INTERNATIONAL NUCLEAR ENERGY RESEARCH INITIATIVE

Development of Crosscutting Materials for the Electrochemical Reduction of Actinide Oxides Used in Advanced Fast Burner Reactors

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Project Abstract

The conditions found in the oxide reduction step during spent nuclear fuel pyroprocessing are among the most aggressive thermal and chemical environments encountered by structural materials. When subjected to the convective flows generated from the pyro-metallurgical process, the high-temperature molten salts, coupled with oxygen gas, have been shown to cause corrosion in the most advanced nickel-based alloys and ceramic and metal coatings. In addition, the vessel could be exposed to uranium, plutonium, and other reactive elements during processing of the spent nuclear fuel. These elements may not only reduce oxides that are components of a coating material resulting in degradation, but may also produce low-temperature eutectic alloys.

The objective of this collaborative study is to use surface engineering and coating technology to improve the chemical, thermal, and corrosion performance of the pyroprocessing vessel and related structural components. The goal is to develop a coating system that will combine the thermal barrier qualities of graded ceramic layers with the corrosion protection of a metallic bond coat. This research will generate unique materials solutions to advance the design limits presently imposed upon structural alloy materials in the harsh environment of oxide reduction of spent nuclear fuel.

One method to achieve this goal is to design coatings with progressive complexity, whereby combinations of materials are used to produce a “functional” gradient in the material properties. The gradients in functionally graded materials (FGM) are primarily guided by material property considerations. The focus of this project will be on developing ternary and quaternary multi-component oxides as well as compatible bond-coating material to strengthen the adhesion of the ceramic coating to the metal substrate.