§61. The Effect of Argon and Helium Glow Discharge Cleaning on Boronized Surface in LHD

Kizu, K., Yagyu, J., Ishimoto, Y., Nakano, T., Tsuzuki, K., Miya, N. (JAEA),
Ashikawa, N., Nishimura, K., Sagara, A.

The purpose of this study is acquiring basic data to design the effective surface conditioning system for next nuclear fusion experimental devices [1]. In late years, neon glow discharge cleaning (Ne-GDC) has been often performed in LHD because helium glow discharge cleaning (He-GDC) leads He accumulation in metal wall, and this helium slowly desorbs to hydrogen plasma as unwished impurity. However, the influence of glow discharge with higher atomic number than helium on boronized wall is not fully investigated, yet. Thus, in this work, boronized samples were introduced into He- and Ar-GDC in LHD and analyzed by Secondary ion mass spectrometry (SIMS).

Silicon (Si) and F82H samples were prepared for this study. These samples were boronized in Radiochemistry Research Laboratory in Shizuoka University. The boronization was conducted with glows discharge of decaborane and He gas mixture. Then, these samples were installed on the sample station at 4.5 L port in LHD, and were exposed to He-GDC (6 or 12 hours) or Ar glow discharge (Ar-GDC) (6.5 or 13 hours). Ne-GDC could not perform for schedule. The change of boron layer thickness and change of hydrogen retention in samples were investigated by SIMS. Impurity distribution like oxygen, carbon and iron will be measured by X-ray photoelectron spectroscopy (XPS) in future.

At first, SIMS measurements were performed to samples exposed to 6 and 12 hours He-GDC. The wear of boron layer was observed only for 12 hours He-GDC sample. The wear thickness was 24 nm. In previous work [2], clear change of thickness was not observed for the sample exposed to 6 hour He-GDC. These results mean that the wear of boron layer by He glow discharge is very small. Then, SIMS measurements for samples exposed to Ar-GDC of 6.5 and 13 hours were performed. Figure 1 shows that the depth profile of boron on Si sample for unexposed and after 13 hours of Ar-GDC. The obvious decrease of boron layer thickness was observed. The average decrease of thickness was 150 nm for 6.5 hours of Ar-GDC and 190 nm of 13.5 hours of Ar-GDC, respectively.

The sputtering yield of boron with 2.3 g/cm^3 in density by He normal injection with 150 eV is about 0.15. The He-GDC conditions of LHD are 130-180 V in glow discharge voltage and 20.5 A in current and 700 m^2 in surface area of vacuum vessel. Therefore, calculated current density is 29.3 mA/m^2. This indicates that 4.6 and 9.2 nm of decrease of boron thickness are expected for 6 and 12 hours of He-GDC. On the other hand, the Ar-GDC conditions are 350 V, 30 A and the sputtering yield of 0.12. These mean that the sputtering thickness is expected to be same level as He-GDC. However, large sputtering thickness like Fig. 1 was observed. This probably means that the current density profile of glow discharge in LHD is different for Ar and He. This difference leads the localized sputtering as Ar-GDC case.

Finally, the hydrogen retention in boron layer before and after GDC were investigated. The tendency of hydrogen retention was same for all samples. After GDC, the hydrogen retention was increased at surface and not changed in boron layer. Figure 2 shows the depth profile of hydrogen in boron layer on Si sample after 12 hr He-GDC. Two processes are possible reason for the increment of hydrogen retention at surface

(i) The impurity bonded to hydrogen like CH was sputtered by He- or Ar-GDC and retained on boron layer.

(ii) Hydrogen atoms sputtered by He- or Ar-GDC were injected into boron layer.

The analysis of atomic ratio of B, C, O, Fe, etc. on surface by XPS is expected to clarify the process of hydrogen retention in boron surface.

Reference

1) Kizu, K. et al,: Ann. Rep. NIFS (2003-2004) 80.
2) Kizu, K. et al,: Ann. Rep. NIFS (2004-2005) 83.

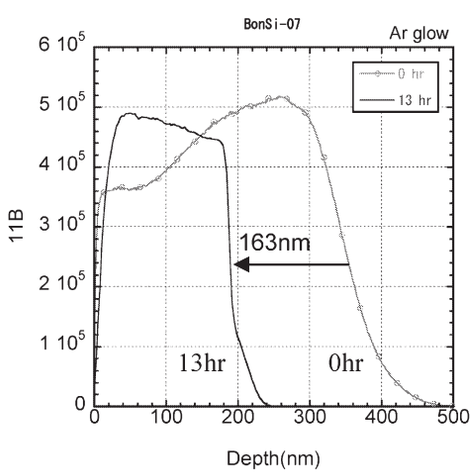

Fig. 1. Depth profile of boron on Si sample before and after 13 hr Ar glow discharge cleaning.

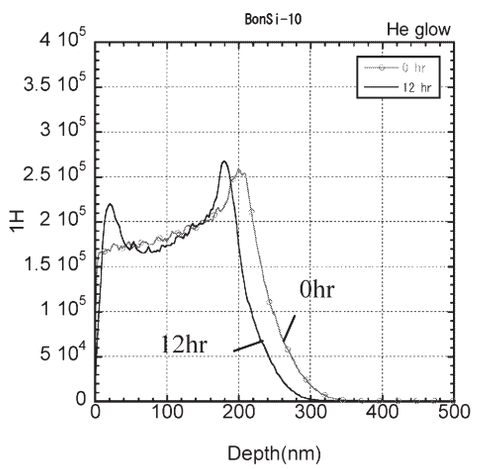

Fig. 2. Depth profile of hydrogen on Si sample before and after 12 hr He glow discharge cleaning.