## §13. Local Tracer Deposition Achieved with Tracer-Encapsulated Solid Pellet Injection on LHD

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Impurity transport can be measured with high accuracy from the observed diffusion of tracer particles deposited locally by the injected TESPEL (Tracer-Encapsulated Solid Pellet [1]). Local deposition of the tracer enables direct measurements of the diffusion coefficient and simplifies the transport analysis. The TESPEL consists of polystyrene as an outer shell (diameter 0.6–0.9 mm) and LiH as an inner core (200 μm size) [2]. In the recent LHD experiments the tracer size was increased for obtaining higher signal of CXRS observation. In addition to LiH, a few other tracer species were tested such as Silicon and Titanium.

The total light emission from the ablating pellet was measured by photo-multipliers (PM) in $H_\alpha$ and Li I lines simultaneously with time resolution of 1 μs. Knowing the pellet velocity, the time dependence is translated to the pellet position in plasma, and thus tracer location and deposition length can be measured. Figure 1 shows an example of the observed ablation rate for the case of LiH tracer. The strong emission on Li I line is clearly seen around $R = 4.06$ *m*, which points to the location of the tracer ablation, although some background Li I emission is present.

For confirming the exact location of the tracer deposition, the pellet was also photographed through $H_\alpha$ and LiI/LiII filters by CCD cameras from two directions. Example of the images made from the side view are shown in Fig. 2. The obtained images are in good agreement with the PM signals. Background Li I light during ablation of the shell is attributed to minor imperfections in TESPEL configuration. Thus, both observation methods confirmed that a high localization of the tracer has been achieved (typically, only a few centimeters in the radial direction).

Being deposited locally in plasma, the tracer is fully ionized and the $Li^{+3}$ ions form a toroidal annular domain, which then diffuse in radial direction. The diffusion is measured by observing the Li III light (λ=449.9 nm) originated from charge-exchange with neutral hydrogen of the NBI. For that, two detector arrays are installed at the location of the neutral beam (port 10.5L) and at the port without NBI (port 7.5L). The net CXRS signal is obtained by subtracting signals from the corresponding detectors. Each detector consists of a lens, optical fiber, and PM equipped with Li III filter. This provides high spatial resolution of 12.5 mm along the minor radius and time resolution of 10 μs. The local value of diffusion coefficient $D$ can be calculated from the measured characteristic time of $Li^{+3}$ density decay. Due to a low S/N ratio of detected signals achieved up to date, only rough estimations are possible. Preliminary calculations show that for the case of $\bar{n}_e = 0.15\cdot10^{19}$ m$^{-3}$ and $T_e(0) = 2.9$ keV, the average value of $D$ is 0.13 m$^2$/s, and for $\bar{n}_e = 1.1\cdot10^{19}$ m$^{-3}$, $T_e(0) = 3.4$ keV, $D$ is 3.1 m$^2$/s.

The obtained results have demonstrated the potential efficiency of the described diagnostic method for the local transport measurements.

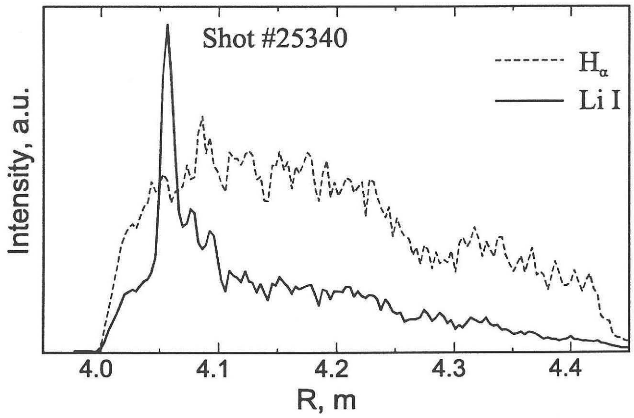


Fig. 1. Ablation rate of TESPEL: $H_\alpha$ intensity (dashed curve) and Li I intensity (solid curve).

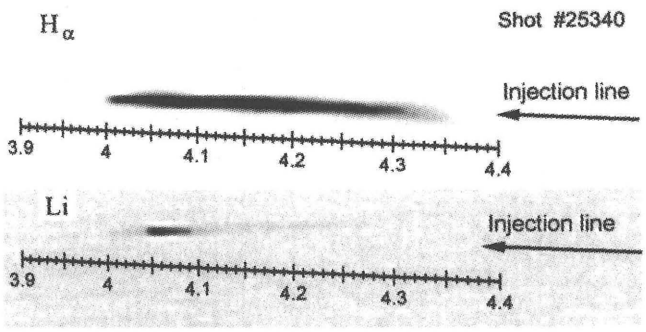


Fig. 2. CCD images of the ablating TESPEL obtained with $H_\alpha$ (top) and Li I filter ($\lambda_0 = 671.7$ nm). Tracer ablation is localized around $R = 4.05$–$4.10$ m.

References

1) Sudo, S. : J. of Plasma Fusion Research, 69(1993)1349.
2) Khlopenkov, K. and Sudo, S. : Rev. Sci. Inst. 69(1998)319.