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RADIATION STABILITY OF TIVNBTA HIGH ENTROPY ALLOY IRRADIATED BY HELIUM AND KRYPTON IONS

I.A. IVANOV[1,2], V.V. UGLOV[3], M.M. BELOV[3], S.V. ZLOTSKI[3], K. JIN[4], N.A. STEPANJUK[3], A.E. RYSKULOV[1], A.L. KOZLOVSKIY[1,2], M.V. KOLOBERDIN[1,2], A.E. KURAKHMEDOV[1], A.D. SAPAR[1]

[1]*Institute of Nuclear Physics, Nur-Sultan, Kazakhstan*
[2]*L.N. Gumilyov Eurasian National University, Nur-sultan, Kazakhstan*
[3]*Belarusian State University, Minsk, Belarus*
[4]*Beijing Institute of Technology, Beijing, China*

High-entropy alloys (HEAs) are a class of crystalline metallic material which does not have an unambiguously identifiable base element and is highly alloyed with multiple elements. Some HEAs have demonstrated the potential of exhibiting superior mechanical properties compared to conventional alloys [1]. It is believed that maximizing the configuration entropy of HEAs promotes the formation of a single-phase disordered solid solution instead of the formation of complex intermetallic or second phases; as a result, the alloy has a simple microstructure with improved properties compared to traditional alloys. Numerous studies have shown that high-entropy alloys have a high elastic limit, wear, creep, and thermal and radiation resistance [2]. Substantial results on the ion irradiation experiments, with both heavy ions and He ions, have demonstrated that controlling chemical complexity can delay the irradiation induced defect evolution, suppressing the void and He bubble formation, as well as the radiation-induced segregation [3]. The use of HEAs as structural materials under extreme environments has been proposed owing to their desirable mechanical properties and thermodynamic stability.

Multicomponent high entropy alloy TiVNbTa and medium entropy alloy TiVTa were synthesized using high-purity metals (>99.9%) by arc melting followed by homogenization. Then annealing was carried out for 24h and 72h at a temperature of 1150°C with cold rolling up to 85 % reduction in thickness.

Ion implantation of alloys was carried out on a DC-60 heavy ion accelerator (Nur-Sultan) separately with He (40 keV, 2×10^{17} cm^{-2}) and Kr (280 keV, 5×10^{15} cm^{-2}) ions, as well as sequentially with helium and krypton ions.

The X-ray diffraction analysis showed that a single-phase solid solution with a BCC lattice is formed in all samples. The results of scanning electron microscopy and X-ray energy dispersive analysis confirm the formation of homogeneous equiatomic multicomponent solid solutions, the grain size in the VNbTiTa and TiVTa alloys was about 100-200 μm.

It was found that irradiation with helium and krypton ions did not lead to change in phase composition, microstructure and the uniformity of the elements distribution of the TiVNbTa and TiVTa alloys. No processes of radiation erosion (blistering or exfoliation) were revealed on the surface of the samples.

Irradiation with low-energy helium and krypton ions only leads to a change in internal stresses. Alloys TiVNbTa and TiVTa have compressive stresses of -0.40 and -0.57 GPa, respectively. Irradiation with helium ions leads to an increase in the level of compressive stresses to -0.64 and -0.94 GPa, and subsequent irradiation with krypton ions leads to a decrease in stresses to -0.49 and -0.63 GPa. CSS irradiation with only krypton ions reduces the stress level to -0.25 and -0.36 GPa.

The paper discusses the mechanisms of radiation stability of high-entropy alloy TiVNbTa and medium entropy alloy TiVTa, the influence of the type of ions on the formation of radiation defects, and their influence on the level of internal stresses.

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