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Hydrogen isotope permeation through tungsten deposition layer formed on Ni plate by plasma sputtering method

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Understanding of tritium behavior in the plasma facing wall of a fusion reactor is important from viewpoints of fuel control and tritium safety. Tungsten is a primary candidate of plasma facing material because of low sputtering rate and low tritium solubility. However, even if tungsten is used on plasma facing wall, formation of deposited layer cannot be avoided in long-term operation of the fusion reactor. Because the structure of deposited layer is greatly different from the structure of original material, tritium behavior has to be understood for not only tungsten bulk but also tungsten deposition layer. In this work, hydrogen or deuterium gas driven permeation through tungsten deposition layer was investigated. Then, diffusivity of hydrogen isotope in tungsten deposition layer was estimated by numerical fitting method with considering an influence of Ni substrate although the influence of Ni substrate was ignored in our previous work [1].
Samples of tungsten deposition layer were formed on circular substrates of nickel by hydrogen plasma sputtering. The thickness of the deposition layer was evaluated to be about 700 nm against 20000 nm in thickness of Ni. The deposition layer with Ni substrate was clamped between a copper gasket and a stainless steel flange. In experiment A, the secondary side was closed in vacuum and hydrogen gas was supplied in the primary side and then the hydrogen permeation flux was obtained from the pressure rise at the secondary side. In experiment B, the secondary side was continuously evacuated and hydrogen or deuterium was supplied in the primary side. The permeated hydrogen isotopes were measured by a quadrupole mass spectrometry. The temperature in these experiments were set from 200oC to 500oC.
The pressure rise with time in experiment A was analyzed by TMAP calculation and diffusivity was evaluated. The obtained hydrogen diffusivity was slightly larger than that obtained by ignoring Ni substrate. It was found that hydrogen diffusion in Ni substrate affects slightly hydrogen permeation rate. The absolute value of hydrogen diffusivity was much smaller than that in tungsten bulk. In experiment B, when deuterium gas was supplied in the primary side after hydrogen permeation experiment was finished, not only deuterium but also hydrogen were appeared in the secondary side. This result indicates that hydrogen trapped in the sample was released by the isotope exchange reaction with deuterium migrating in tungsten deposition layer. Deuterium gas soak is considered to be effective for tritium recovery from tungsten deposition layer.

[1] K. Uehara et al., Fusion Eng. Des. 98-99 (2015) 1341-1344.

Eligible for student paper award?

Yes

Author: Mr MORI, Daisuke (Kyushu University)

Co-authors: Prof. KATAYAMA, Kazunari (Kyushu University); Prof. FUKADA, Satoshi (Kyushu University)

Presenter: Mr MORI, Daisuke (Kyushu University)

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