Study on the Hydrogen Isotope Permeation Behaviors of the $FeAl/Al_2O_3$ Composite Coating

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In order to minimize the tritium permeation through the structural materials of the fusion tritium breeding blanket and tritium systems, a $FeAl/Al_2O_3$ Composite Coating prepared by pack cementation and in-situ oxidation process has been developed as the tritium permeation barrier for Chinese DEMO fusion reactor by our research team of Tritium Materials and Technology (TMT Team) in China Institute of Atomic Energy (CIAE). The deuterium permeation experiment have been performed as well as the thermal desorption spectrometry (TDS) test. The hydrogen isotope permeation properties and mechanisms are discussed in this paper.

The behaviors of deuterium permeation have been compared for various samples with $FeAl/Al_2O_3$ coating, natural oxidation film and Ni-plating. The apparent deuterium permeability in the sample with $FeAl/Al_2O_3$ coating is at least three orders of magnitude lower than that in the "pure matrix". The apparent activation energy of deuterium permeation is 7.66×10^{-4} J/mol for the coated sample and 6.13×10^{-4} J/mol for the sample with natural oxidation film. The pressure exponent of the steady permeability is between 0.5 and 1. The mechanism of permeation was evaluated from the different characteristic of curves of permeation rate for various samples. The trapping effect of defects in materials on hydrogen isotope was analyzed by thermal deuterium desorption spectra. Further research efforts will be made to understand the interactions between hydrogen isotopes and the disfigurement of the barrier coatings and the substrate materials by positron annihilation (PA) method.

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