ФИЗИЧЕСКИЙ ФАКУЛЬТЕТ

INTERNAL STRESS OF FCC AND BCC HIGH ENTROPY ALLOYS IRRADIATED BY HELIUM

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In this paper, we explore the comparison of irradiation damage and ion concentration of faced-centered cubic (FCC) phase and body-centered cubic (BCC) phase high entropy alloys. We conclude that the irradiation damage of FCC is higher than that of BCC phase HEAs. The change of residual stress and the dislocation density ratio of residual stress under different phases shows that the degree of distortion of BCC is higher than that of FCC phase HEAs under irradiation.

***Key words*:** high entropy alloys; helium; microstress, macrostress; dislocation.

INTRODUCTION

The good performance of institutional materials under harsh conditions such as high temperature and high radiation is a guarantee of safe and reliable nuclear energy. Therefore, high-entropy alloys (HEAs) containing several major elements have emerged and have shown extremely high performance. The ability to accumulate lattice strain conferred radioresistance to HEAs.[1] Lattice strain increases with increasing chemical complexity.[2]This article compares the irradiation damage results of high entropy alloys under face centered cubic structure and body centered cubic structure, as well as the changes in residual stress and dislocation density of crystals before and after irradiation with fluence $2*10^{17}cm^{-2}$.

RESULTS AND DISCUSSIONS

We have simulated the disordering dose and ion concentration of FCC and BCC under helium ion irradiation as a function of depth, respectively, using the SRIM program. As shown in the figure 1(a) and 1(b), the peak position of FCC and BCC-HEAs are almost the same, which is between 150-200nm. FCC-HEAs has higher atom displacement and thus higher irradiation damage, while the BCC-HEAs has higher ion concentration.

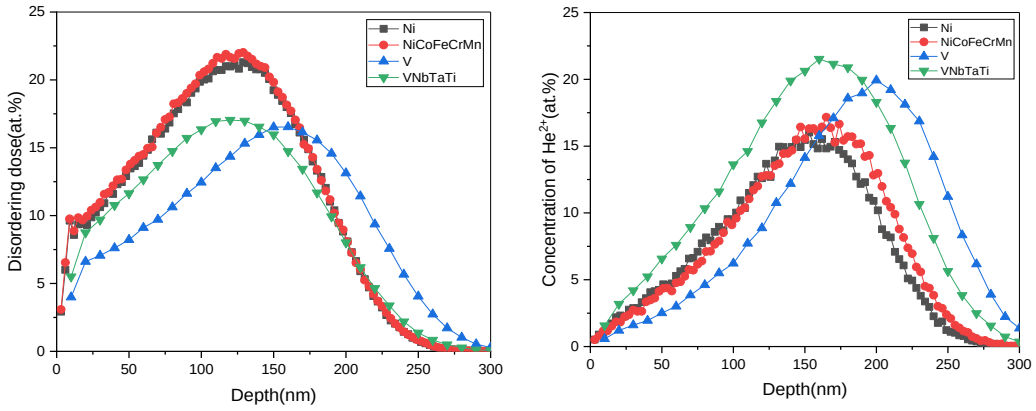
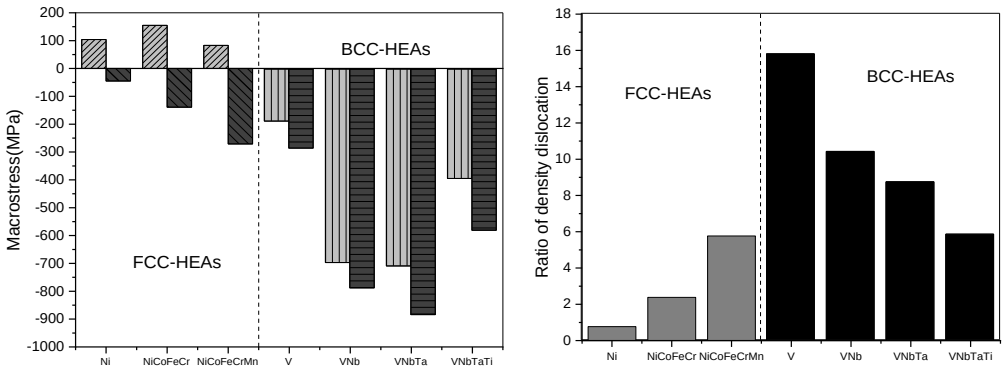


Fig. 1. The disordering dose and ion concentration of FCC and BCC-HEAs under helium ion irradiation as a function of depth, respectively

Using XRD and glancing X-ray diffraction (GXRD) methods, we obtained the changes in macrostress and density dislocation of FCC and BCC high-entropy alloys before and after helium ion irradiation. As shown in the figure, a positive value represents stretching and vice versa a negative value represents compression. As can be seen in Figure 2(a), the macrostress of the FCC-HEAs is in a tensile stress before irradiation, and irradiation leads to compression, which in turn shows negative values, and the "wall" becomes more effective with increasing of chemical complexity. For the BCC-HEAs, it is always in compression, and irradiation also enhances the effect of compression, and the alloy also has an increasing trend of compression effect before adding Ti elements again. In contrast, the compression effect of BCC after irradiation is significantly stronger than that of FCC.



(a) *(b)*

Fig. 2. (a) Macrostress of FCC and BCC HEAs; *(b)* The ratio of dislocation density for FCC and BCC-HEAs

Also, we explored the density of dislocation. In previous studies, it was found that the higher the irradiation dose (radiation damage), the higher the degree of radiation hardening of metal materials.[3]For convenience, we performed

a post-irradiation to pre-irradiation ratio, as shown in Figure 2(b). We can see that for FCC high entropy alloys, the density of the ratio of dislocation increases with increasing elements, while for BCC it keeps decreasing. For the BCC phase, the increase in compositional complexity promotes the accumulation of the ratio of dislocations, but also enhances radiation resistance.[1] So in Figure 2(b), as the elements increase, the ratio of the dislocation density after irradiation to the initial state dislocation density gradually decreases. From Figure 2(b), BCC solid solution will have higher strength compared to FCC solid solution. The difference in hardness of soft FCC alloys and hard BCC alloys can enable them to meet different needs respectively.

CONCLUSION

In this article, we focus on the difference on macrostress and density of dislocation between FCC and BCC-HEAs under irradiation with helium ions. By comparison we can conclude that FCC-HEAs suffer higher irradiation damage at the same dose of irradiation.

References

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