§3. R&D of In-situ Dust Collection Using Silica Aerogel

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Silica (SiO_2) aerogel has been used as a dust collector in space plasma research: an aerogel (a silicon-based solid with porous) has sponge-like structure in which 99 % of the volume is empty space. In fusion devices, the same type of silica aerogel has been tested to detect accelerated dust particles and their trajectories, i.e. incident dust particles are trapped into the aerogel, and they are remained after vacuum vent. Information of the dust transport such as trapped angle and velocity as well as the particle properties such as size, shape and morphology can be evaluated by surface analysis. Four kinds of Silica aerogels with different densities, 0.020-0.061g/cc, were provided by KEK/JAXA. In this experiment, the highest surface density (0.0061g/cc) was chosen.

Two kinds of materials, i.e. Silica aerogel (15 mm x15 mm, t = 15 mm) and Si samples (10 mm x20 mm, t = 0.6 mm), are installed on the same holder. This holder is set on the movable probe system at the 4.5 lower port and the top of this holder was kept at the first wall level during LHD experiments. The total exposure time during hydrogen plasma discharges is about 300 seconds. After this experiment, Silica aerogels were extracted from high vacuum level, 10^{-6} Pa to atmosphere of 10^{4} Pa. Surface morphologies on the surface of aerogel was measured by digital microscope (THX-1000, KEYENCE). One of these images are shown in Fig.1. The dust size of 10 x 20 micron is observed and the dust surface is the same level of the aerogel surface. Thus, it is considered the dust particle itself is trapped into the base aerogel.

Number density of dust particles trapped into or on the aerogel is two times larger than that on the Si target. This method is applicable for analysis of the dust deposition process without disturbance at changing pressure from a high vacuum area to atmosphere.

For comparison of the aerogel exposed to the plasma, image of as-reserved aerogel surface is shown in Fig.2. It is found that only the aerogel exposed to plasma have many small wrinkles on the surface. At the last campaign in 2009FY, the same type aerogel was exposed to glow discharges in LHD. Figure 3 shows a comparison of surface morphologies on the side and the top surfaces on the aerogel. Only the top surface have wrinkles, while the side surface looks flat surface similar to the as-received aerogel. These results show that these wrinkles are produced by the plasma exposure. Following two reasons are considered. One is due to deposition of particle flux such as plasma ions, neutrals and impurities during plasma experiments or glow discharges. Second is due to the thermal effect, i.e. heat load caused by plasma and radiation. Since aerogel material is low thermal conductivity, even small heat load on the surface increases the surface temperature. At present, thermal effect is considered as the main reason.

This work is supported by NIFS budget KCPP009.

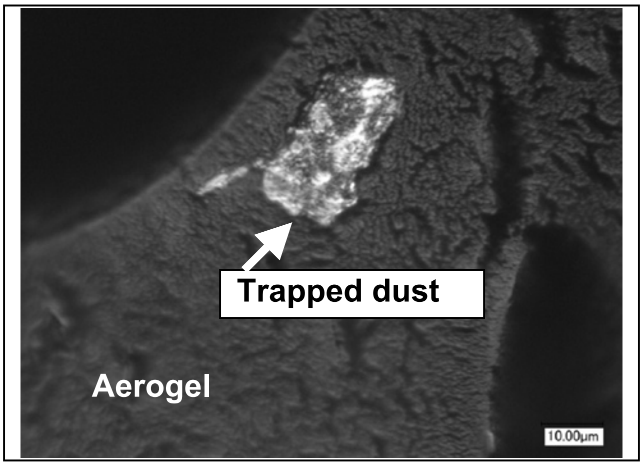

Fig.1 Surface morphology of trapped dust particle into silica aerogel. Black areas are a surface of carbon film behind. Magnification of the scope is 2000.

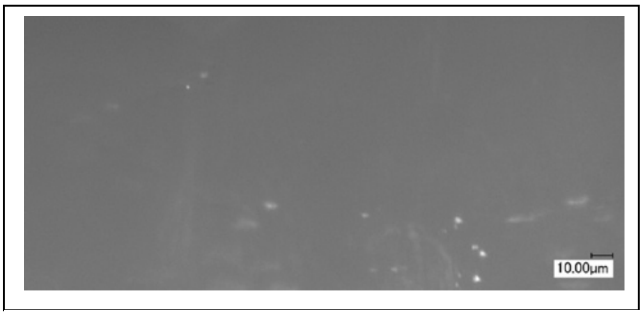

Fig.2 Surface image of as-reserved silica aerogel. White background is aerogel surface.

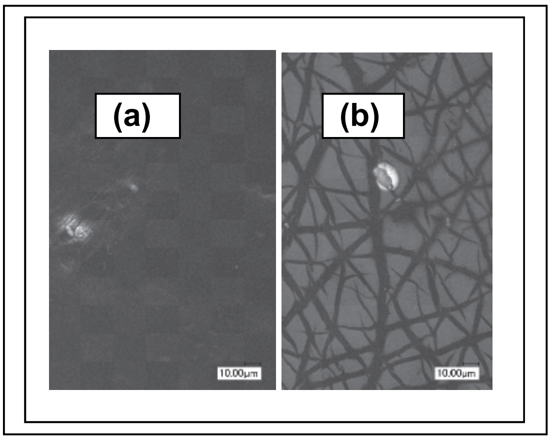

Fig.3 Comparison of surface morphologies on (a) the side and (b) the top surfaces.