§5. Impurity Behavior in Quasi-Steady State Discharge with Internal Diffusion Barrier

Nakamura, Y., Sakamoto, R., Motojima, G.,
Tamura, N., Kobayashi, M., Peterson, B.J.,
Tanaka, K., Goto, M., Morisaki, T.

In LHD, Super Dense Core (SDC) plasmas with Internal Diffusion Barrier (IDB) for particle transport can be produced by particle fueling with pellet injection. The development of repetitive pellet injector enables us to maintain the SDC plasmas for long time. As a result, a quasi-steady state discharge with IDB ($n_{e\text{-bar}} = 3 \times 10^{20}\,m^{-3}$) was achieved over 3 s. In this discharge, we observed a temporal peaking of radiation profiles measured by AXUVD silicon photodiode arrays. Therefore, we investigate impurity behavior in quasi-steady state discharges with internal diffusion barrier.

Figure 1 shows a typical long pulse discharge with IDB. In the initial stage of this discharge, the NBI heating power of 10 MW is injected into the plasma and the average plasma density rapidly builds up to a high-density level of 4×10^{20} m^{-3} with high repetitive pellet injection. Then the average plasma density is controlled so as to keep more than 3×10^{20} m^{-3} by a feedback control loop with CO_2 laser interferometer signal, using particle fueling with intermittent pellet injection. The stored plasma energy amounts to ~ 1 MJ and it is maintained almost constant during the discharge. In spite of keeping the average plasma density, the density profile changes with time as shown in Figure 2, where the radial profiles of density and temperature at the times just before pellet injection are indicated. The density profile becomes peaked remarkably until 5.2 s, and then the central density decreases and the density in the peripheral region increases with time. On the other hand, the electron temperature profile has a flat one in the core region and the whole profile does not change during the discharge. The radiation profiles from the plasma are measured by a system of two 20-channel fan-beam cameras with AXUVD silicon photodiodes. The radiation signals are integrated along each chord line and the reconstruction of two-dimensional distribution of local radiation is under investigation. However, we can observe a remarkable peaking of radiation profile as compared with density profile peaking as shown in Fig. 3. The peaked radiation increases by more than twice at 5.2 s, despite of keeping the line-averaged density constant. The radiation profile peaking is closely related to the peaking of density profile. This suggests that there is a possibility of impurity accumulation due to sharp density gradient in the first half period of the discharge.

Another important feature of impurity behavior in this discharge is that the peaking of density and radiation profiles stops during the discharge and no radiation collapse due to impurity accumulation is observed. It seems to be an impurity shielding effect in the ergodic layer, which is a unique feature of helical system. The edge magnetic islands in helical devices have a screening effect on intrinsic impurities and it depends on local power balance in the separatrix region. This impurity screening effect will be investigated comprehensively for various discharges with peaked density profile and flat temperature profile or inverse profiles in near future.

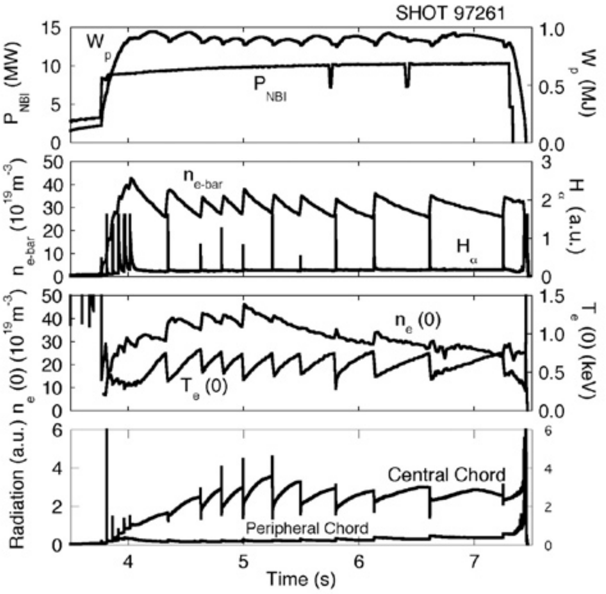

Fig. 1. A typical long pulse discharge with IDB

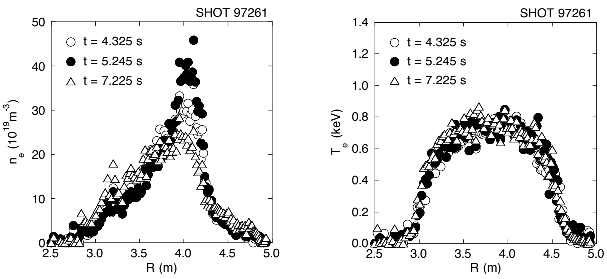

Fig. 2. Radial profiles of density and temperature

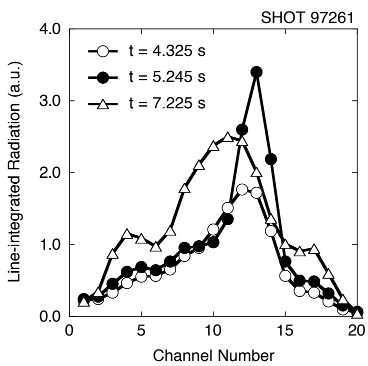

Fig. 3. Radial profiles of line-integrated radiation