§29. Development of a New Type TESPEL for Achieving the Shallower Penetration into LHD Plasmas

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We have developed a Tracer-Encapsulated Solid Pellet (TESPEL)[1, 2] in order to promote a precise study of the impurity transport. To put it plainly, the TESPEL is a double-layered impurity pellet. In general, the TESPEL consists of a polymer as an outer shell and a tracer impurity as an inner core. This form enables us to have the following unique features; a) the TESPEL can produce a both poloidally and toroidally localized 'tracer' impurity source in the plasma. b) the total amount of the tracer impurity deposited in the plasma can be identified clearly, since the size of the inner core of TESPEL can be measured. c) various elements can be selected as the tracer impurity.

Recently, some of these features of the TESPEL have been greatly improved. Previously, the region where the tracer is deposited is mainly regulated by the outer diameter of the TESPEL. In this case, the smaller TESPEL can contain the lesser amount of the tracer impurity and then we face the problem that the TESPEL for a shallow penetration results in a shortage of the tracer amount for the diagnostics. In order to solve this problem, we developed the TESPEL with the thinner outer shell based on the fabrication technology of a polystyrene (-C_8H_8-) polymer shell[3]. Figure 1 shows a comparison result of the deposition location of the tracer impurities (here, a vanadium, V, and a cobalt (II) chloride, $CoCl_2$, are simultaneously used) with between the conventional (thick-shell-type) TESPEL and a new thin-shell-type TESPEL. The outer diameter of both TESPELs is the same, around 700 μm. The thickness of the outer shell is around 200 ~ 250 μm in the conventional TESPEL. On the other hand, the thickness of that is about 70 ~ 80 μm in the new type TESPEL (70 % thinner than the conventional one). Here, as can be seen from Fig. 1(a, b), the profiles of electron density and electron temperature of a target plasma for the both cases are almost the same. And parameters for the TESPEL injection, such as an acceleration gas pressure are set to be the same. As indicated in Fig. 1(d), with the thin-shell-type TESPEL, the location where the tracer impurity is most deposited is around $r_{eff}/a_{99} \sim 0.81$, in fact , ~ 0.06 in r_{eff}/a_{99} (~ 3 cm in r_{eff}) shallower deposition of the tracer impurity, compared with that with the conventional thick-shell-type TESPEL, is achieved. As can be also recognized from Fig. 1(d), the amount of the V tracer impurity inside the thin-shell-type TESPEL can be much increased (here, by a factor of around 2.5), compared with that with thick-shell-type TESPEL. Therefore this result clearly indicates that the flexibility of the TESPEL is successfully expanded with the new thin-shell-type TESPEL.

1) Sudo, S.: J. Plasma Fusion Res. **69** (1993) 1349.
2) Sudo, S. and Tamura, N.: Rev. Sci. Instrum. **83** (2012) 023503.
3) Takagi, M. et al.: Fusion Technology **41** (2002) 278.

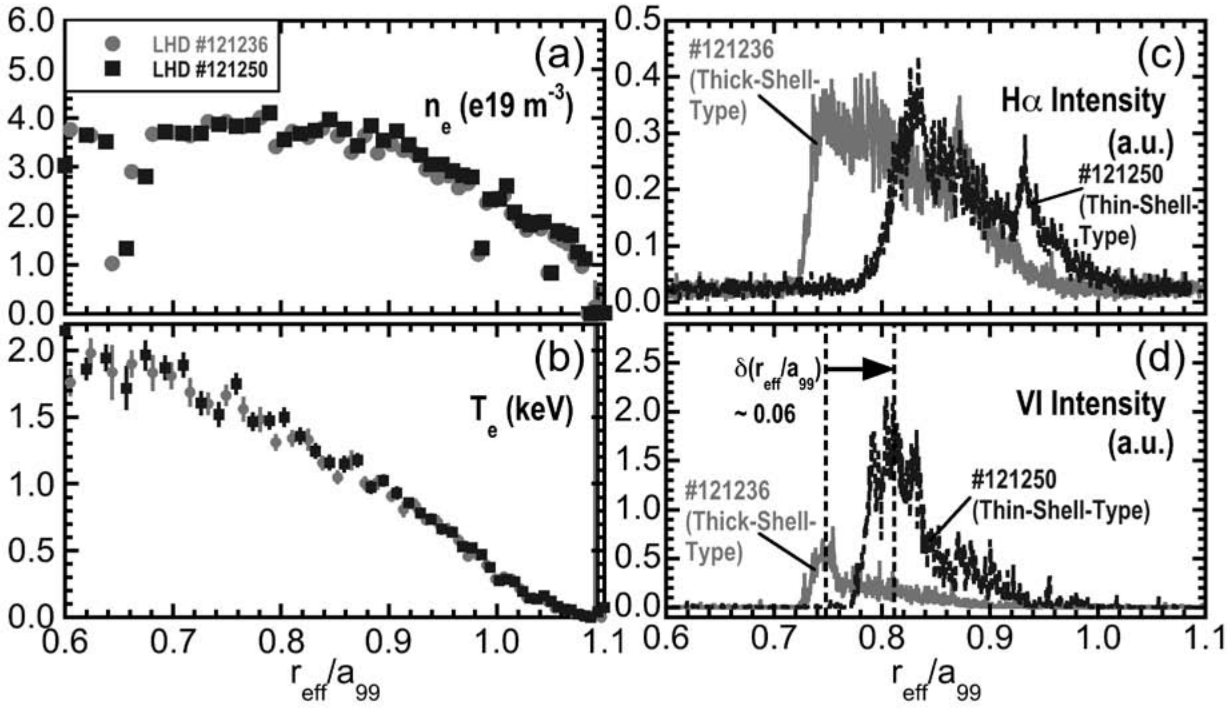

Fig. 1. A comparison result of the deposition location of the tracer impurities (in this case, a vanadium, V, and a cobalt (II) chloride, $CoCl_2$, are used) with between the conventional (thick-shell-type) TESPEL (O.D ~ 700 μm, thickness = 200 ~ 250 μm) and a new thin-shell-type TESPEL (O.D ~ 700 μm, thickness = 70 ~ 80 μm).