NUCLEAR ENERGY RESEARCH INITIATIVE

Establishing a Scientific Basis for Optimizing Compositions, Processing Paths, and Fabrication Methods for Nanostructured Ferritic Alloys for Use in Advanced Fission Energy Systems

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Program Area: Generation IV

Collaborators: None

Project Description

The objective of this research is to develop high-performance fuel cladding, duct, and internal structural material systems for a variety of future fission reactors, including advanced fast burner reactors envisioned in the Global Nuclear Energy Program (GNEP). This research will focus on an emerging alloy class— nano-structured dispersion strengthened ferritic alloys (NFAs)— that has shown a very high promise of achieving the necessary objectives.

Researchers will develop a deformation processing database using a science-based approach to address limitations in directionally worked product forms in NFAs which have anisotropic microstructural and strength properties. They will construct a database over a wide range of conditions to map re-crystallization regimes that lead to more isotropic behavior. They will examine strain and temperature regimes that may allow superplastic deformation resulting in fine, stable grain structures that can be optimized for creep strength and properties. Researchers will assess severe deformation paths to solid state joining and map regimes of efficient diffusion bonding, guided by an understanding of the thermal stability of NFA microstructures. Through a semi-combinatorial approach, they will optimize NFA compositions to enhance a variety of performance indices (e.g., corrosion resistance) and explore utilizing γ-α phase transformation for achieving equiaxed microstructures that reduce strength and fracture toughness penalties associated with oxide dispersion strengthened martensitic steels. Identification and optimization of the NFAs fills a missing element in alloy design, namely their basic character, thus providing a basis of understanding for property optimization. In the final task, researchers will provide additional low-cost information of the use of NFAs in severe nuclear environments.

Workscope

The following tasks comprise the primary workscope of this project:

- Deformation processing database
- Solid state joining
- Alternative alloys and alloy optimization
- Identification and optimization of the NF
- Target of opportunity irradiations, exploratory mechanical testing and modeling