§10. Change of Surface Properties of First Wall Due to Installation of Closed Divertors

Yoshida, N., Yugami, N., Kimura, Y., Fujiwara, T., Yoshihara, R. (Kyushu Univ.),
Oya, Y., Okuno, K. (Shizuoka Univ.),
Hatano, Y. (Univ. Toyama),
Masuzaki, S., Tokitani, M., Ashikawa, N.

Study of steady state operation is one of the major subjects of LHD/NIFS. In order to perform long duration plasma discharges, particle balance should be controlled. Because He plasma is mainly used for long pulse discharge experiments in LHD, plasma induced surface modification of 316LSS and W and its effects on the retention and desorption of He and H isotope in LHD were examined by exposing many coupes of these materials at the plasma facing wall.

After the experimental campaign plasma exposed coupons were taken out from LHD and the modification of the plasma facing surfaces were examined by means of TEM and SEM for microstructure and surface morphology, XPS and GD-OES for chemical analysis, and TDS for vacuum properties. Vacuum properties of the plasma-exposed coupons were examined by using the following combined experiments. Namely, 2keV-D_2^+ or 2keV-He^+ were injected at first, and TDS measurements were started after 2 hours later. Ramping rate was 1K/s.

Plasma induced surface modification in LHD can be classified into two types as follows.

(1) Erosion dominant area (ED area); in the area close to the main plasma and where flux of impurity carbon is low, surface erosion by sputtering is dominant. Sub-surface layer of about 20nm-thick is damaged heavily mainly by He bombardment under He discharge experiments and glow discharge cleaning with He gas. Extremely dense He bubbles in nano-size and dislocation loops are formed there. Deposited elements such as C, O and even Fe, Cr, Ni were mixed with substrate elements due to the collision with energetic particles from the plasma.

(2) Deposition dominant area (DD area); wide area of the inner wall was colored by the impurity deposition. Major component of the deposited layer is C transported directly and indirectly from the graphite divertors, while the wall elements (Fe, Cr, Ni) are less than 1 at%. The deposited layer is mainly amorphous and very porous.

In case of W coupons, heavy damage in the erosion dominant area enhance the retention of D very much due to the trapping effects by the dense He bubbles (see Fig.1). Most of the retained D, however, desorb below 550K. This fact indicates that effects of He bombardment will be small above this temperature.

TDS spectrum of M3 and M4 from D ion injected 316LSS is shown in Fig.2. In case of 316LSS covered by thick deposition (DD area), retention of D below 400K is suppressed very much. In the ED area, very heavy radiation damage by He results in the reduction of D desorption below 400K. Though, these results seem good for particle control, one should keep in mind that desorption in this temperature range might be increase at high fluence as observed in QUEST. We should make clear the desorption of D at much higher fluence comparable with that of long pulse discharges.

Capacity for He retention in 316LSS is very large and more over desorption rate keeps very high revel (~1x10^{18}He/m^{2}s) up to 1000K. These facts indicate that if the wall temperature increased quickly, large desorption will continue long. Desorption of He from the impurity deposited 316LSS is also quite high especially near the wall temperature.

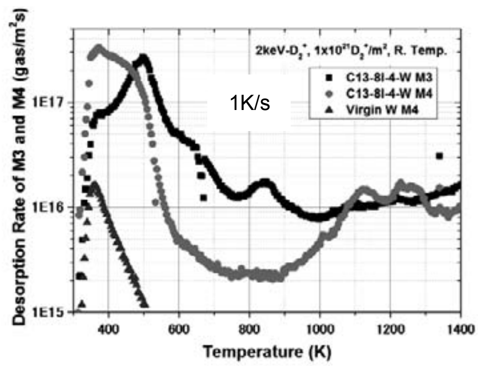

Fig. 1 TDS spectrum of M4 (D_2+He) and M3 (DH) from the D injected recrystallized W coupons at ED area. Desorption of M4 (D_2) from the D injected virgin W is also plotted in the figure as a reference.

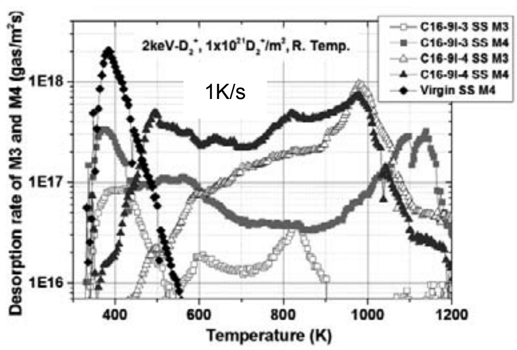

Fig.2 TDS spectrum of M4 and M3 from the D ion injected 316LSS coupons placed at the ED area (C16-9I-3-SS) and at the DD area (C16-9I-4-SS). That of a virgin coupon is also shown.