§68. In Situ Sampling of Dust Particles in LHD and their Characterization

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Of late there has been growing concern over formation of dust particles due to plasma-surface interaction [1-4], because dust particles 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. Therefore, it is important to reveal their formation mechanism, their transport as well as their accumulation area. Investigation of dust in fusion plasma research devices has been carried out mainly using the filtered vacuum collection method [1-4]. Here, we will describe the results regarding characterization of dust particles collected in main discharges and glow ones of LHD using in-situ sampling method.

Table 1 shows surface number density (mm^{-2}) and typical size range of materials collected around the 4-O port. Agglomerate dust particles are collected by the in-situ sampling in main discharges, while they are not by the in-situ sampling in glow discharges. These results suggest that such agglomerate dust particles are mainly produced in main discharges and such agglomerate dust particles are removed from the surface in glow discharges. Moreover flakes in glow discharges are more abundant than those in main discharges. Deposited materials are collected by the in-situ sampling in main discharges and glow ones, while no such materials are collected by the filtered vacuum collection. Thus, in-situ sampling gives more information about formation and transport of dust particles than the filtered vacuum collection.

Figure 1 shows a typical SEM image of agglomerate dust in-situ collected near the 4-O port during main discharges in the 9th campaign. The most important feature of agglomerate dust is the fact that most primary dust particles in agglomerates is around 10 nm in size, suggesting agglomeration between oppositely charged dust particles plays an important role [5]. Dust particles can be charged positively by secondary electron emission from them due to incidence of high energy electrons, high energy ions, and VUV light. Ionization potential of dust particles tend to decrease with increasing their size in a size range below 10 nm. Escape efficiency of electrons created in dust particles increases with decreasing their size. Due to the balance between these two size effects on secondary emission of electrons from dust particles, dust particles around 10 nm in size have a high probability to be charged positively. Moreover agglomeration rate between oppositely charged dust particles is accelerated by the electrostatic attraction, while that between ones having like charge is reduced significantly by the electrostatic repulsion. Therefore, agglomeration between oppositely charged dust particles is a possible formation mechanism of agglomerate dust particles.

	Spherical dust	Agglomerate dust	Flake	Deposit
Filtered vacuum collection	100000 1nm-1μm	600 100nm-1μm	5 >1μm	0
In-situ sampling in main discharges	exist 40nm-1μm	1 100nm-1μm	0.1 >1μm	1 >1μm
In-situ sampling in glow discharges	exist 40nm-1μm	0	10 >1μm	2 >1μm

Table 1. Surface number density (mm^{-2}) and typical size range of materials collected around the 4-O port. Materials collected by the filtered vacuum collection were observed by SEM and TEM, whereas those collected by the in-situ sampling were observed by SEM. TEM observation is effective for a size range of 1-100 nm, while SEM observation is effective for a size range above 40 nm.

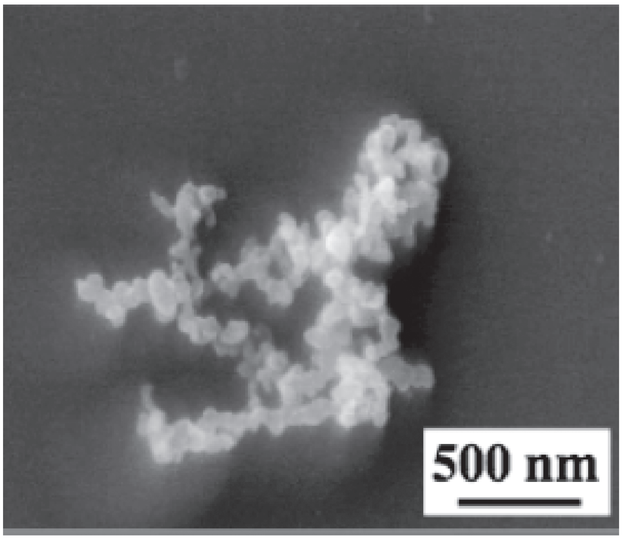

Fig. 1. Typical SEM image of agglomerate dust in-situ collected near the 4-O port during main discharges in the 9th campaign.

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