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Structural and mechanical responses of (ZrTiNbTa)C4 and ZrC ceramics under energetic He-ions

High entropy carbide ceramics (HECCs) are potential structural materials for advanced reactor concepts where numerous helium atoms would be produced due to the (n, α) nuclear transmutation reaction. However, the irradiation behaviors of high entropy ceramics are not well understood until now. In present work, the responses of high entropy (ZrTiNbTa)C4 and its binary constituent ZrC ceramics to energetic He-ions irradiation have been studied. X-ray diffraction analysis showed that He-ions irradiation resulted in peak shift and broadening of diffraction peaks in both (ZrTiNbTa)C4 and ZrC, which denotes lattice expansion and structural damages induced by the irradiation. Transmission electron microscope observation revealed that nano-sized spherical helium bubbles distribute uniformly in the grain interiors of (ZrTiNbTa)C4 while string-like bubbles with a preferred orientation are observed in ZrC grains. The accumulation and coarsening of He bubbles at grain boundaries are confirmed for both (ZrTiNbTa)C4 and ZrC, but no grain boundaries tearing was observed. Nanoindentation characterization gives that the irradiation induced hardening of (ZrTiNbTa)C4 is less definite than that of ZrC, which is attributed to irradiation induced bubbles and defect clusters act as obstacles during the deformation upon nanoindentation. Based on the experimental results, it can be concluded that the high entropy (ZrTiNbTa)C4 exhibits a less microstructural damage and reduced hardening than ZrC under identical irradiation conditions, suggesting the HECCs may possess a better irradiation resistance than the binary carbides.

Primary authors: ZHU, Yabin; SHEN, Tielong (Institute of Modern Physics, Chinese Academy of Sciences, P.R. China)

Presenter: ZHU, Yabin

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