§2. Characteristics of Hydrogen Absorption in Vanadium Pumping Panel

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A pumping panel made of a Group Va metal (V, Nb or Ta) is one of promising means for particle flux control in the divertor region. In the case of steady-state regime, a superpermeable membrane should be used for particle control, while a periodically regenerated absorption panel (simpler and cheaper) can be acceptable for an intermittent operation in non-tritium devices.

The capability of a niobium panel to absorb atomic hydrogen so far has been investigated for particle control application in divertors [1]. For Nb panels, we found that the absorption rate remarkably decreased in the low temperature range (80 ~ 200 °C). In order to investigate the absorption rate in the vicinity of room temperature (< 80 °C), the experimental setup was rearranged so as to control the panel temperature independently of atomizer heating. At first, H absorption properties of V panel were investigated. The panel was degassed at 600 °C and then kept in vacuum for cooling to room temperature during a night. The basic vacuum was ~ $5x10^{-7}$ Pa. Then hydrogen was admitted to required pressure and the atomizer was switched on (Fig. 1) for relatively short time (typically a few tens of seconds). The pressure drops due to absorption in the panel but this decrease is not very large due to high pumping speed of Turbo Molecular Pump during the experiment. Thus the absorption rate is measured by the change of H partial pressure of QMS at any panel temperatures. The panel temperature increases during the atomizer operation and the procedure is repeated at next higher temperature. At reaching a definite panel temperature due to heating by atomizer radiation (~200 C) the temperature is increased further by electric current through the panel. At a definite temperature (~450 C) a noticeable desorption of H_2 begins. Then the hydrogen influx is stopped and the panel is degassed at 600 C. Then the same influx of gas is admitted again and the absorption is observed by the same way but at step-by-step decrease of panel temperature.

Figure 2 shows the results of experiments at two initial hydrogen pressures: 0.01 and 0.21 Pa. In this case, the maximum (at T_p~400 C) densities of H atom absorption flux corresponding to 0.01 Pa and 0.21 Pa are $1.1x10^{15}$ and $1.1x10^{16}$ H/cm^2/s, respectively. In order to simplify the comparison of temperature effects at different pressures, the absorption rate for each pressure are normalized to the absorption rate being maximum for the given pressure (i.e. to 650 l/s and 340 l/s for 0.001 and 0.21Pa, respectively). The temperature dependence of H atom absorption by V panel, $S_{ab}(T_p)$, was investigated in the range of T_p of (30-500) C at different flux densities of H atoms. S_{ab} was found to change with T_p but not very much: the ratio S_{abmax}/S_{abmin}< 3 over the whole temperature interval investigated. Three temperature ranges can be distinguished: T_p=(30-200) C, T_p=(200-400) C and T_p>400 C. S_{ab} increases with T_p very gently in the range (30-200) C; the most probable cause of such a behavior appears to be saturation of panel surface by adsorbed H atoms. The increase of S_{ab} with T_p becomes stronger in the range of (200-400) C. The causes of S_{ab} change in this temperature interval remain unclear at the moment. 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. The cause of this hysteresis remains unclear and further investigation would be required.

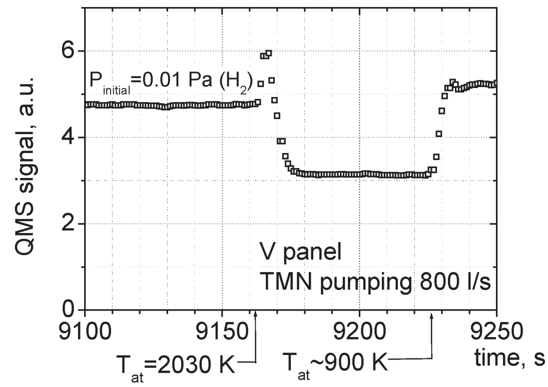

Fig. 1. Typical picture of H atom absorption observed by a Quadra Mass Spectroscopy

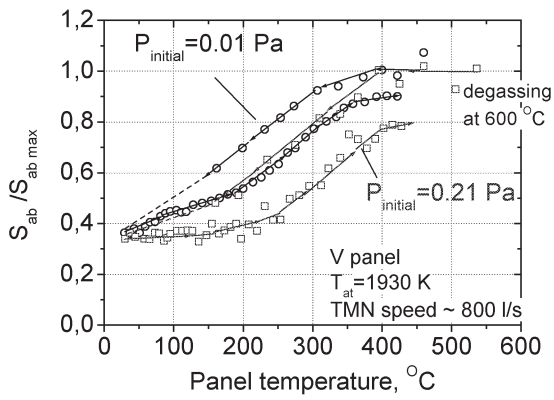

Fig. 2. Temperature dependence of normalized hydrogen absorption rate for different gas pressures

References

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