

§21. Study of Directionality of the Deposition Layer in LHD Using the Directional Material Probe

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A simple new method for deposition layer studies, directional material probe (DMP), is proposed. It focuses on the directionality of the deposition layer formation. The probe consists of a flat disk and a pin as depicted in Fig. 1. If deposits have directionality, shadow of the pin is formed on the deposition layer on the disk. If there is no shadow on the deposition layer, it suggests that the deposition layer was formed isotropically. It can be applied to plasma-wall interaction studies in fusion devices and laboratory plasma devices such as linear divertor simulators to reveal the material migration mechanisms in such devices. The directional material probe method has been applied to plasma-wall interaction studies in LHD, and the position-dependent variation of the directionality in the deposition layer formation was found.

The DMPs were installed on the plasma facing surfaces in the LHD vacuum vessel before the experiment campaign in 2010 on trial. In the LHD vacuum vessel, the first wall panels are made of stainless steel (SUS316L), and the divertor plates are made of isotropic graphite. Two of the DMPs are shown in Fig. 2. One of them (DMP1) was installed on the first wall near the divertor plates in the torus-inboard side, and the other (DMP2) was installed on the first wall in a vertically elongated poloidal cross-section on the mid-plane in the torus-outboard side. Schematic view of the DMP is depicted in Fig. 3. The diameter of the disk and the shading pin of the DMP were 30 mm and 5 mm, respectively, and they were made of titanium. The DMPs were taken out from the vacuum vessel after the experiment campaign. Figures 4 (a) and (b) are photos of DMP1 and 2, respectively. The direction of the magnetic field lines on the each surface is shown in the each photo. On the surface of DMP1, a clear shadow of the deposition can be seen. The direction, shown by the yellow arrow in Fig. 4(a), is almost perpendicular to the direction of the magnetic field lines. That suggests the deposits were not carried by plasma flow along the field lines. The length of the shadow is 7.5 mm. As depicted in Fig. 4(c), the incident angle of the deposits on the DMP1 can be estimated by the length of the shadow, and it is about 45°. This incident angle is similar to the angle estimated by the observation of the cross-section of the deposition layer on the material probe with TEM in ref.1. The material probe in ref.1 was installed on similar position to the DMP1. In the material probe case, the dominant deposit was carbon, and its source was considered to be the divertor plates near the material probe. The deposition layer on the material probe was considered to be formed by the direct deposition of the sputtered carbon from the divertor plates, and it was qualitatively confirmed by the simulation using ERO code²⁾. In the DMP1 case, the mechanism of the deposition layer formation is considered to be same as the

previous case. On the other hand, no clear shadow can be seen on the surface of DMP2. That suggests the deposits came to the surface isotropically.

1) Tokitani, M. et al.: J. Nucl. Mater. **417** (2011) 668.

2) Kawamura, G. et al.: Contrib. Plasma Phys. **50** (2010) 451.

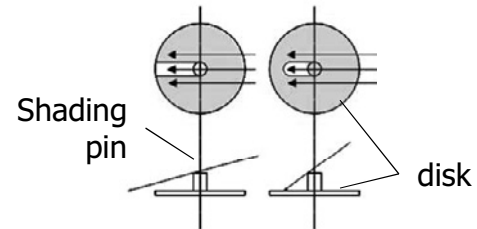


Fig. 1. Schematic views of the idea of the directional material probe. The hatched parts are deposition layer. Arrows show the incident angles and directions of deposits. Two figures are for different incident angles of deposits, respectively.

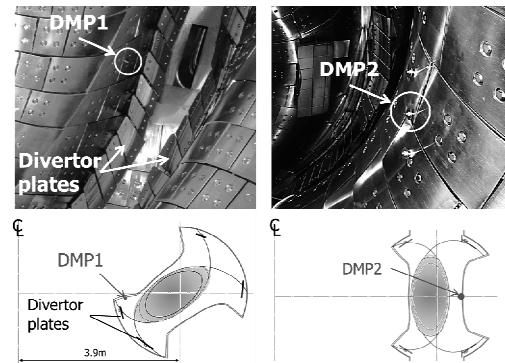


Fig. 2. Photos of the DMPs in the LHD vacuum vessel and their positions in the poloidal cross-sections in the experiment campaign in 2010.

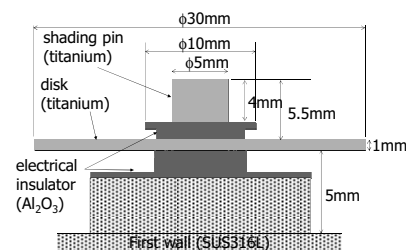


Fig. 3. Schematic view of the DMP.

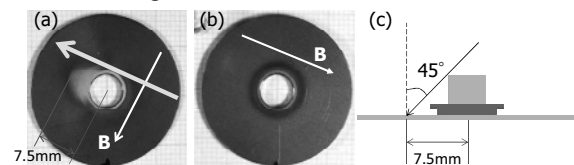


Fig. 4. Photos of the surfaces of (a) DMP1 and (b) DMP2 after the experiment campaign. Direction of the magnetic field lines at the each DMP's position is shown by white arrow. (c) The incident angle of the deposits revealed from the shadow of the deposition on the surface of DMP1.