§18. Dust Transport Control in LHD by Applying dc Bias

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Dust particle accumulation in fusion reactors is a significant problem for the safe operation of fusion reactors such as the International Thermonuclear Experimental Reactor [1]. Dust particles can cause safety problems associated with their chemical activity, tritium retention, and radioactive content [2]. It is critical to reduce dust accumulation for long-term operation of fusion reactors. It is thus important to develop methods for removing dust and for suppression of dust formation. Here, we report experimental results for dust collection in the Large Helical Device (LHD) at the National Institute of Fusion Science using biased substrates as a first step toward developing a novel method for removing dust from fusion reactors by applying a local bias potential.

Dust collection in the LHD was conducted using DC-biased Si substrates (15×10 mm^2) located at the bottom of the first wall over a total discharge period of 920 s for H_2 and He main discharges (15th campaign on 11th and 12th August 2011). The bias potential $\Delta\phi$ was set to –70 V, 0 V, +30 V, and +70 V with respect to ground. The holder was set on a movable sample stage at the 4.5L port. Using the movable stage, the holder was exposed only during discharge periods. The size and shape of the dust particles deposited on the substrates were measured by scanning electron microscopy (SEM) The dust particle flux on the substrates was obtained from the particle area density on the substrates and the discharge period.

The collected dust particles were classified into two kinds: spherical carbon particles smaller than 300 nm and stainless-steel flakes smaller than 1 μm. In previous dust collection studies [3], we also found agglomerates. However, agglomerates were rarely observed in the present study. Figure 1 shows the $\Delta\phi$ dependence of the total flux, which was obtained by integrating the size distribution between 50 nm and 1 μm [4]. The spherical particle flux increases exponentially by 1.5 orders of magnitude when $\Delta\phi$ is increased from –70 to +70 V. The total flake flux increases by one order of magnitude when $\Delta\phi$ is increased from –70 to +30 V and decreases when $\Delta\phi$ is increased from +30 to +70 V. The transport mechanism is currently unclear. The present results suggest that flakes and spherical particles have different transport mechanisms. These results indicate that +30 V is a suitable potential since it attracts both spherical particles and flakes, allowing them to be removed from fusion devices. On the other hand, a negative bias may repulse dust particles that they may be deposited in undesirable places.

These results suggest that the local bias potential is useful for removing carbon and metal dust particles from the shadow area in fusion devices.

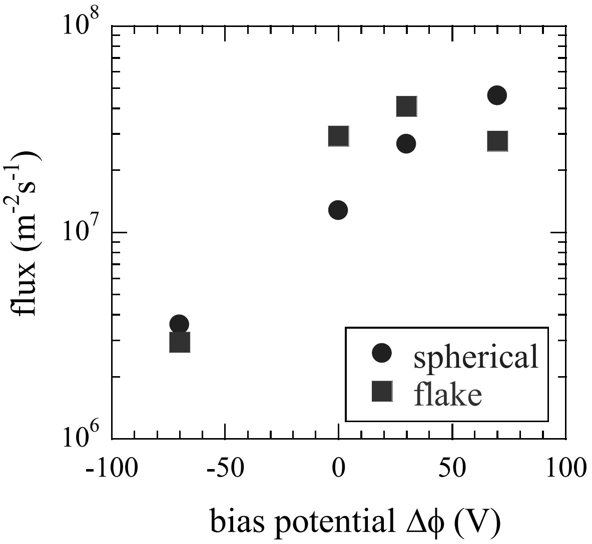

Fig. 1. Bias potential dependence of integrated flux of dust particles.

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[2] N. Taylor, et al., Fusion Engineering and Design 86 (2011) 619.
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[4] K. Koga, et al., J Nucl. Mater (2013) in press. (doi: 10.1016/j.jnucmat.2013.01.154)