Spectroscopic Measurement of reflected neutral particles on MAP

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Abstract

Low energy hydrogen plasma was applied onto the copper, molybdenum, tungsten and graphite targets by the steady state linear plasma facility MAP(Material And Plasma). The Hα (656.285nm) spectrum emitted from the reflected hydrogen atoms were measured to investigate the hydrogen reflection process. We found that the spectrum was composed of two groups. One is the low energy component (group 1) and the other is the high energy (group 2). The results indicates that the backscattered hydrogen atoms is included in the group 2 spectrum. We found that the energy of the reflected hydrogen atoms is lower in the graphite target experiment than in the metal target experiments.

1 Introduction

Neutral particles reflected on the surface of the plasma facing material make interactions with plasma and have excitation, ionization and charge exchange. These interactions cause radiation, energy loss and momentum transfer in the edge plasma region in the fusion devices. Thus the neutral particles have a strong effect on the plasma transport. The neutral particles from the wall is considered to be generated by the different type of processes; backscattering of incident ions and desorbing of neutrals in the material by diffusion and ion bombardment.

In this study, low energy hydrogen plasma was applied onto the copper, molybdenum, tungsten and graphite targets in the linear plasma facility MAP. We made spectroscopic measurements of the hydrogen spectrum to investigate the energy and angular distribution of reflected hydrogen atoms. We evaluated broadening, peak shift, intensity of the Hα spectrum and compared the results of each target experiments.

2 Experiment

The linear steady plasma facility MAP is schematically shown in Fig.1. Low energy hydrogen plasma is generated at the plasma source and applied onto the target. The length and the diameter of the plasma column is 70cm and 3cm, respectively. From the Langmuir probe measurement, the plasma density is about $10^{18}/\mathrm{m}^3$ and the electron temperature is about 10 eV in the hydrogen plasma. The target is installed to be inclined to the magnetic field so as we can make spectroscopic measurements at a different incident angles to the target.

The emission of the plasma is observed by a scope with a optical lens. This scope can be moved horizontally and vertically, so that we can get the spatial profile of the Hα spectrum. A 1m Czerny Turner monochrometer with a photomultiplyer was used in the spectroscopy. The resolution of the monochrometer in wavelength is 0.012 nm. To calibrate the wavelength of the obtained Hα spectrum, we used the Dα spectrum (656.103nm) from a deuterium lamp.

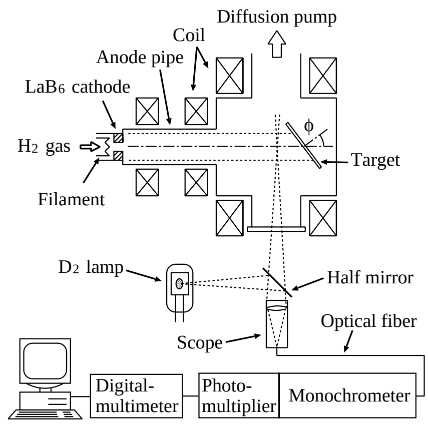

Fig.1: Schematic diagram of the linear plasma facility MAP.

We made the spectroscopic measurement in whole the region of the plasma column, because the spatial change of the intensity, the wavelength shift and broadening of the Hα spectrum shows the energy and the angular distribution of the reflected hydrogen atoms. In the experiments of each target material, we set the target at the incident angle of 0°, 30°, 45° and 60° on the target surface to investigate the reflection angle of the hydrogen atoms.

3 Results and discussion

The Hα spectrum was found to be decomposed into two curves[1]. One is the narrower curve that represents low energy hydrogen atoms (**group 1**) and the other is the broader curve that represents high energy hydrogen atoms (**group 2**). We evaluated broadening, peak shift and intensity of each decomposed curves.

Figure 2 shows the spectrum broadening and Fig. 3 shows the peak shift of decomposed group 1 and group 2 curves.

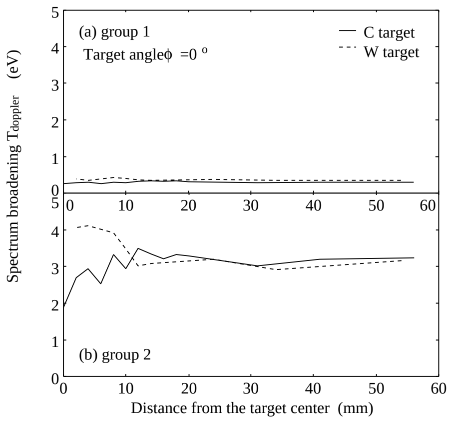

Fig.2: Spectrum broadening of the group 1 and group 2 curves in the graphite target experiment and the tungsten target experiment at the target angle of $\phi = 0^o$: (a) group 1 curve; (b) group 2 curve.

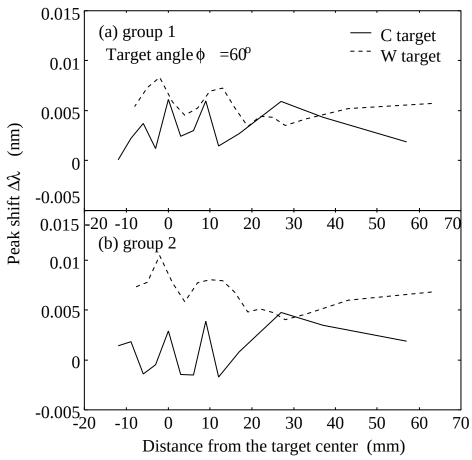

Fig.3: Peak shift of the group 1 and group 2 curves from 656.2849nm in the graphite and the tungsten target experiments at the target angle of $\phi = 60^o$: (a) group 1 curve; (b) group 2 curve.

In the metal target experiments, spectrum broadening and peak shift of group 2 curve increases near the target (the results of tungsten target experiment are shown). This shows that the spectrum of the backscattered hydrogen atoms is included in the group 2 curve. The peak shift near the tungsten target is about 0.006 nm, which corresponds to the energy of 0.04 eV in the collective motion of reflected hydrogen atoms. This value is too small compared with spectrum broadening of group 2 (3 - 4eV). This indicates that the Hα lines of the backscattered hydrogen atoms are included in the shorter wavelength side of the group 2 curve[1]. But in the graphite target experiment, spectrum broadening slightly decreases near the target and peak shift is not observed. This indicates that the backscattering is not main process in the graphite target[2].

Figure 4 shows the intensity of the Hα spectrum and the decomposed intensities of the group 1 and the group 2 curves.

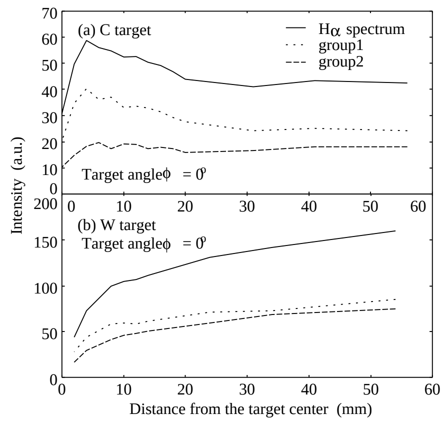

Fig.4: Intensity of the Hα spectrum and the decomposed intensities of group 1 and group 2 curves at the target angle of $\phi = 0^o$: (a) graphite target experiment; (b) tungsten target experiment.

In the graphite target experiments, the intensity of Hα spectrum increases near the target, which is found to be mostly contributed by the group 1 curve. The intensity of the group 1 curve is twice as large as that of the group 2 curve within 20mm from the target surface. This suggests that the energy of the hydrogen atoms near the target is lower in the graphite target experiment than in the tungsten.

References

[1] K. Kobayashi, S. Ohtsu and S. Tanaka, submitted to J. Nucl. Mater.

[2] K. Kobayashi, S. Ohtsu and S. Tanaka, submitted to Fusion Technol.