Polarization measurements of Hα radiation from backscattered H* atoms by proton impact on polycrystalline tungsten surface

We observed Hα line from the reflected hydrogen atoms when the protons were irradiated to the polycrystalline tungsten surface at 35keV. The spatial intensity distribution and polarization degree of Hα line from reflected H* were observed. From these experimental results, it was shown that Hα line is aligned to the reflected direction of hydrogen atom.

1. Introduction

Tungsten is planned to use as material for the divertor plates in ITER because of the high sputtering threshold energy for light ion bombardment, the highest melting point among all the elements, and less tritium retention compared with carbon-based materials [1-3]. Divertor plates in a fusion device are exposed to high intensity heat fluxes of energetic particles. Many experiments indicate that tungsten retains tritium and deuterium due to their bombardment of hydrogen isotope plasma. The resultant retentions of the isotopes raise to the safety and economic problems, and should be minimizes for future fusion reactor operations. Thus, many efforts are being made to predict hydrogen isotopes retention in various forms of tungsten under the actual fusion reactor condition. The retention, reflection, recycling, sputtering of hydrogen isotope atom in tungsten surface attracts extensive attention from the viewpoint of estimating the inventory of tritium atoms in a nuclear fusion device. We paid attention to the reflection processes of the hydrogen atoms by the proton irradiation to the tungsten surface, and then we measured spatial intensity distribution of the Hα line from reflected hydrogen and the degree of polarization distribution.

2. Experimental apparatus

The experiment was performed in a beam line connected with a medium-current ion implanter (ULVAC IM-200MH-FB) at the National Institute for Fusion Science (NIFS), as shown in figure 1.

![Fig. 1. Experimental apparatus](image-url)
Details of the ion source and beam line are described elsewhere [4]; 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 transmitted through a 5-mm-diameter aperture hole entered normally on a polycrystalline tungsten surface, supported by a linear-motion manipulator. A bias voltage of ~100 V was applied to the disk, with the aperture hole used to retard secondary electrons emitted from the tungsten surface. The pressure of the vacuum chamber was maintained at ~1 × 10⁻⁵ Pa without introducing the ion beam, whereas it reached ~3 × 10⁻⁵ Pa under ion-beam irradiation of the tungsten surface. The ion beam entered perpendicular onto the tungsten surface. 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).

3. Result and discussion

We measured the spatial distribution of Hα line intensity from reflected H⁺ atoms under irradiation of H⁺ ion-beam (35keV). Figure 2 shows the two-dimensional spatial Hα line intensity distributions. The polycrystalline tungsten surface is located at Z = 650 (pixel). Reflected hydrogen atoms which emit Hα are strongly reflected in the direction of 180 degrees with respect to the incident protons.

Next, we measured the polarization degrees of Hα line from reflected H⁺ atoms. The polarization with respect to surface is expressed as,

\[ P = \frac{I_\| - I_\perp}{I_\| + I_\perp} \]

where \( I_\| \) and \( I_\perp \) are Hα line intensities polarized along the surface and perpendicular to the surface, respectively. In fig.3, we show the polarization degrees of Hα line at Z=644, with emission lines intensities \( I_\| \) and \( I_\perp \). The degree of polarization of Hα line from the hydrogen atom, which is reflected in the direction perpendicular to the tungsten surface, becomes negative. And, as for the Hα line from reflected H⁺ atoms which have a parallel velocity component to the tungsten surface, the degree of polarization becomes positive value. In other word, this experimental result shows that the Hα lines are aligned to the reflected direction of H⁺ atoms.

On this conference, the details of the spatial distribution of the degree of polarization are explained.

![Fig.2. The spatial intensity distribution of Hα radiation from reflected H⁺ atoms.](image)

![Fig.3. The polarization degrees P and intensity of Hα radiation from reflected H⁺ atoms at z=644 (pixels).](image)

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References