# Radiation Effects of High Entropy Alloys

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**ABSTRACT:**

Advanced radiation-resistant materials with high mechanical strength and corrosion resistance are essential for the advancement of sodium-cooled fast reactors (SFR) and molten salt reactors (MSR). However, the steels currently employed in these applications have limitations, such as inadequate irradiation performance, insufficient high temperature strength, and compatibility issues in corrosive environments. To address these challenges, the proposed research will focus on a comprehensive investigation of the neutron irradiation effects on the mechanical properties of a novel class of alloys known as high entropy alloys (HEAs). It is hypothesized that the complex nature of HEAs leads to a retardation of radiation damage accumulation, resulting in enhanced radiation damage tolerance.

The proposed research aims to investigate the microstructure changes induced by neutron irradiation at three temperatures and their subsequent effects on mechanical performance. Furthermore, we will compare the radiation damage tolerance of HEAs with that of a 304L SS. We will conduct mechanical deformation experiments, including tensile testing, microhardness measurements, and nanoindentation, on both pristine and neutron-irradiated HEA samples. Additionally, high temperature nanoindentation in electron microscope will be employed to evaluate the local mechanical properties at irradiated temperatures. These experiments will enable us to determine the strength, hardness, and Young's modulus of neutron irradiated HEAs. By comparing the pristine and irradiated HEAs, we can assess the effects of neutron damage on material degradation. We will employ a multimodal characterization approach spanning from the atomic scale to the mesoscale to examine the microstructural evolution under both irradiation and deformation conditions. This characterization will involve the identification of radiation-induced defects, assessment of chemical composition in the bulk and at interfaces, analysis of phase changes, and investigation of defects and grain structure changes induced by mechanical deformation. Furthermore, we will utilize advanced microstructural data to validate numerical models that predict the deformation behavior at the structural mechanics level. A polycrystal microstructure will be reconstructed using experimental data, forming the basis for crystal plasticity simulations. The deformation model employed in these simulations will incorporate dislocation motion and its resistance due to dislocation loops and precipitates based on crystal plasticity theory, and it will be coupled with a phase-field model for damage initiation and growth. Once the simulations have been validated against experimental data, they will be utilized to predict the mechanical strength of HEAs.