The influence of irradiation on the deuterium permeation behavior of oxidized Fe-Cr-Al steel

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One of the most promising tritium permeation barriers in fusion reactor is alumina, which has excellent ability to reduce the tritium permeation. Our research has shown that through oxidizing the Fe-Cr-Al steel at 700 ℃, the deuterium permeability of oxidized Fe-Cr-Al steel could be 4 orders lower than that of RAFM steel, which could be attributed to the dense alumina layer with thickness of 50-120 nm formed on the surface of oxidized Fe-Cr-Al steel [1].

In this study, both the influence of displacement damage and the transmutation atoms He have been considered to investigated the irradiation effects on the deuterium permeability of oxidized Fe-Cr-Al steel. The uniform distributed displacement damage with average of 1.2 dpa and 12 dpa were introduced into the oxide layer using 1 MeV Au ions based on the calculation of SRIM 2008. The maximum displacement damage in Fe-Cr-Al substrate is 4.2 dpa and 42 dpa. In these irradiation condition, the Au ions were almost all introduced into the Fe-Cr-Al substate to prevent its influence on the permeation behavior of the oxide layer. After Au ions' irradiation, the uniform distributed He atoms were introduced in the oxide layer using 2.6 MeV He ions combined with the Al foil retarder. Positron annihilation spectroscopy experiments and deuterium gas permeation experiments have been performed for the single and combined Au and He irradiated sample. The permeation experiments have shown that for the two different average displacement damage, the change of deuterium permeability is within one order, which mean that the oxidized Fe-Cr-Al steel has good ability to tolerance irradiation.

[1] Yi-Ming Lyu, Yu-Ping Xu, Xin-Dong Pan, et. al., Efficient deuterium permeation reduction coating formed by oxidizing the Fe-Cr-Al ferritic steel in reduced oxygen atmosphere at 973 K [J], Journal of Nuclear Materials, 530(2020): 151962.