§25. Measurement of Ion Flux to First-Wall in LHD

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Prediction of the particle load on first-wall in next step devices, such as ITER and FFHR, is important from the viewpoints of tritium inventory, damage and erosion of the first wall. Charge-exchange is a main mechanism of the neutral transport to first-wall. On the other hand, the mechanism of cross-field transport of plasma from scrape-off layer to first-wall has not been well understood.

In this study, we measured ion flux to first-wall ($\Gamma_{i,FW}$) in LHD by using bias voltage applied electrodes (50×20×^{t}1 mm). The electrodes were installed on first-wall panels at torus outboard-side in every horizontally elongated cross-sections as shown in Fig. 1, and they made a toroidal array of $\Gamma_{i,FW}$ monitor. Unfortunately, one of the electrodes installed in toroidal section #5 could not used in experiment for the deterioration of its electrical insulation.

Figure 2 shows time evolutions of ion saturation current measured by the $\Gamma_{i,FW}$ monitor and Langmuir probes on a torus inboard-side divertor plate. During stable discharges (t = 1.6-2.8s in Fig. 2), $\Gamma_{i,FW}$ was about three orders of magnitude smaller than ion flux to divertor plate. Charge-exchange neutral flux was estimated theoretically to be order of 10^{19} H/m^{2}s typically[1)], and $\Gamma_{i,FW}$ (~ 1 A/m^2, in Fig. 2), is less than that. On the other hand, $\Gamma_{i,FW}$ became comparable to ion flux to the divertor plate during radiation collapse as shown in Fig. 2.

Time correlation between $\Gamma_{i,FW}$ ($I_{sat,wall}$) and total radiation power (P_{rad}) was stronger than that between $\Gamma_{i,FW}$ and ion flux to divertor plates ($I_{sat,div}$) as shown in Fig. 3. This result suggests that photo-ionization is dominant source of $\Gamma_{i,FW}$. Assuming electron and ion temperature to be 0.5 eV, electron density around first-wall can be estimated to be around 6×10^{14}/m^3. Typical neutral pressure at torus outboard-side is 10^{-3} - 10^{-4} Pa. Thus degree of ionization is 0.1 – 1 %. We sometimes observed frequent large spikes during discharge in low field experiment. It looks like blob, but we cannot conclude up to now whether the spikes were caused by transport or local photo-ionization for the lack of time resolution of bolometer.

Several kinds of toroidal asymmetries of $\Gamma_{i,FW}$ behavior were observed. One of them is shown in Fig. 4. We have observed a poloidally rotating radiation belt with helical structure and ion flux to divertor plates which is synchronized with the belt during detachment[2)]. In this campaign, it was observed that ion flux synchronized with the belt also appeared first-wall. Figure 4 shows time evolutions of $\Gamma_{i,FW}$ ($I_{sat,wall}$) at all toroidal sections during detachment. Spikes of $\Gamma_{i,FW}$ with time scale of 0.1 s are observed at all toroidal sections. As shown in the right figure in Fig. 4 (magnification of the left figure), The spikes have a structure with toroidal mode number of 2.

1) Kobayashi, M. et al.: J. Nucl. Mater., **350** (2005) 40
2) Masuzaki, S. et al.: J. Plasma Fus. Res., **350** (2005) 40

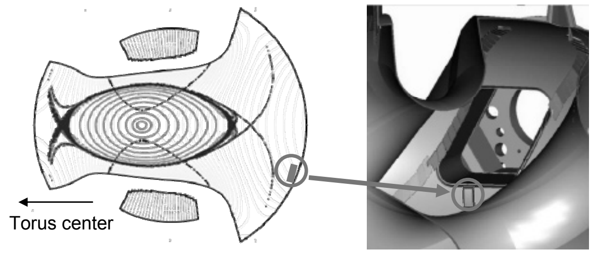

Fig. 1 Position of ion flux monitor on first-wall.

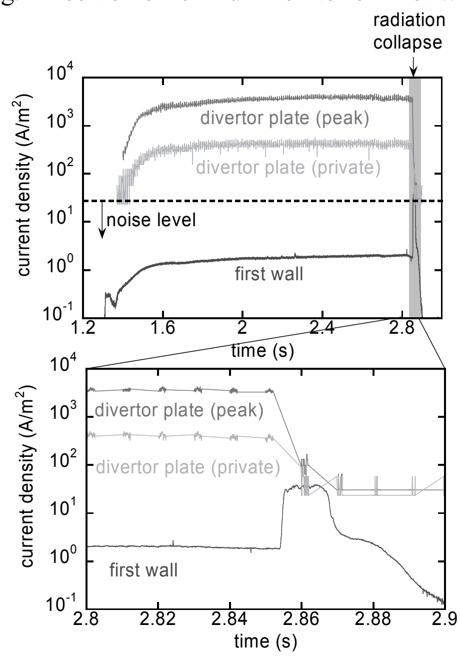

Fig. 2 Typical time evolutions of ion saturation current measured at first-wall and divertor.

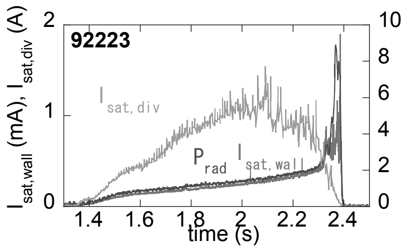

Fig. 3 Time evolutions of ion saturation current to a divertor plate and first-wall, respectively, and radiation power during a discharge.

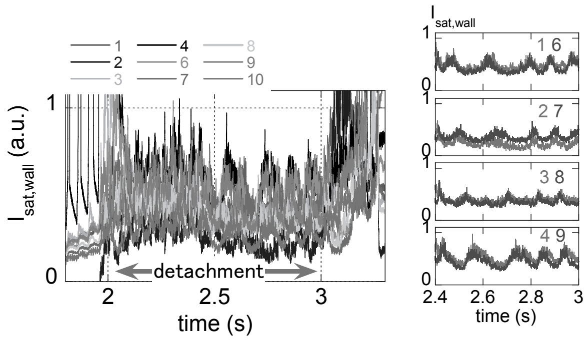

Fig. 4 Time evolutions of ion saturation currents to $\Gamma_{i,FW}$ monitors during detachment discharge.1 – 10 indicate the toroidal section number.