§ 44. Recent Experimental Results from Tracer Encapsulated Solid Pellet Injection on LHD

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In order to promote impurity particle transport studies, a tracer-encapsulated solid pellet (TESPEL) has been developed. TESPEL is a double-layered impurity pellet, which consists of polystyrene polymer (-CH (C_6H_5) CH_2-) as an outer shell (typically, 0.3-0.9 mm ϕ) and tracer particles as an inner core (typically, 0.2 mm size). TESPEL injection has been implemented for various important studies, such as for heat transport and high-energy particle transport, as well as for impurity transport study on the Large Helical Device (LHD) [1].

As an important matter found from the experimental results related to the impurity transport so far obtained by the TESPEL injection, in the higher density case (n_{e_bar} = 3.5 x 10^{19} m^{-3}), the inward convection is required to account for the experimental result obtained, even with the inward convection velocity at the plasma edge less than 1 m/s, which is rather different from the case with the lower density (n_{e_bar} = 1.8 x 10^{19} m^{-3}) [2]. In the last LHD campaign, the TESPEL injection experiment with the electron density over 3.5 x 10^{19} m^{-3} has been performed. As seen in Fig. 1(a), the Ti tracer impurity deposited inside the LHD plasma (ρ = 0.7~0.8) was still accumulated even with n_{e_bar} = 5.6 x 10^{19} m^{-3}. On the other hand, at that density, the intrinsic impurities, such as Fe and Cr, coming out from the vacuum vessel wall (ρ > 1.0) were diffused away from the core plasma. This experimental result indicates that the pumping out mechanism of the impurities should exist on the periphery of the plasma (ρ > 0.7~0.8). In the next LHD campaign, in order to investigate the pumping out mechanism of the impurities quantitatively, the TESPEL injection aimed at the tracer depositing outside the periphery of the plasma will be tried.

In the study of the high-energy particle by means of the pellet charge exchange diagnostic, which consists of a TESPEL injection and a natural diamond detector-based energy analyzer, in order to estimate the space-resolved energy spectrum of plasma ions quantitatively, it is important to know the electron density, which changes with the TESPEL traveling across the plasma, in the TESPEL ablation cloud. In order to evaluate the electron density in the luminous cloud surrounding the TESPEL injected into the LHD plasma, measurements of Hydrogen Balmer beta line broadening are made [3], since the outer shell of TESPEL is made of polystyrene. The highly time-resolved spectra of light emissions from the TESPEL ablation cloud were measured with a spectrometer coupled with an intensified CCD, which operated in the fast kinetic mode. In LHD #36912, the electron density, which is derived from the line width of the Balmer beta due to the Stark broadening, in the ablation cloud of TESPEL, which has a diameter of 0.8 mm and no tracer, increased up to 1.3 x 10^{22} m^{-3}. The question of whether the deduced electron density from the line broadening observed in the ablation cloud reflects the maximum electron density in that region or not is discussed with the hydrogen ice pellet case. The result derived from the discussion indicates that the measured width of the line broadening in the pellet cloud does not always show the maximum electron density in that region.

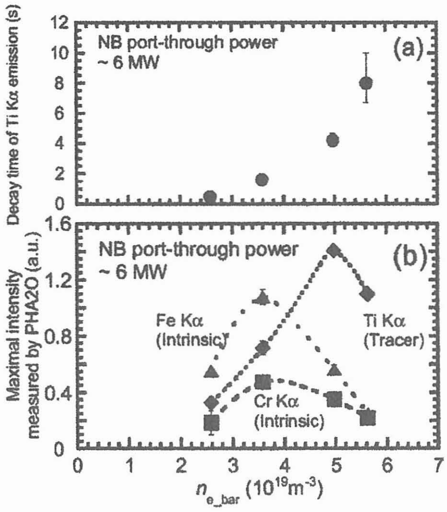

Fig. 1. The dependence of (a) the decay time of Ti Kα emission and (b) the maximal intensity of the emissions of Fe Kα, Cr Kα and Ti Kα measured by PHA at Port 2-O on the line-averaged electron.

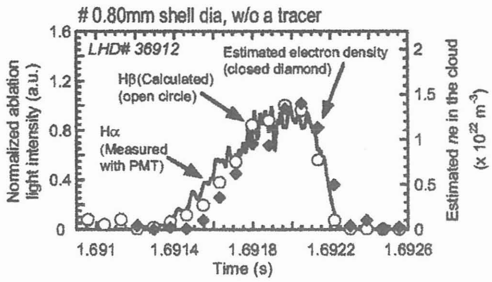

Fig. 2. An example of the temporal evolution of the estimated electron density (closed circle) and the Balmer beta line intensity (closed diamond), which is calculated from the fitted Lorentzian curve, in the TESPEL ablation cloud. The solid line indicates the Balmer alpha line emission from the ablation cloud (solid line) measured with the photo-multiplier.

References:

1) Sudo, S.: Plasma Phys. Control. Fusion **44**, (2002) 129
2) Tamura, N. et al.: Plasma Phys. Control. Fusion **45**, (2003) 27
3) Tamura, N. et al.: Proc. 30th EPS Conf. Controlled Fusion Plasma Phys. (2003) P-1.59 (St. Petersburg, Russia).