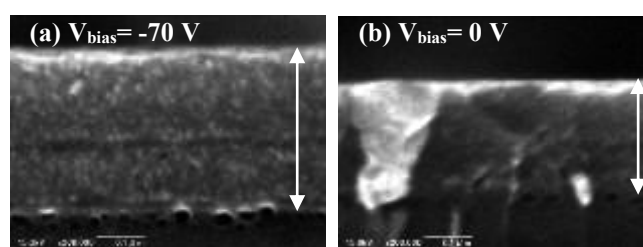


Fig. 2. SEM images of cross section of deposited films on Si substrates for the long-term dust collection, for (a)  $V_{\text{bias}} = -70$  V, (b)  $V_{\text{bias}} = 0$  V.

- 1) Roth, J. et al.: J. Nucl. Mater. **390-391** (2009) 1.
- 2) Koga, K. et al.: Plasma Fusion Res. **4** (2009) 034.
- 3) Koga, K. et al.: J. Nucl. Mater. **438** (2013) S727.