§33. Influence of Deposition Layer on Hydrogen Isotope Permeation in Plasma Facing Wall

Katayama, K., Uehara, K., Date, H., Ushida, H., Fukada, S. (Kyushu Univ.),
Ashikawa, N.

Understanding of hydrogen permeation behavior through the plasma facing wall to the coolant is an important issue from a viewpoint of fuel particle control, fuel cycle system design and tritium safety management. During plasma operation, plasma facing wall is eroded by an incident of energetic particles and sputtered atoms deposits on the wall. It has been reported that metal deposition layers formed under hydrogen isotope plasma can trap a certain amount of hydrogen isotopes in the deposition process[1,2]. However, hydrogen permeation rate through metal deposition layer have not been quantitatively evaluated to date. In this work, hydrogen permeability through W deposition layer formed on nickel substrate by hydrogen plasma sputtering was quantified.

The experimental apparatus for hydrogen permeation is schematically shown in Fig.1. The nickel plate on which W deposition layer was formed was clamped between a copper gasket and a stainless steel flange. The flange connected to stainless steel tubes was inserted in a quartz tube and set at a center position of an electric furnace. The permeation cell was heated to the preset temperature by an electric furnace. The temperature of furnace was controlled by thermocouple 2 contacting to the outer surface of the quartz tube. The sample temperature was measured by thermocouple 1 contacting to the sample surface from the primary side. Just after the secondary side was closed under vacuum condition, hydrogen gas or mixed gas of hydrogen with argon was introduced into the primary side. From a pressure rise in the secondary side, hydrogen permeation flux was obtained. Two W deposition samples, 0.409 μm and 0.711 μm in thickness, were prepared. In the experiments, hydrogen pressure range was 10^3~10^5 Pa and temperature range was 250~500 °C.

In Fig.2, the observed hydrogen permeation fluxes were compared with the fluxes through Ni plate, W bulk, which were calculated by using literature data. The hydrogen permeation flux through W deposition layer under the steady state condition was approximately 2 orders of magnitude larger than that through W bulk.

The numerical calculation of one dimensional diffusion of hydrogen and the simulated pressure rise in the secondary volume was fit to the experimental one by varying diffusivity and solubility as parameters. The obtained diffusivity was compared to the diffusivity in W bulk in Fig.3. It was revealed that diffusivity in W deposition layer was smaller than that in W bulk. This implies that hydrogen solubility in W deposition layer is much larger than W bulk.

This work was partly supported by the JSPS-NRF-NSFC A3 Foresight Program in the field of Plasma Physics (NSFC:No.11261140328, NRF: No.2012K2A2A6000443).

1) Katayama, K., et al., J. Nucl. Mater., **438** (2013) 1010.
2) Temmerman, G.De, et al., J. Nucl. Mater., **389** (2009) 479.

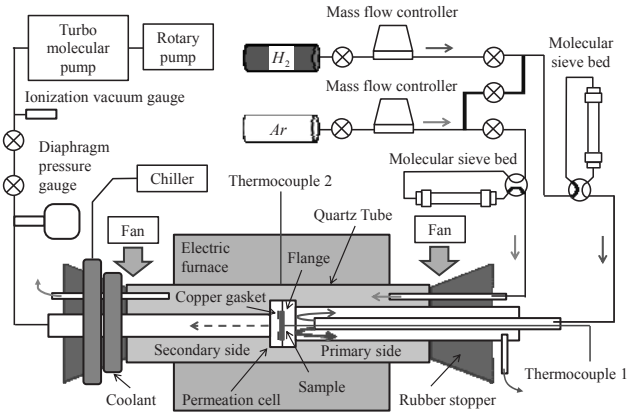

Fig.1 Experimental apparatus for hydrogen permeation

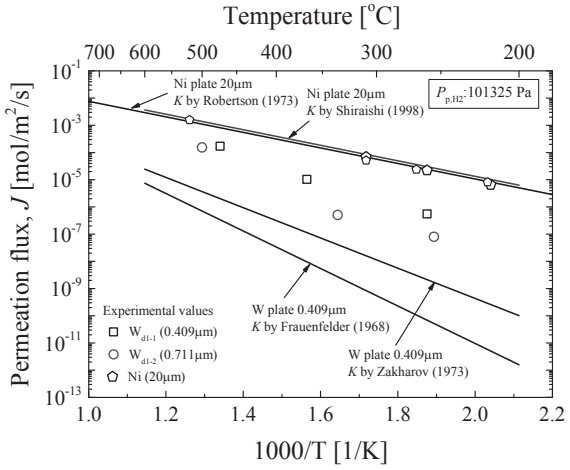

Fig.2 Hydrogen diffusivity in W deposition layers compared with bulk values.

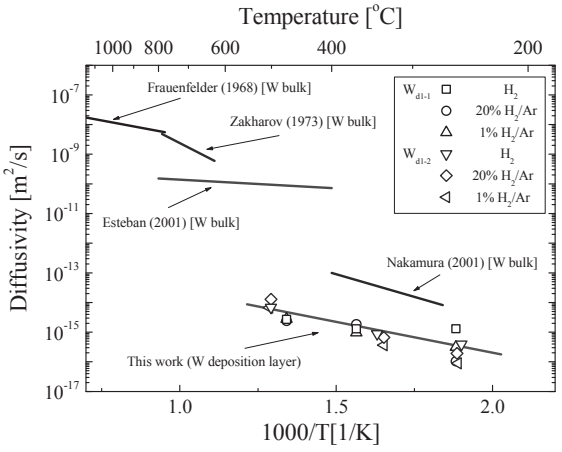

Fig.3 Equilibrium hydrogen concentration in W deposition layers compared with bulk values.