§14. Plasma Atomic Processes Explored by Optical Emission Spectroscopy of Excited Atoms Sputtered from the Metal Surface by Ion Bombardment

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Plasma atomic processes such as sputtering and backscattering processes have been explored by optical emission spectroscopy of excited atoms from the tungsten metal surface by ion bombardment. Since neutral atoms produced from the wall surface penetrate into the plasma across the magnetic fields and they play a role of cooling processes of the plasma, the clarification of these mechanisms is demanded from the point of the control of the fusion plasma. We have already reported that the mean normal velocities of excited tungsten atoms sputtered by krypton and argon ion bombardments depended on the energy difference between work function and ionization potential of the excited state, whereas they were almost independent on the incident beam energy and species[1),2)].

In the present work, we paid attention to the reflection processes of the hydrogen atoms by the proton irradiation to the polycrystalline tungsten surface at 35keV, and then we observed the Hα line. The spatial intensity distribution and polarization degree of Hα line from reflected H* were observed.

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 vacuum chamber after mass/charge separation. The ion beam entered perpendicular onto the tungsten surface. Incident H+ ions were neutralized by charge transfer processes at the tungsten surface, and excited hydrogen atoms, H*, were produced. The polarizer was installed between quartz window and Hα band-pass filter. After passing through a quartz window, Hα band-pass filter and condenser lens, the Hα image from the reflected H* atoms was projected on the two-dimensional (2D) charge coupled device (CCD). Each exposure time was 10 minutes.

Figure 1 shows a typical CCD image of Hα emission from reflected H* atoms. Neutralized H* emitted Hα line and were strongly reflected in the direction of 180 degrees with respect to the incident beam axis. As the next step, we measured the polarization degrees of Hα line from reflected H* atoms. The polarization with respect to surface is expressed as,

$$P = \frac{I_{\parallel} - I_{\perp}}{I_{\parallel} + I_{\perp}} \quad ,$$

where $I_{\parallel}$ and $I_{\perp}$ are Hα line intensities polarized along the surface and perpendicular to the surface, respectively. The spatial distribution of the polarization degrees P are shown in Fig.2. The polarization degrees of Hα had negative values when the H* reflected in the direction perpendicular to the surface, while they became positive values when the reflected H* atoms had parallel velocity component to the tungsten surface. In other word, this experimental result shows that the Hα lines are aligned to the reflected direction of H*atoms. This fact has been predicted by Kato et.al.[4)]

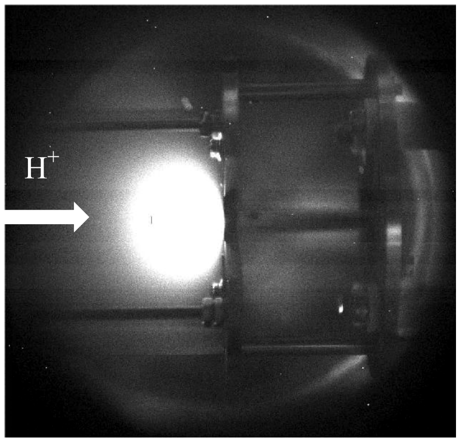

Fig. 1. A typical CCD image of Hα emission from reflected H* atoms.

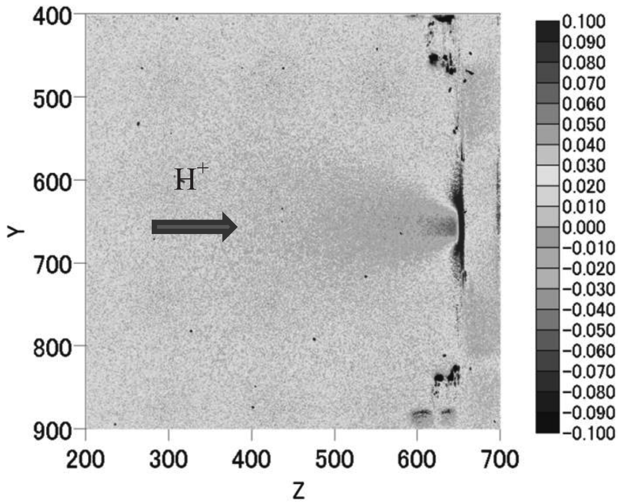

Fig. 2. The spatial distribution of the polarization degrees P of Hα radiation from reflected H* atoms.

A part of these results had been reported at the Plasma conference 2014 in Tokimesse, Niigata.

1) Motohashi K. et.al.: Nucl. Instrum. Meth.B, **283**, 59(2012).
2) Sakai Y. et al.: Research Report NIFS-PROC-**91**, 1,(2013).
3) Sakaue H.A. et.al.: Proceedings of Plasma conf. 2014, 18PB-075(2014).
4) Kato et.al.: J. Phys. Conf. Series, **488**, 132012(2014).