§14. Plasma Atomic Processes on Metal Surface by Ion Bombardment

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In plasma science, it is very important to understand the kinematics of neutral atoms produced from the wall surface by sputtering and backscattering processes. Because, they penetrate into the plasma across the magnetic fields and play a role of cooling processes of the plasma. Therefore, the clarification of these mechanisms is demanded from the point of the control of the fusion plasma. We have already reported about the mean normal velocities of excited tungsten atoms sputtered by krypton and argon ion bombardments [1-3]. In this paper, we report about the mean velocities of excited hydrogen atoms produced by charge exchange under the irradiation of H^+ ion.

The experiments were performed in a beam line connected with a medium-current ion implanter of the National Institute for Fusion Science (NIFS). Details of the ion source and beam line are described elsewhere [1,3]; hence, they will be only briefly explained here. The H+ ion beam, accelerated to 35 keV, was introduced into a reaction chamber after mass/charge separation, and it entered vertically on the polycrystalline tungsten surface. We observed the Hα line after passing through a Hα band-pass filter and condenser lens, using the two-dimensional (2D) charge coupled device (CCD).

Figure 1 shows the two-dimensional spatial Hα line intensity distributions. The polycrystalline tungsten(W) surfaces located at Z = 650 (pixel). Incident H^+ ions entered vertically the position of Y = 650(pixel) of the surface from right side in this figure. Excited hydrogen atoms neutralized by charge transfer processes on the tungsten surface were strongly backscattered in the direction of 180 degrees with respect to the incident H^+ ions, as shown in Fig.1.

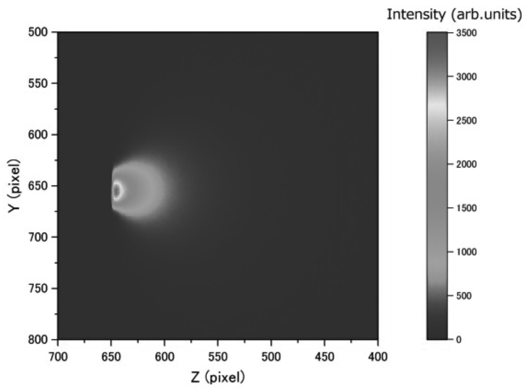

Fig. 1. The spatial intensity distribution of Hα radiation from reflected H* atoms.

The mean velocity of excited hydrogen atoms is estimated by analyzing the intensity of Hα radiation against the perpendicular distance from the surface. The intensity $I(z)$ at the perpendicular distance z is written by the following equation,

$$I(z) = \sum_k I_{0k} \exp\left(-\frac{z}{< v_\perp > \tau_k} \right) \quad (1),$$

where I_{0k} is the intensity from a particular transition k at the surface (z=0), $v_\perp$ is the vertical velocity component normal to the surface, τ_k is the lifetime of the excited state. Figure 2 shows the normalized Hα intensity plotted by semi-log scale as a function of the perpendicular distance from the W surface z. In the figure, although the decay curve seems a straight line, we have found two components from the curve by a curve fitting analysis. The steep slope is decay component of n=3 state, another is cascade. This lifetime of n=3 state of H atom was calculated from two Einstein A coefficients for spontaneous emissions, which corresponded to the n=3→2 and the n=3→1 transitions, respectively. The mean kinetic energy estimated from line of the steep slope was around 2.8 keV when we assumed τ_1~10.0 ns for the steeper decay. This mean kinetic energy agrees well with the result obtained by the TRIM(TRanspotation of Ion in Material) calculation.

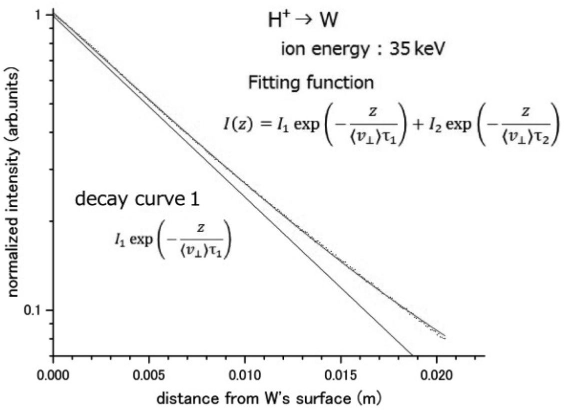

Fig. 2. The normalized photon intensity of Hα plotted by semi-log scale as a function of the perpendicular distance from the W surface z.

[1] K.Motohashi, K.Nogami, Y.Sakai, et.al.: Nucl. Instrum. Meth.B, **283**,(2012) 59.
[2] Y.Sakai et al.: Research Report NIFS-PROC-**91**, 1,(2013).
[3] K.Nogami, Y.Sakai, et al.: J. Vac. Sci. Technol. A 33, 061602(2005)