§59. Study on Generation Mechanism of Particles in LHD

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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 using ex-situ dust sampling method [1-4]. Moreover, most such studies focused on dust particles around μm in size [1-4]. Recently, Kyushu University group of us reported formation of carbon dust nano-particles due to interaction between ECR hydrogen plasmas and carbon walls [5, 6]. This report motivates us to study small dust particles in LHD. Here, we will describe the results regarding characterization of dust particles collected from LHD using the filtered vacuum collection method.

The total mass of dust particles collected by each filter was obtained as the difference of filter mass before and after dust collection. Figure 1 shows the distribution of surface mass density after the 8th campaign. The mass densities depend little on the collected location, especially the values at the location No. 15 on the divertor made of carbon (IG-430) are similar to those at other locations where the first wall is made of stainless steel (SS316). The inner surface area of the LHD chamber without and with ports are 400 m^2 and 700 m^2, respectively. Assuming the area of 400 m^2, the total dust inventories after 7th, 8th, and 9th campaign are estimated to be 3.9, 1.4, and 1.1 g, respectively. The total inventory of dust particles collected from LHD after the 4th campaign in March 2001 is 16.2 g [3]. Therefore, LHD becomes cleaner during its operation history and the total dust inventory after the 9th campaign is the lowest among the reported values for several devices such as JT-60U and ASDEX-Upgrade [3, 4].

There exist dust particles ranging in size from 1 nm to 10 μm. The smaller their size is, the higher their number density is. The size distribution of dust particles is expressed in terms of an inverse power law size distribution function, that is, the Junge distribution. This size distribution suggests that small dust particles grow into large ones in LHD. Dust particles are classified into small and large size groups: small dust particles below 1 μm in size are spherical and their major composition is C, while large ones above 1 μm in size are irregular in shape and their major compositions are Fe and Cr. Figure 2 shows cumulative percentage of volume and surface area of dust particles at location No. 13 after 8th campaign. Small dust particles of 1nm to 1μm in size have 70% of the total surface area, while they have 10% of the total volume. These small dust particles cannot be bypassed, because they may contain a large amount of tritium due to their wide surface area in future fusion devices such as ITER.

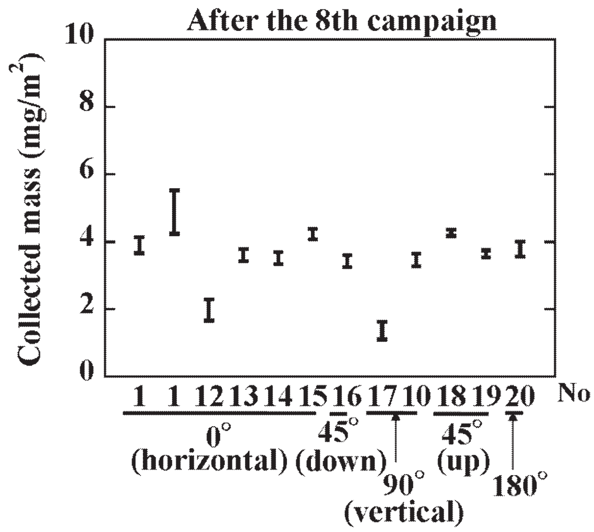

Fig. 1. Distribution of surface mass density of dust particles after 7th (a), 8th (b), and 9th campaign. No. 15 is on divertor target.

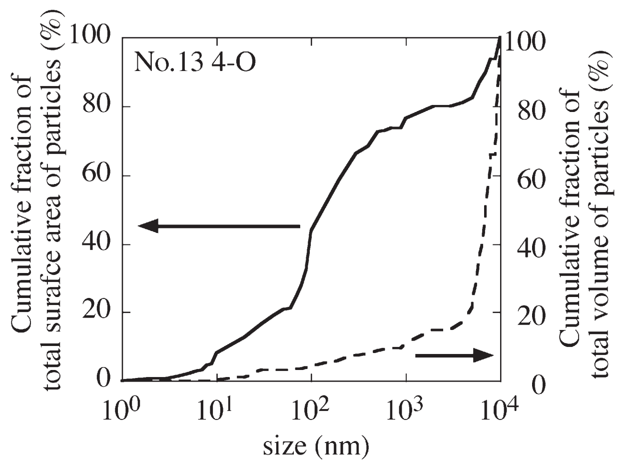

Fig. 2. Cumulative percentage of (a) volume and (b) surface area of dust particles at location No. 13 after 8th campaign.

References

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