Deuterium permeation behavior in the CoCrFeMnNi high-entropy alloy

Yu-Ping Xu, Hai-Shan Zhou, Guang-Nan Luo

Institute of Plasma Physics, Chinese Academy of Sciences, Hefei, 230031, China;

xuyp@ipp.ac.cn

Comparing with traditional alloys with one primary element and several elements in small quantity, high-entropy alloys (HEAs) composed of four or more metallic elements mixed in an equimolar or near equimolar ratio. HEAs have preferable physical and mechanical properties such as high strength, high ductility, good corrosion resistance and resistance to irradiation. Among all the HEAs candidates, CoCrFeMnNi, which is one of the most widely investigated HEAs to date, has excellent mechanical properties under various temperatures. Thus, it can be predicted that this material has the potential to be modified and applied in fusion devices, despite of its high activation elements, i.e., Co, Ni. For the safety concern, it is important to figure out the compatibility of hydrogen isotopes with HEAs.

In this work, the hydrogen isotope permeation behavior of this material has been mainly checked by a gas-driven permeation (GDP) device. The crystalline structure of the CoCrFeMnNi HEA has been checked by XRD and confirms to be single face-centred cubic (FCC) phase. GDP experiments show that the HEA sample has comparable deuterium permeability and the diffusion coefficient with 316L stainless steel and other austenitic steels which share FCC crystalline structure, and more than 10 times higher than that of the ferritic steels which share body-centred cubic (BCC) structure. It is indicated that the crystalline structure may be the key factor that determines the hydrogen isotope permeation behavior in alloys with Fe as the main element. Efforts are being made to prove the assumption by first-principles calculations and GDP experiments on a duplex stainless steel (Fe-22Cr-5.5Ni-3Mo), which has a mixed phrase of FCC and BCC.