§79. The Effect of Helium Glow Discharge on Boronized Surface in LHD

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

The purpose of this study is acquiring basic data for designing effective surface conditioning system for next nuclear fusion experimental devices [1]. It is generally difficult for a nuclear fusion experimental device with superconducting coils to rise wall temperature during coil operation larger than 200 °C indicating that the thermal desorption of hydrogen isotopes after boronization is not expected. Therefore, the glow discharge cleaning using the noble gas like helium (He), neon and argon plays an important role. On the other hand, glow discharge leads surface sputtering which is the source of impurity migration in a vacuum vessel. For these reasons, investigation of an effect of He glow discharge (He-GDC) on the boronized sample was performed in LHD during the 8th campaign.

Two kinds of samples were prepared for this work. One is samples boronized in LHD during the 7th campaign, and the other is samples boronized in Radiochemistry Research Laboratory in Shizuoka University. Sample materials were VPS-W on CFC and F82H which is low activation ferritic steel. These samples were exposed to He-GDC in 8th campaign for three hours or six hours. Then, deposited and sputtered impurities element and change of quantity of accumulated hydrogen by exposed He-GDC duration were investigated.

Chemical composition of samples boronized in Shizuoka University was analyzed by X-ray photoelectron spectroscopy (XPS) and secondary ion mass spectrometry (SIMS). The thickness of boron coating was about 300 nm. Figure 1 shows the analysis result of the F82H sample which was exposed for He-GDC of LHD for six hours. The boron membrane before He-GDC contained oxygen (O) of 12% in constant through the membrane. Carbon (C) was accumulated on the surface. Hydrogen (H) was retained uniformly in a thickness direction of the boron membrane indicating that H deposited on the sample surface with boron (B) during boronization process by decaborane ($B_{10}H_{14}$). The wear of a boron membrane by He-GDC for six hours was not clear.

In order to clarify the effect of He-GDC, average atomic ratio of C and O against matrix atoms (iron (Fe) and B) near surface (depth 0-40nm) were derived. The relation between the average atomic ratio and He-GDC duration for samples boronized in Shizuoka University is shown in Fig. 2. The decreasing of C and the increasing of O by He-GDC were observed. Increase of O suggests that O atoms sputtered within He-GDC from the wall which was not coated by boron in a LHD vacuum vessel was deposited to the boron coated surface. In addition, decreasing of C indicates that the quantity of C sputtered from sample by He-GDC was larger than that quantity of deposited on the sample that was sputtered at another surface (ex. divertor region). A tendency of increase of oxygen and decrease of carbon was also confirmed by the SIMS analysis of samples boronized during the 7th campaign in LHD. These results indicate that the wall conditioning advances by He-GDC not only during boronization process but also after boronization as long term effect.

The change of retained H was also investigated by SIMS. The H/B signal intensity ratios of SIMS decreased to about 80% of non-irradiation sample with overall B layer after He-GDC of six hours. However, because injection range of He with several hundred eV is around several nm, desorption of H from the depth of several hundred nm cannot be simply explained by sputtering. More examination is necessary as future work.

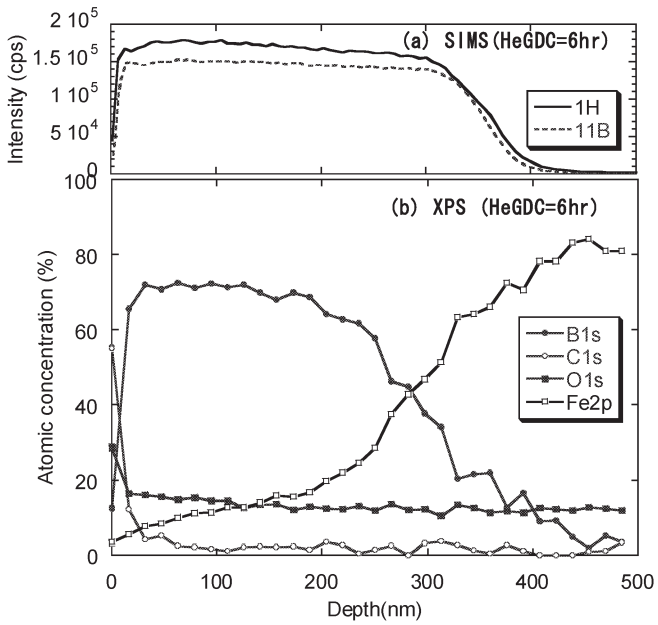

Fig. 1. Depth profile of H, B, C, O and Fe in sample which was boronized in Shizuoka Univ. and was exposed 6hr He-GDC in LHD.

Reference
1) Kizu, K. et al,: Ann. Rep. NIFS (2003-2004) 80.
2) Yamaki, T. et al.: J. Nucl. Mater. **217** (1994) 154.

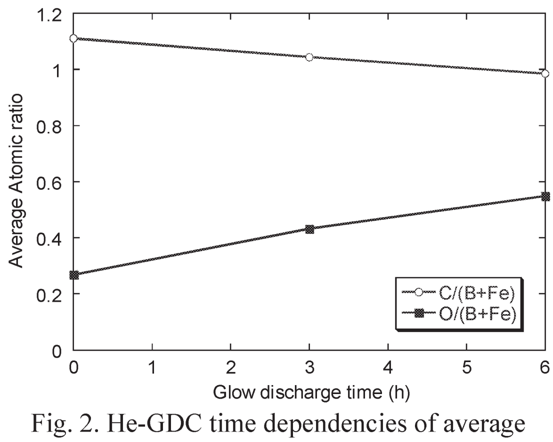

Fig. 2. He-GDC time dependencies of average atomic ratio of C and O in a depth 0 ~ 40 nm.