§42. Impact of Excited States of Reflected Hydrogen Atoms on Hydrogen Recycling

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Hydrogen recycling control is one of the most important issues for a stable steady state operation. So far, it has been suggested that some of hydrogen atoms reflected on material are electrically exited depending on the collision conditions such as energy of hydrogen atoms and a kind of material. However, there is less experimental data and analysis and electrically exited state of a reflected atom is not took into account in the boundary plasma modeling. It is important to investigate the mechanism of such phenomena to understand the hydrogen recycling. We have discussed electrically excited state of reflected atoms through results in GAMMA 10[1].

In GAMMA10, the plasma is produced with ion cyclotron range of frequency (ICRF) waves and confined by the magnetic mirror and the electrostatic potential produced by electron cyclotron heating (ECH). Plasma particles flowing out to the end region hit the end plates and neutralized gas is pumped out with a large-scale cryo-pump system. In this experiment, a target plate with the diameter of 0.1 m was installed at 0.7 m downstream from the end-mirror coil. The target material was tungsten or carbon. The H_α emission profile near the target plate was measured using a high-sensitive CCD camera with an interference filter.

When the target was exposed to the plasma, the Hα emission was localized just in front of the target as shown in Fig.1. A retarding field analyzer indicated an effective ion temperature was about 250 eV. The electron density and temperature could not be measured at that time but typically they were $<10^{-17}$ m^{-3} and ~30 eV, respectively. The Hα emission decreased exponentially with distance from the target as shown in Fig. 2. There were two exponential components for the tungsten target: a short decay length ~5 mm and a long decay length ~80 mm as shown in Fig. 2(a). On the other hand, there was one exponential component for the carbon target as shown in Fig. 2(b). Taking into account the low plasma density ($<10^{-17}$ m^{-3}), both decay lengths are too short to be attributed to emission from reflected hydrogen neutrals and neutrals produced by dissociation via the molecular ion, if they are at electronic ground state. The mean free path of the hydrogen atom reflected on the target is the order of 10^2 m. Here, the energy reflection coefficient is assumed to be 0.5. Possible candidates for such short decay lengths are exited hydrogen atoms produced via reflection on the target and dissociation of vibrationally excited molecules. Actually, Hα emission resulting from hydrogen atoms which are excited by reflection on a Mo target is observed by Tanabe et al[2]. If the reflected atoms are excited via reflection on the tungsten target, the penetration length calculated by the life time and the thermal velocity of the reflected atom is ~4 mm. It is comparable to the short decay length (~5 mm) shown in Fig. 2(a). The decay length for Hα emission may be apparently increased through a cascade process from n=4 and 5 to n=3. The long decay length shown in Fig. 2(a) and Fig. 2(b) could possibly be attributed to the cascade process. In another experiments performed in NIFS, there were two decay lengths for emission from tungsten which is sputtered by Kr ions, suggesting the cascade process from higher excited level.

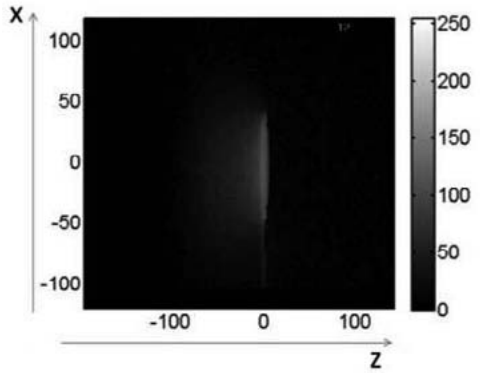

Fig. 1 Hα emission profile in front of the tungsten target exposed to the west-end plasma.

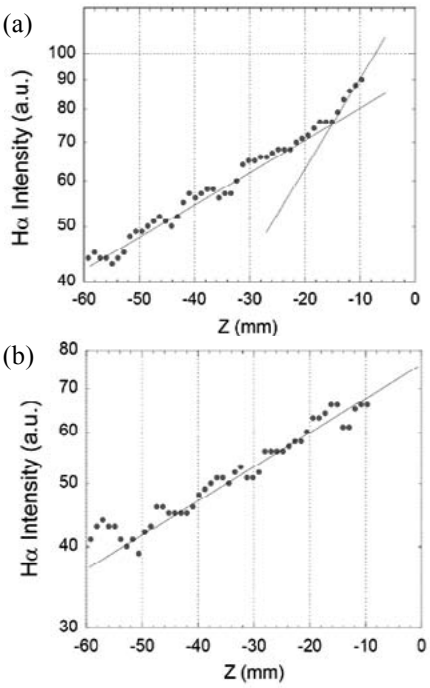

Fig. 2 Ha line intensity as a function of length in Z direction (X=0) from the target. (a) tungsten target and (b) carbon target.

1) Nohara, R., Sakamoto, M. et al.: 30th JSPF Annual Meeting, Tokyo (2013) 05pE45P.
2) Tanabe, T. et al.: J. Nucl. Mater. 220-222 (1995) 841-845.