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P4.209 The relationship between microstructure of ceramic coatings and γ-ray irradiation effect on deuterium permeation

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Control of tritium permeation through structural materials is important in terms of fuel economy and radiological safety in fusion reactors; therefore, ceramic coatings have been researched as tritium permeation barrier for decades. Microstructural changes of the coatings, such as crystallization and deterioration, influence hydrogen isotope permeation behavior under reactor operation. In addition, recent research on deuterium permeation through metals under γ-ray irradiation indicated that deuterium permeation increased mainly by γ-heating. In this study, the γ-ray irradiation effect on deuterium permeation through ceramic coatings with different microstructures has been investigated.
Erbium oxide and yttrium oxide coatings were fabricated on reduced activation ferritic steel F82H substrates without heating by arc deposition and magnetron sputtering, respectively. A deuterium permeation apparatus was installed into a γ-ray irradiation chamber at Shizuoka University, and temporal changes of deuterium permeation flux under irradiation using a 26 TBq cobalt-60 γ-ray source were detected.
Deuterium permeation flux through the coatings increased during γ-ray irradiation at 250–300 °C, but noise was too large to detect changes in permeation flux at above 300 °C. The permeation flux of erbium oxide coating increased by crack formation during the permeation experiment at 500 °C. After deterioration of the coating, the permeation increase during γ-ray irradiation was approximately 0.5–0.6%, which was lower than that of the F82H substrate. On the other hand, the yttrium oxide coating had an amorphous structure and started crystallization at 500 °C. Although the irradiation effect before the crystallization was derived from the F82H substrate, the effect derived from the coating was detected after crystallization because the rate-determining process of permeation shifted to the coating. Compared the result at 300 °C before and after crystallization, the irradiation effect decreased to less than 0.5%, proving that the ceramic coatings reduced the deuterium permeation as well as the γ-ray irradiation effect.

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