U.S. DEPARTMENT OF ENERGY
NUCLEAR ENERGY RESEARCH INITIATIVE
ABSTRACT

PI: **Ronald Baney** **Proposal No.: 99-0229**

Institution: **University of Florida**

Collaborators: **None**

Title: **An Innovative Ceramic Corrosion Protection System for Zircaloy Clading**

Light Water reactor (LWR) fuel performance is currently limited by thermal, chemical and mechanical constraints associated with the design, fabrication, and operation of the fuel in a nuclear environment. Corrosion of the zirconium based alloy cladding around the fuel is the primary limiting factor. Recent developments at the University of Florida to develop thin ceramic films with great adhesive properties to metal substrates offers an innovative breakthrough for eliminating a major weakness of Zircaloy clad. A more immediate approach will be to coat existing Zircaloy clad tubes with a ceramic coating for corrosion protection. A longer-term approach will be to demonstrate clad systems based entirely upon ceramic matrix composites. A novel boron-containing burnable poison outer layer will also be demonstrated as part of the ceramic coating development. In this proposed effort, emphasis will be on the ceramic coating with only demonstration of feasibility on the composite approach. This proposed program is expected to give a step change in clad lifetime before failure due to Corrosion.

In the development of ceramic coatings for Zircaloy clad, silicon carbide and zirconium carbide coatings will first be applied to Zircaloy coupons by thermal assisted chemical vapor deposition, plasma assisted chemical vapor deposition and by laser ablation deposition. All of these processes are in use at the University of Florida and have shown great potential. The potential problems of adhesion and thermal expansion mismatch of the ceramic coating to the Zircaloy substrate will be addressed. Several solutions to this potential problem will be examined. These include the use of a zirconium oxide compliant layer, employment of a laser roughened surface and the use of a gradient composition interlayer. These solutions have already been shown to be effective for other high modulus coatings on metal substrates. Mechanical properties and adhesion of the coatings will be monitored as a function of the coating process parameters. The corrosion protection of the various coatings will be evaluated by accelerated corrosion testing. Engineering requirements for coating a full size Zircaloy clad tube will be determined.

In the second approach, the University of Florida will demonstrate the feasibility to develop ceramic composite cladding as the cladding material of the future for Light Water Reactors.

A clad system based upon ceramic matrix composites (CMC's) also presents several technical and scientific challenges. The ceramic matrix composite tubes must be constructed in a way to be close to existing Zircaloy systems and not require a major redesign of reactor geometry . This constraint requires preparation of thin walled tubes. The tubes must be leak proof and be resistant to water

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corrosion and erosion at reactor operating conditions. The feasibility of utilizing preceramic polymer based and Chemical Vapor Deposition (CVD) based silicon carbide post coating layers will be demonstrated. Capping and joining of ceramic parts is also expected to present a challenge. The feasibility of developing an adhesive for joining a ceramic cap to the composite tube based upon a silicon carbide powder filled preceramic polymer will be demonstrated.