§11. Study on Impurity Behaviour by a Multiple Tracer TESPEL Injection

Sudo, S., Tamura, N., Muto, S., Suzuki, C., Funaba, H.

Impurity behaviours in LHD are studied by a Tracer-encapsulated Solid Pellet (TESPEL) injection [1]. By containing multiple tracers in a TESPEL, the different tracer species have been compared simultaneously under the same plasma condition [2]. As the diameter of TESPEL is about 700 μm, the density disturbance on the bulk plasma is less than typically 10 %. The amount of the tracer particles deposited locally inside a plasma is about several 10^{17} particles which is smaller than that of the bulk plasma by a factor of three orders of magnitude. Triple tracers, V, Mn and Co are mainly used, because the charges of nuclei of intrinsic impurities, Cr and Fe are in between those of the tracers. By observing simultaneously the temporal evolution of Kα intensity and Li-like line emission of the tracers and intrinsic impurities (Fe and Cr), the clear difference of transport properties between the intrinsic impurities and the tracers deposited inside the plasma has been observed.

The temporal evolution of Kα intensity of Cr and Fe and the line averaged density is shown in Fig. 1 for the medium (#106986, $n_e=3.4\times10^{19}$ m^{-3}) and high density (#106999, $n_e=6.6\times10^{19}$ m^{-3}) cases. It shows that the density increase is small by the TESPEL injection. In the medium density case, the intrinsic impurities are contaminated in the plasma, while they are suppressed to get into the plasma in the high density case. As shown in Fig. 2, all the three tracer species are kept for a long time in the high density case in contrast to the case of intrinsic impurities, while the Kα intensity of tracers decays within 1 s in the medium density case. The density dependence of the estimated particle numbers of Fe in the plasma by comparing the Kα intensities of the tracers Co and Mn is shown in Fig. 3. The upper value is given based on Co data and the lower is given based on Mn data. This is understandable because Z of Co is 1 higher than Fe, the emission intensity of the Fe Kα becomes higher than that of Co at the same temperature in our electron temperature range. The inverse of the decay times of Kα emissions of Mn and Co versus density are shown in Fig. 4. As the density is increased, the decay time becomes longer. When the density n_e is higher than 5.0×10^{19} m^{-3}, the impurity line intensities are kept constant, so the inverse of the decay time becomes zero.

1) S. Sudo and N. Tamura Rev. Sci. Instrum. 83 023503 (2012).
2) S. Sudo, et al. Nucl. Fusion 52 (2012) 063012.

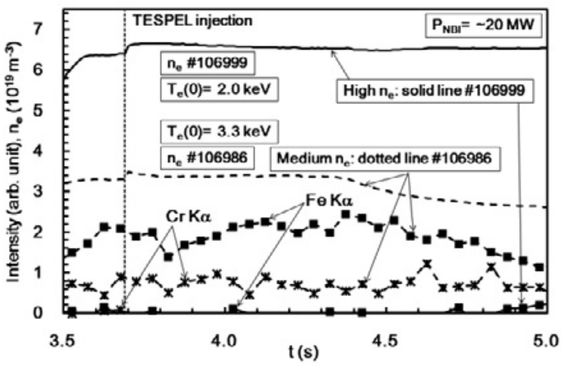

Fig. 1 Temporal evolution of line averaged density and Kα intensities of intrinsic impurities, Fe and Cr for the cases of medium and high density plasmas.

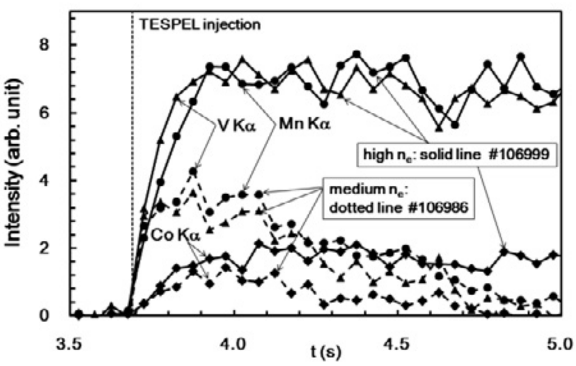

Fig. 2 Temporal evolution of Kα intensities of tracer impurities, V, Mn and Co deposited inside the LHD plasma for the two density cases corresponding to Fig. 1.

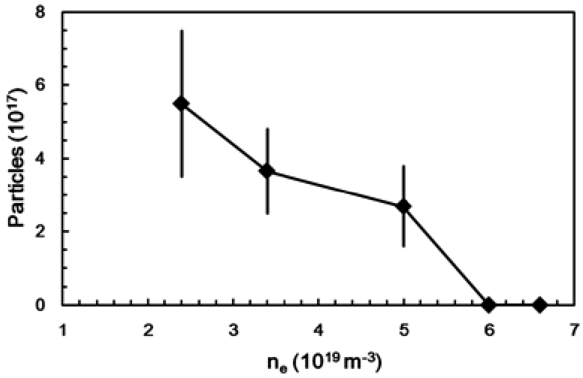

Fig. 3 Density dependence of estimated particle numbers of Fe in the plasma from comparison of the Kα intensities of tracers Co and Mn.

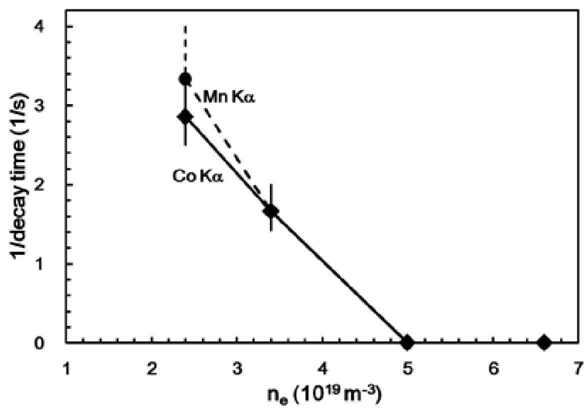

Fig. 4 Inverse of decay time of Kα emissions of Mn and Co. When the density, n_e , is higher than 5.0×10^{19} m^{-3}, the intensity is kept constant, so the inverse of the decay time becomes zero.