18PB-075

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

プロトンのタングステン金属表面照射による反射水素Hα線の偏光度空間分布測定

Hiroyuki. A. Sakaue[1], Daiji Kato[1], Izumi Murakami[1], Shouta Mineta[2], Yasuhiro Sakai[2], Kenji Furuya[3], Takahiro Kenmosu[4], Yasuji Sasaki[5], Takahiro Miyamoto[5], Makoto Sakurai[5] and Kenji Motohashi[6]

坂上裕之[1)], 加藤太治[1)], 村上泉[1)], 峯田翔太[2)], 酒井康弘[2)], 古屋謙治[3)], 剣持貴弘[4)], 佐々木康二[5)], 宮本貴裕[5)], 櫻井誠[5)], 本橋健次[6)]

[1]*National Institute for Fusion Science, 322-6 Oroshi-cho, Toki 509-5292, Japan*
[2]*Department of Physics, Toho University, 2-2-1 Miyama, Funabashi, Chiba 274-8510, Japan*
[3]*Faculty of Arts and Science, Kyushu University, 744 Motooka, Nishi-ku, Fukuoka 819-0395, Japan*
[4]*Department of Biomedical Engineering, Faculty of Life and Medical Sciences, Doshisha University, Tatara-Miyakodani, Kyotanabe, Kyoto 610-0394, Japan*
[5]*Department of Physics, Kobe University, 1-1 Rokkodai, Nada-ku, Kobe 657-8501, Japan*
[6]*Department of Biomedical Engineering, Faculty of Science and Engineering, Toyo University, 2100 Kujirai, Kawagoe, Saitama 350-8585, Japan*

[1]核融合科学研究所 〒509-5292 土岐市下石町322-6
[2]東邦大学理学部物理学科 〒274-5810 船橋市三山2-2-1
[3]九州大学基幹教育院 〒819-0395 福岡市西区元岡744
[4]同志社大学生命医科学部医工学科 〒610-0394 京田辺氏多々羅都谷1-3
[5]神戸大学理学部物理学科 〒657-8501 神戸市灘区六甲台町1-1
[6]東洋大学理工学部生体医工学科 〒350-8585 川越市鯨井2100

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.

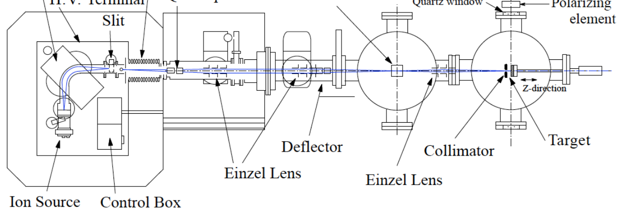

Fig.1. Experimental apparatus

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 $\sim 1\times 10^{-6}$ Pa without introducing the ion beam, whereas it reached $\sim 3\times 10^{-5}$ 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.

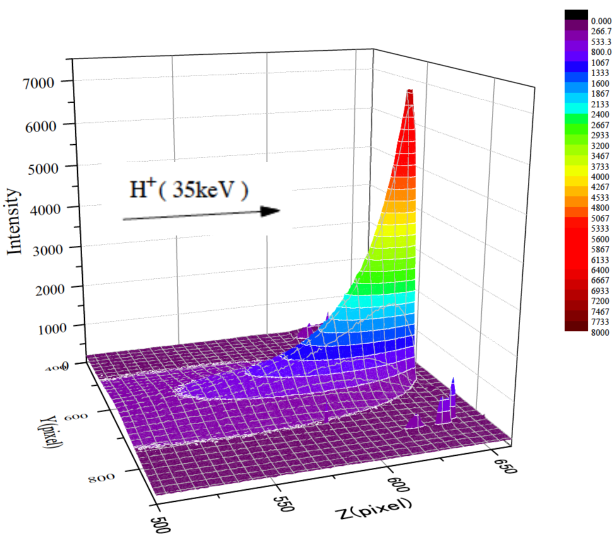

Fig.2. The spatial intensity distribution of Hα radiation from reflected H* atoms.

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

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

where $I_{\parallel}$ 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 $I_{\parallel}$ 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.

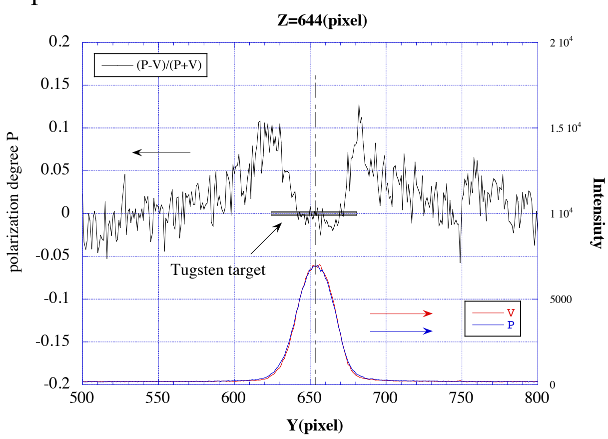

Fig.3. The polarization degrees P and intensity of Hα radiation from reflected H* atoms at z=644 (pixels).

Acknowledgments

This study was conducted with the support and under the auspices of the NIFS Collaboration Research Programs (NIFS09KBAF002 and NIFSKBAF008). This work was partly supported by the Grant-in-Aid for Scientific Research (A)(23246165).

References

[1] J.Roth, E.Tsitrone, A.Loarte, et al., J. Nucl. Mater. **390-391** (2009) 1-9

[2] Z.Tian, J.W.Davis, A.A.Haasz, J. Nucl. Mater. **399** (2010) 101-107.

[3] K.Ohya, J.Kawata, T.Tanabe, et al., J. Nucl. Mater. **258-263** (1998) 1055-1059

[4] K.Motohashi, K.Nogami, Y.Sakai, H.A.Sakaue, D.Kato and T. Kenmotsu: NIMB **283** (2012) 59-62.