§95. Correlation between Crystal Structure Change and Tritium Retention on Mixed-layer of First Wall

Okuno, K., Oya, Y., Kobayashi, M., Uchimura, H., Toda, K., Sato, M. (Shizuoka Univ.), Matsuyama, M., Hatano, Y., Hara, M. (Univ. Toyama), Sagara, A.

i) Introduction

Tungsten is considered to be a candidate for plasma facing materials (PFMs) in future fusion devices. During the plasma operations, carbon (C), as one of typical impurities in vacuum vessel, will be implanted into the surface of tungsten (W), and a tungsten-carbon (W-C) mixed layer will be formed on the surface of plasma facing tungsten tiles. In addition, the energetic hydrogen isotopes will be implanted into PFMs, and the hydrocarbon will be dynamically formed and re-emitted to the plasma via the sputtering processes. These behaviors will be controlled by the energy of hydrogen isotope ions implanted to the W-C mixed layer. In our previous studies, we have already elucidated that effect of chemical form of C on hydrocarbon emission for C^+ implanted W, Highly Oriented Pyrolytic Graphite (HOPG) and WC. The chemical states of hydrocarbon sputtered by H2+ irradiation for W was determined by the amount of C-H bond on the W surface. This study focuses on the implantation energy on the chemical form of sputtering particles for HOPG. By comparing with the sputtering behavior for C^+ implanted W, the dynamics of hydrocarbon formation was discussed.

ii) Experimental

C^+ implanted W (10 keV C^+ implanted into tungsten with a flux of 1.0×10^{17} C^+ m^{-2} s^{-1} and a fluence of 1.0×10^{21} C^+ m^{-2}) and HOPG were used as samples and preheated in a vacuum at 1173 K for 30 min to remove the impurities. The in-situ sputtering measurement was done during 0.3 - 3.0 keV H_2^+ implantation with the ion flux of 1.0×10^{18} H^+ m^{-2} s^{-1} at 673 K. For the elucidation of chemical state of carbon for hydrocarbon sputtering, C^+ implanted W, WC and HOPG were used for comparison.

iii) Results and discussion

Figure 1 shows the ratio of sputtering particles for HOPG as a function of hydrogen ion implantation energy. For the implantation energy more than 0.3 keV, CH_4 was the major chemical form of hydrogen released for HOPG, while ~40% of hydrogen for HOPG was released as CH_3 in the case of implantation energy of 0.3 keV. It was clear that

the sputtering process was changed by implantation energy. By the SRIM code simulation, the energy consumption at the top surface of samples was large in the case of lower hydrogen ion implantation energy of 0.3 KeV, indicating that the physical sputtering would be the major sputtering process, although the chemical sputtering should be the key process for higher implantation energy.

For the C^+ implanted W, the major chemical forms during 3.0 keV hydrogen ion implantation were CH_3 (~50 %) and CH_2 (~40 %), although that during 0.3 keV was CH_2 (~78%). The existance state of carbon in C^+ implanted W was quite different from that in HOPG and carbon would form the amorphous like mixed layer. In addition, the carbon concentration for C^+ implanted W was lower (~30 %) than for tungsten carbide. Therefore, the direct sputtering of hydrogen on the surface should be high for C^+ implanted W without interacting with hydrogen retained in the W-C mixed layer, leading the emission of hydrocarbon with lower hydrogen concentration like CH_3 and CH_2.
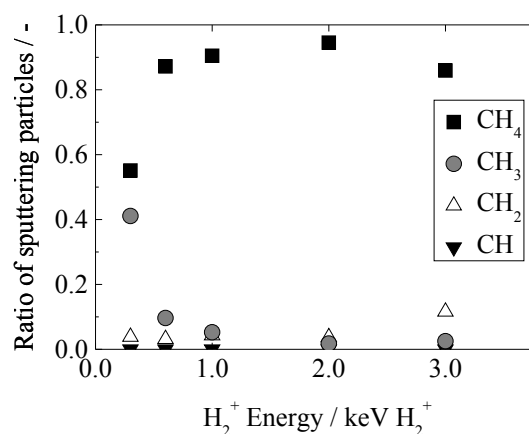

Fig.1 The release rates of sputtered hydrocarbons for HOPG during various energy hydrogen implantation.

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