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Study on Hydrogen Isotope Permeability of High Entropy Alloy Coating

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Abstract : Tritium permeation through structural materials is a significant issue for fusion demonstration (DEMO) reactor blankets in terms of fuel cycle efficiency and radiological safety. Reduced activation ferritic (RAFM) steel CLF-1 is a prime candidate for the China's CFETR blanket structural material, facing high permeability of hydrogen isotopes at reactor operational temperature. To confine tritium as much as possible in the reactor, surface modification of the steels including fabrication of tritium permeation barrier (TPB) attracts much attention. As a new alloy system, high entropy alloy (HEA) contains at least five principal elements, each of which ranges from 5 at% to 35 at%. This high mixing effect entitles HEA extraordinary comprehensive performance. So it is attractive to lead HEA into surface alloying for protective use. At present, studies on the hydrogen isotope permeability of HEA coatings is still insufficient and corresponding mechanism isn't clear. In our study, we prepared three kinds of HEA coatings, including AlCrTaTiZr, (AlCrTaTiZr)N and (AlCrTaTiZr)O. After comprehensive characterization of SEM, XPS, AFM, XRD and TEM, the structure and composition of the HEA coatings were obtained. Deuterium permeation tests were conducted to evaluate the hydrogen isotope permeability of AlCrTaTiZr, (AlCrTaTiZr)N and (AlCrTaTiZr)O HEA coatings. Results proved that the (AlCrTaTiZr)N and (AlCrTaTiZr)O HEA coatings had better hydrogen isotope permeation resistance. Through analyzing and characterizing the hydrogen isotope permeation results of the corroded samples, an internal link between hydrogen isotope permeation behavior and structure of HEA coatings was established. The results provide valuable reference in engineering design of structural and TPB materials for future fusion device.

Keywords : high entropy alloy, hydrogen isotope permeability, tritium permeation barrier, fusion demonstration reactor
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