§2. Hydrogen Absorption Properties in Vanadium and Niobium Pumping Panels

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A superpermeable membrane (Group Va metal) pumping is one of candidates for particle exhaust in the divertor region, while a periodically regenerated absorption panel can be acceptable for an intermittent operation in non-tritium devices. Hydrogen absorption performance so far has been investigated for a Nb panel and the drop of absorption rate has been found in low temperature range [1]. Therefore, hydrogen absorption properties in low temperature range, in particular, in the vicinity of room temperature (< 100 C) were investigated for a Group Va metal panel (Nb and V).

In order to investigate the absorption rate in the low temperature range, the experimental setup was rearranged as shown in Fig. 1. The panel and the atomizer were setup on the same plane, and a thermal shield plate was inserted between both so as to control the panel temperature independently of atomizer heating. Figure 2 shows the result of experiment with a V panel. The panel was degassed at 600 C and then kept in vacuum for cooling to room temperature during a night. The experiment was started without preheating of the panel and the H absorption rate S_{ab} was measured at each elevated panel temperature. In this figure, the absorption rate is normalized to the maximum absorption rate. S_{ab} was found to change remarkably with T_p. Three temperature ranges can be distinguished in the increasing phase of panel temperature: T_p=(30-200) C, T_p=(200-400) C and T_p>400 C. S_{ab} was small in the range (30-200) C and remains almost constant (S_{ab}/S_{ab}^{max}~0.2). The remarkable increase of S_{ab} with T_p was seen in the range of (200-400) C. S_{ab} reaches its maximum at T_p~400 C and remains constant at T_p>400 C where V is covered by an O monolayer segregated from the metal bulk. Besides, one can see that there is a significant hysteresis for the absorption rate in the cycle of increasing and decreasing of panel temperature. In the same way, S_{ab} was measured for a Nb panel (Fig. 3). Several different features of hydrogen absorption were found in comparison with V panel. In the temperature range of (30-100) C, S_{ab} was very small (S_{ab}/S_{ab}^{max}~0.05). The remarkable increase of S_{ab} with T_p was observed in the range of (100-400) C. S_{ab} saturates at T_p>400 C similarly in the case of V panel. However, the temperature dependence of absorption rate is almost the same in the up and down phase of T_p and there is no significant hysteresis for S_{ab}. The radical decrease of H absorption rate in the low temperature region is caused by the formation of a multilayer impurity coverage, which is not 'transparent' for thermal hydrogen atoms. When the metal panel is exposed to impurity gases (O_2, H_2O, etc), the growth of oxide layer on the meal surface (for example, VO, V_2O_3 for V) is observed in combination with surface analysis. The difference between V and Nb panels in temperature dependence of H absorption rate is attributed most probably to that in the dissolution of oxygen on the surface into the bulk.

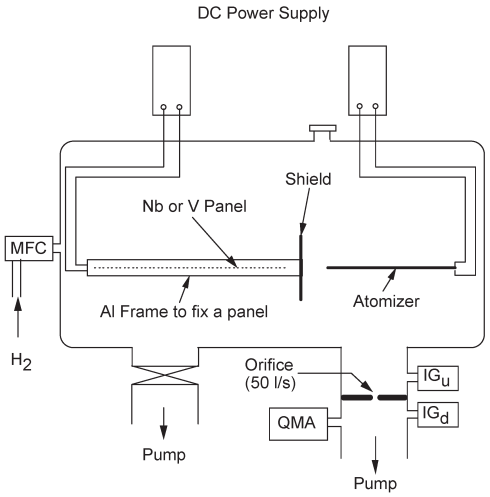

Fig. 1. A schematic view of experimental setup

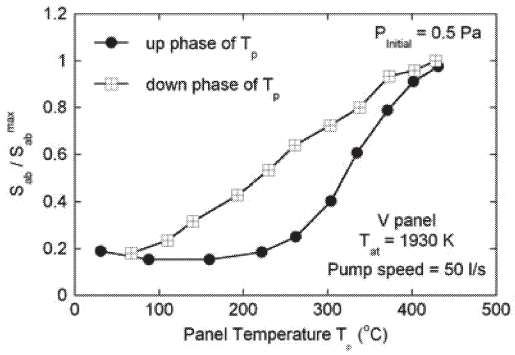

Fig. 2. Temperature dependence of normalized hydrogen absorption rate for V panel

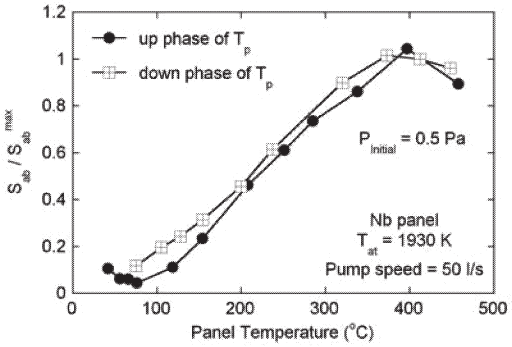

Fig. 3. Temperature dependence of normalized hydrogen absorption rate for Nb panel

Reference

[1] Nakamura,Y., et al., J. Nucl. Mater. 337-339(2005)461.