Radiation Resistance in Multicomponent Equiatomic Alloys

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Abstract

Multicomponent equiatomic alloys, including medium- and high-entropy alloys (MEAs and HEAs), have been demonstrated notably high irradiation resistance, which is commonly attributed to their extraordinary interstitial behaviors or chemical disorder. The recent progress in simulating radiation damage and microstructural evolution in multicomponent equiatomic alloys will be discussed and some interesting results will be highlighted. These simulations provide the detailed mechanisms on the generation and evolution of irradiation-induced defects in face-centered cubic MEAs and HEAs to understand the new mechanisms of their irradiation tolerance. As compared with Ni, the primary radiation damage produced by displacement cascades in a HEA-NiCoCrFe exhibits delayed defect accumulation and enhanced defect suppression, which is attributed to the stronger thermal spike, lower thermal conductivity, and smaller binding energy of interstitials. In addition, the interaction of the displacement cascades with a pre-existing stacking fault tetrahedron (SFT) in a MEA-NiCoCr and Ni is employed to understand their differences of void swelling. The probability for SFTs to directly transfer to voids under irradiation in the NiCoCr MEA is much smaller than that in Ni, which is due to their lower formation energy and higher binding energy relative to those of voids in the NiCoCr MEA. This probably provides a novel pathway for void swelling resistances in MEAs and HEAs, as observed in experiments. The correlation between the defect behaviors and irradiation resistance is found to play an important role in controlling material performance under irradiation, thus providing significant insights and strategic guidance for developing MEAs and HEAs for nuclear applications.

Keywords: High entropy alloys; Medium entropy alloys; Displacement cascade; Radiation resistance; Defect evolution