§14. Titanium Tracer-Encapsulated Solid Pellet (Ti TESPEL) Injection Experiments on LHD

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In order to measure the local particle transport, the tracer-encapsulated solid pellet (TESPEL) [1] injection system has been installed in LHD during the 3rd campaign of LHD experiment [2] and the injection of TESPEL has been accomplished successfully in several plasma shots, and the highly local deposition of tracer particles was confirmed by the CCD images of ablating TESPEL and also by the high time-resolved observation of the ablation lights from TESPEL [3]. These obtained results have demonstrated the potential for the local transport diagnostic by means of TESPEL.

The TESPEL consists of polystyrene (-CH(C_6H_5)CH_2-) as an outer shell (typical diameter 700 - 900 μm) and the tracer material as an inner core. These sizes of the outer shell and the tracer particles were optimized for the LHD plasma of the 4th campaign in contrast with the case for the 3rd campaign. The obtained TESPEL velocity, accelerated by pneumatically, is approximately around the velocity of 350 m/s. In the 3rd campaign, lithium hydride (LiH) and silicon (Si) has been used as the tracer material. For the 4th campaign, in addition, titanium (Ti) was used as the tracer in order to measure the higher Z impurity transport. The several Ti micro-balls (typical diameter 60 - 100 μm) has charged a TESPEL inside. The total amount of Ti is approximately 1 x 10^{16} - 1 x 10^{17} particles.

Figure 1 shows an example of the ablation rate of Ti TESPEL, which observed by the photo-multipliers equipped with interference filters. The sharp peak (shaded portion) of the light emission through the Ti I filter (thick line) (λ_0=400.3 nm, $\delta\lambda$= 2.0 nm) denote the local deposition of Ti tracer. The obtained width of deposition even with the Ti tracer was typically only a few cm in radial direction. The behavior of the injected Ti tracer into LHD plasma has been successfully observed by X-ray pulse height analyzer (PHA). The Kα lines emitted from Ti, Cr and Fe, obtained by PHA system are shown in Fig. 2. The behavior of the only Ti has been dramatically changed in response to the Ti TESPEL injection at t = 2300 ms. The Kα line emission of Ti has risen to the peak, approximately 150 ms after the Ti TESPEL injection and returned to the base level for about 200 ms. This behavior of the Kα line emission of Ti was simply compared with that calculated by the impurity transport code (MIST code). Figure 3 shows the result by the MIST code with D = 2500 cm^2/s and v = 0 cm/s. This result can trace the behavior of the Ti Kα line emission obtained by PHA system reasonably.

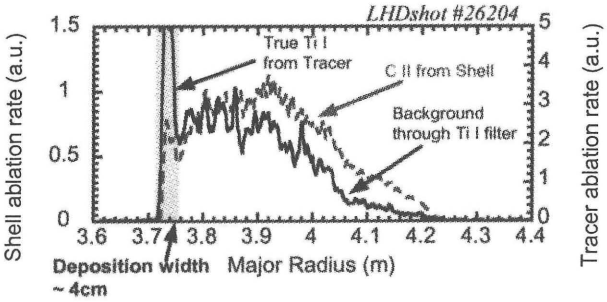

Fig. 1 Typical ablation rate of Ti TESPEL. The sharp peak (shaded portion) of the light emission through the Ti I filter (thick line) represents the local deposition of the tracer. In this case, the deposition width is approximately 4 cm.

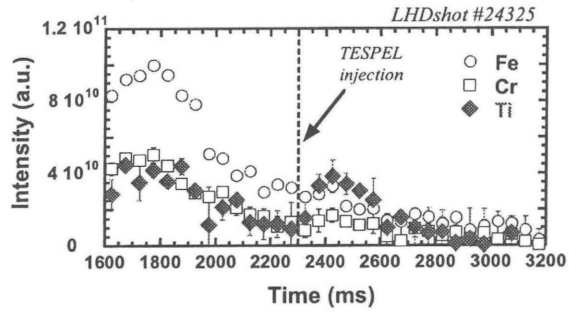

Fig. 2 Temporal evolution of the Kα line Intensity obtained by PHA system.

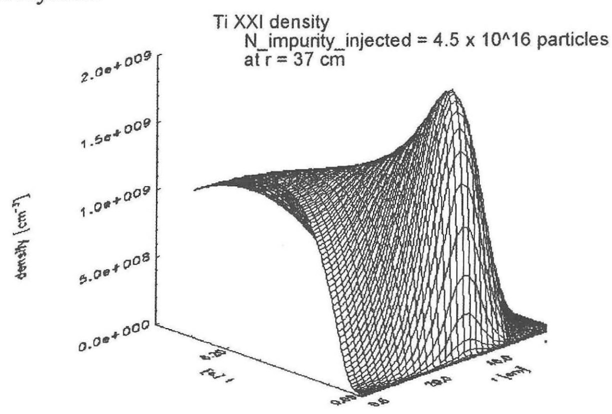

Fig. 3 Ti XXI density calculated by the MIST code.

References:

[1] Khlopenkov, K., Sudo, S., Rev. Sci. Instrum. 69, 319 (1998).

[2] Tamura, N. et al., Annual Report of NIFS, April 1999-March 2000, 160 (2000)

[3] Khlopenkov, K. et al., Annual Report of NIFS, April 199-March 2000, 63 (2000).