§24. Quantitative Evaluation of Hydrogen Isotope Retention under Complex Ion Irradiation on PFM

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i) Introduction

Tungsten is considered to be a candidate for plasma facing materials (PFMs) in ITER due to higher conductivity and higher melting point. During the plasma operations, carbon, which will be retained in the vacuum vessel as the impurities, will be sputtered by the plasma and will also contaminate the plasma. In addition, the chemical form of hydrocarbons will also influence on the formation of carbon mixed layer on PFMs, leading the enhancement of tritium retention in PFMs. Therefore, the elucidation of reemission behavior of hydrocarbons for tungsten – carbon mixed layer is quite important for tritium safety. In the present study, H_2^+ was implanted into C^+ implanted tungsten as a function of implantation energy and reemission mechanism of hydrocarbons for tungsten – carbon mixed layer was studied.

ii) Experimental

The disk-type tungsten (Allied Material Co. Ltd.) cut from a rod of tungsten under stress-relieved condition was used. The 10 keV C^+ was implanted into tungsten with the ion flux of 1.0×10^{17} C^+ m^{-2} s^{-1} up to the ion fluence of 1.0×10^{21} C^+ m^{-2} to prepare the C^+ implanted tungsten sample. Thereafter, H_2^+ was implanted into tungsten with ion flux of 1.0×10^{18} H^+ m^{-2} s^{-1} at 673 K to evaluate the chemical sputtering behavior for tungsten. The ion energy of H_2^+ was varied from 0.6 keV to 3.0 keV. The sputtering particle measurements for the C^+ implanted tungsten sample during H_2^+ implantation was observed directly by a quarupole mass spectrometer.

iii) Results and discussion

Figure shows the implantation ion enegry dependence on sputtering hydrocarbons for C^+ implanted tungsten. The CH_3 was a major hydrocarbon species during 3 keV H_2^+ implantation, although the emission rate of CH_2 was increased compared to that of CH_3 during 0.6 keV H_2^+ implantation. It can be said that the reemission rate of hydrocarbons largely depends on the H_2^+ implantation energy. For the H_2^+ implantation with higher energy, most of ion energy would be consumed at the bulk of C^+ implanted tungsten. Therefore, liner energy transfer at the surface region for H_2^+ implantation with lower ion energy should be high compared with that with higher ion energy, leasing to the enhancement of CH_2 reemission by phycical sputtering process. The sputtering rate of hydrocarbons during 0.6 keV H_2^+ implantation was about 3% of that during 3 keV H_2^+ implantation and large reduction of hydrocarbon reemission was found for 0.6 keV H_2^+ implantation. In our previous study, the density of tungsten-carbon mixed layer clearly depends on the depth from the surface and tungsten-carbon mixed layer with lower density was extended around the surface region. In the case of H_2^+ implantation with lower ion energy, most of hydrogen would be implanted into tungsten-carbon mixed layer with lower density. Therefore, the reaction with carbon should be limited, leading to the reduction of hydrocarbon reemission. The hydrogen concentration near surface region was reduced, leasing the reemission of hydrocarbon with lower hydrogen, like CH_2.

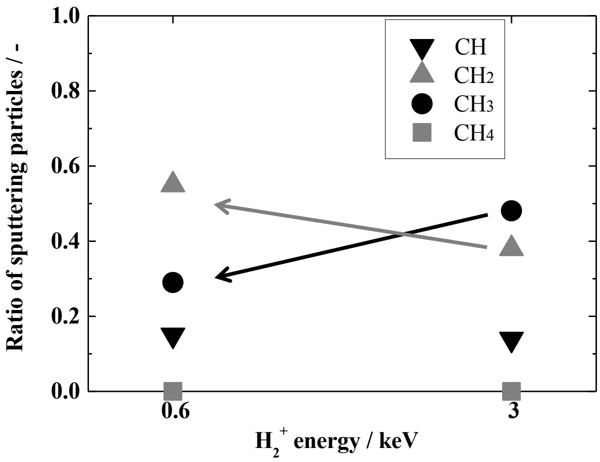

Fig. Implantation ion energy dependence on hydrocarbon remission for C^+ implanted W