§55. Study on Hydrogen Recycling and Particle Control in the Spherical Tokamak QUEST

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Understanding of hydrogen recycling is one of the most critical issues from the viewpoint of the steady state operation of fusion plasma. It is necessary to investigate comprehensively from macroscopic and microscopic viewpoints. In QUEST, stainless steel surfaces of the plasma facing components (PFCs) have been covered with tungsten (W) in a step by step manner. Figure 1 shows an internal view of the vacuum vessel of QUEST. In 2010 FY, upper divertor plates, upper CS guard plates, lower CS guard plates and inner divertor plates were covered with W by an atmosphere-plasma-spray (APS) method. Middle CS guard plates and lower divertor plates had already been covered with W by a vacuum-plasma-spray (VPS) and APS methods, respectively. On the whole, almost all surfaces of the PFCs except the outer part of the vacuum vessel have been covered with W. It is important to study hydrogen retention properties of APS and VPS tungsten from viewpoint of hydrogen recycling to understand the hydrogen recycling in QUEST.

Figure 2 shows SEM micrographs of the surfaces of APS-W and VPS-W, indicating that W beads of APS-W are deposited in a flattened shape and some of those of VPS-W are kept a similar shape to the original (spherical) one. In this time, the VPS-W sample was exposed to deuterium plasma and then the deuterium absorption property was measured by thermal desorption spectroscopy (TDS). The plasma parameters are the following: density is ~2.6×10^{17} m^{-3}, temperature ~ 7 eV, space potential ~24 V and ion flux ~3×10^{21} D m^{-2} s^{-1}. The fluence is ~2×10^{25} D m^{-2}. Figure 3 shows surface temperature dependence of TDS spectrum of VPS-W exposed to the plasma. The main desorption peak is ~750 K for the samples of which surface temperature is 520 K and 590 K. On the other hand, for the samples of which surface temperature is higher, there is no peak around ~750 K and the main desorption peak shifts to higher temperature (i.e. 950 K to 1200 K). Figure 4 shows the surface temperature dependence of deuterium retention of VPS-W and the bulk tungsten (bulk-W) without surface treatment. The retention of the bulk-W sample decreases with the surface temperature but, on the other hand, the retention of the VPS-W decreases until 590 K and then increase with the surface temperature, indicating that deuterium trap mechanism of VPS-W is different from that of bulk-W. The mechanism should be studied in detail. It seems to be important for QUEST, because study on hydrogen recycling at high temperature wall up to 773 K is one of the missions of QUEST.

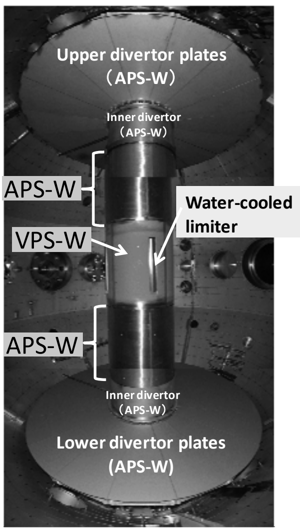

Fig. 1 Internal view of the vacuum vessel of QUEST.

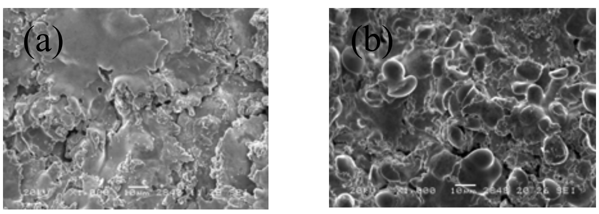

Fig.2 SEM micrographs of (a) APS-W and (b) VPS-W.

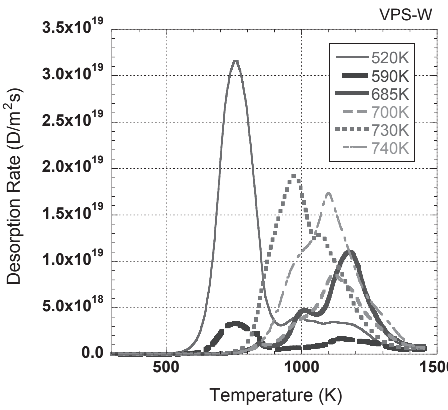

Fig.3 TDS spectra of VPS-W samples of which surface temperature during plasma exposure is in the range of 520 K to 740 K.

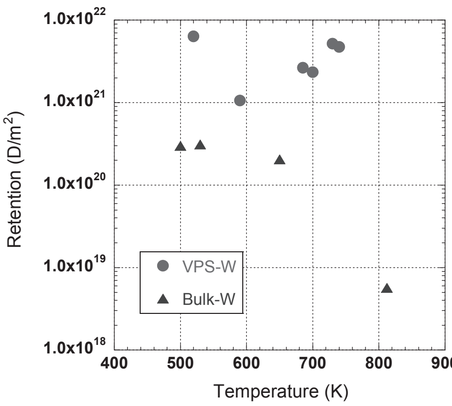

Fig.4 Surface temperature dependence of deuterium retention of samples of VPS-W and bulk-W.