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Surface oxidation effect on deuterium permeation in reduced activation ferritic steel F82H for DEMO application

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Tritium permeation through structural materials is a significant issue for the Japan's DEMO reactor blanket concept. Reduced activation ferritic steel F82H is a prime candidate for the blanket structural material. The previous study showed a thin chromium oxide layer formed on a steel substrate worked as tritium permeation barrier; however, heat treatment parameters at atmospheric pressure for the formation of a chromium oxide layer and its permeation behavior in DEMO reactor environments are not clear. In this study, surface oxidation treatments for F82H have been performed to evaluate the effect of the chromium oxide layer on deuterium permeation and its stability under actual DEMO reactor conditions.
To form a tight chromium oxide layer without formation of iron oxide which causes cracks in the layer, F82H steel plates were heat-treated under low oxygen partial pressure conditions: for 5 min at 700–720 °C in gas flow of argon-hydrogen mixture. After surface observation and analysis, gas-driven deuterium permeation measurements were performed at 300–600 °C. The selected samples were exposed to purge gas of helium with 1 vol% hydrogen or liquid lithium-lead for 100 h at 500 °C for the simulation of DEMO blanket conditions.
The optimized heat-treatment parameter for chromium oxide formation without iron-oxide formation was determined: for 5 min at 710 °C in half-and-half argon-hydrogen mixture gas. The thickness of the layer was estimated to be less than 100 nm. Deuterium permeation flux of the sample decreased by a factor of 10 in comparison with untreated F82H in the first measurement at 300 °C, and showed a further decrease by a factor of 150 at 500 °C due to an increase in the layer thickness by 1.5 times during the permeation measurements. However, the chromium oxide layer was lost with an increase in deuterium permeation after exposure to DEMO blanket environments.

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