§5. Impurity Transport Study in the Impurity Hole Phenomenon by Laser Blow-off

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The impurity hole phenomenon is observed in the plasmas with high ion temperature or high ion temperature gradient on LHD [1),2)]. In the impurity hole plasmas, the carbon density which is measured by the charge exchange spectroscopy (CXS) at the center is decreased. In order to evaluate the behavior of impurities in the impurity hole phenomenon, titanium (Ti) was injected by the laser blow-off [3)] system. The emission lines from Ti XX at 259.3 Å and 309.1 Å were observed by the Schwob-Fraenkel type VUV spectrometer. The transport property of the impurity is evaluated by comparing with calculation results of the impurity transport code, STRAHL [4)], where the impurity transport is characterized by the diffusion coefficient, D, and the convection velocity, v.

Temporal development of the intensities of the emission lines from Ti XX in the cases of (a) the magnetic axis position $R_{\rm ax}^{\rm vac} = 3.75$m and the magntic field strength $B = -2.64$T (Laser timing $t = 4.200$ s), where impurity hole was not observed, and (b) $R_{\rm ax}^{\rm vac} = 3.60$m, $B = -2.85$T (Laser timing $t = 4.239$ s), where rapid decrease in the signal intensity of CXS was observed, are shown in Fig. 1. If it is assumed that the average charge state of titanium is 18, the number of titanium atoms which penetrated into the plasma was about 1.67×10^{18}. The decay time of the Ti XX 259.3 Å line in Fig. 1(a) is about 500ms, while the Ti XX 259.3 Å line in Fig. 1(b) disappeared within 200 ms after the injection. The experimental results are compared with the calculation results by the impurity transport codes, STRAHL. Figure 2 shows the calculated intensities of Ti XX lines by STRAHL code (a) for the case of Fig.1(a) with inward v at the peripheral region and (b) for the case of Fig.1(b) with outward v. The spatial profiles of the electron temperature, $T_{\rm e}$, electron density, $n_{\rm e}$, assumed D and v are also shown. The decay time of Ti XX line at 259 Å in the case of Fig.1(a) is reproduced in Fig.2(a) with $D = 0.2$ m^2/s and inward v at peripheral region. A rapid decay of the Ti XX line in Fig.1(b) is reproduced with outward v in Fig.2(b). This result shows that the outward v exists in the plasmas with the impurity hole phenomenon.

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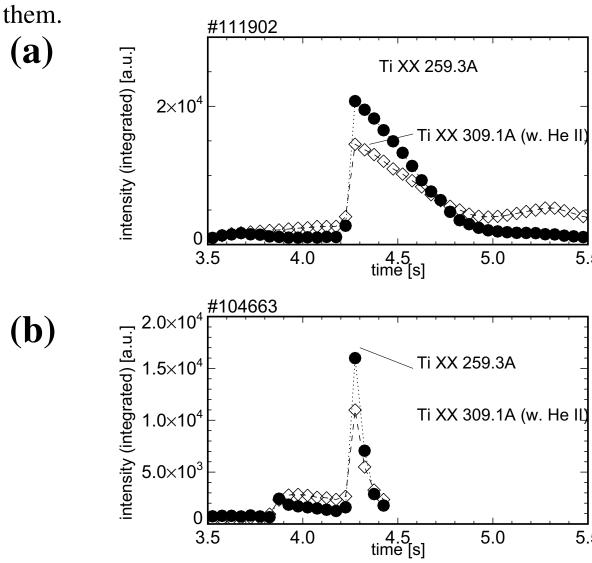

Fig. 1: Temporal development of the intensity of the emission lines from Ti XX. (a) $R_{\rm ax}^{\rm vac} = 3.75$m, $B = -2.64$T, Laser timing $t = 4.200$ s. Impurity hole was not observed.
(b) $R_{\rm ax}^{\rm vac} = 3.60$m, $B = -2.85$T, Laser timing $t = 4.239$ s. Rapid decrease in the signal intensity of CXS was observed.

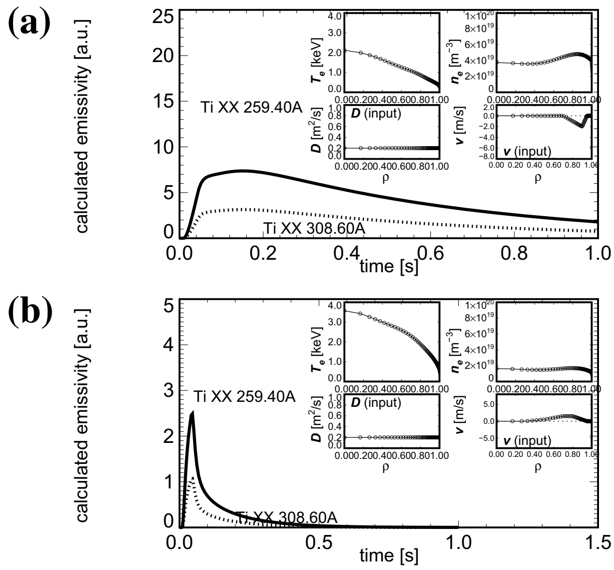

Fig. 2: Calculated intensities of Ti XX lines by STRAHL code (a) for the case of Fig.1(a) with inward v at the peripheral region and (b) for the case of Fig.1(b) with outward v.

1) K. Ida, M. Yoshinuma, et al., Phys. Plasmas **16** (2009) 056111
2) M. Yoshinuma, K. Ida, et al., Nucl. Fusion **49** (2009) 062002
3) E.S. Marmar, et al., Rev. Sci. Instrum. **46** (1975) 1149
4) R. Dux, 2006 STRAHL Manual Report IPP 10/30, Max-Planck-Institut für Plasmaphysik, Garching