§19. Effects of Hydrogen Plasma Irradiation on Dust Particles Accumulated on Walls

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Reduction of dust accumulation in future nuclear fusion devices is of critical importance because of safety issues related to chemical activity, tritium retention, and radioactive content of dust particles [1]. To understand their generation and transport mechanisms in fusion devices is important to suppress dust deposition. Although some studies have been carried out to discuss the mechanisms, their generation and transport mechanisms are still unclear [2, 3]. To cralify them, we have developed a divertor simulator using helicon discharges. Here, we examine etching effects of hydrogen plasmas on corrected dust particles.

Experiments were carried out with the divertor simulator [3]. Gas of pure H_2 was supplied at 13 sccm in flow rate at pumping port to reduce effects of gas flow on dust transport. The gas pressure was 6.7 Pa. H_2 plasmas were generated by applying pulseed RF voltage of 13.56 MHz to a helicon antenna. A graphite target of 35 mm in diameter and 8 mm in thickness was placed to produce dust particles due to interactions between the carbon wall and the H_2 plasmas. Dust particles were collected on dc biased Si substrates of 15x10 mm^2 set on a substrate holder which were set on the reactor wall at 110 mm below the graphite target. The size and shape of the dust particles collected on the substrates were measured with a scanning electron microscope (SEM). Their composition was obtained by energy dispersive X-ray (EDX) analysis.

Collected dust particles can be classified into two kinds: spherical particles and flakes. EDX analysis shows that the major composition of the dust particles is carbon, which is the primary component of the graphite target. Size, size distribution, shape, and composition of spherical dust particles in the divertor simulator coincide well with those in LHD, whereas composition of flakes in the divertor simulator does not coincide with those in LHD. Thus, we have concentrated on the spherical particles in the divertor simulator in this study. During the dust collection, hydrogen plasmas are irradiated to dust particles deposited on the substrates so that the particles might be etched by hydrogen plasmas. Such etching effect is evaluated from the erosion yield Y_{tot} of carbon films [4]. The volume of collected dust particles V_{col} is deduced from size distribution of collected dust particles. The etched volume V_{etch} of dust particles is obtained from Y_{tot}. A ratio R of integrated V_{etch} and V_{col} + V_{etch} in a size range between 30 nm and 1 μm, which is given by

$$R = \frac{\int V_{etch}\, dd}{\int V_{etch}\, dd + \int V_{col}\, dd}$$

is obtained to evaluate the contribution of etching due to hydrogen plasma irradiation. Figure 1 shows the bias voltage dependence of R. R has low values below 5 % for V_{bias} =-50V – 70V.

These results indicate that the contribution of etching due to hydrogen plasma irradiation can be negligible in this bias range.

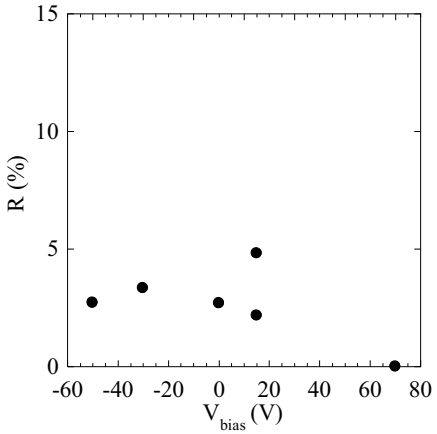

Fig. 1. Etched volume V_{etch} and volume V_{col} of collected particles as a function of their size.

[1] J. Winter: Plasma Phys. Control. Fusion, 40 (1998) 1201.
[2] S. I. Krasheninnikov and T. K. Soboleva: Plasma Phys. Control. Fusion 47 (2005) A339.
[3] K. Nishiyama, et al., J. Nucl Mater (2013) in press. (doi: 10.1016/j.jnucmat.2013.01.169)
[4] J. Roth: J. Nucl. Mater. 266 (1999) 51.