NUCLEAR ENERGY RESEARCH INITIATIVE

In-Situ X-ray Spectroscopic Studies of the Fundamental Chemistry of Pb and Pb-Bi Corrosion Processes at High Temperatures: Development and Assessment of Composite Corrosion-Resistant Materials

PI: Dr. Carlo U. Segre, Illinois Institute of Technology

Project Number: 05-028

Collaborators: None

Related Program: Gen IV

Project Description

This project is in support of the development of fast reactor designs for transmutation and small, proliferation-resistant power reactors using Pb and LBE liquid metal coolants. Use of these reactors for direct production of hydrogen becomes possible if temperatures of 800 °C can be achieved, but current experience is limited to 550 °C due to accelerated corrosion and embrittlement observed at higher temperatures.

The project will characterize the corrosion tolerance of various materials for use in advanced liquid metal reactors by probing their surface interactions with lead (Pb) and lead-bismuth eutectic (LBE) liquid metal coolant at temperatures up to 1,000 °C. A thin film of coolant, on the order of a few atomic layers, will be deposited on the surface before heating, enabling researchers to study the solid-liquid interface between the candidate composite materials and liquid metal coolants. The coolant edges will be probed with X-ray Absorption Spectroscopy (XAS) as a function of temperature and time to determine how they react with the solid underneath. Researchers will utilize a unique resource, the undulator beamline available at the Materials Research Collaborative Access Team, to support this project. Real time *in-situ* methods for corrosion characterization enable researchers to directly observe the fundamental chemical mechanisms that lead to corrosion.

Promising candidate materials as well as materials whose surfaces have been modified by applying the novel process of Ionized Plasma Deposition (IPD) will be studied. The IPD process has recently been developed and promises to revolutionize the development of composite coatings and to create surface treatments not possible by simple deposition techniques. IPD can impregnate a substrate material with a coating designed to have a specific composition, thickness, penetration, and nanostructure.

Work Scope

- Develop techniques for deposition of thin coolant layers onto a substrate, heat treatment procedures, and XAS measurement methodology.
- Study coolant reaction with steel substrates and candidate materials such as molybdenum, tantalum, zirconium, silicon-carbide, and correlate data with conventional dip tests.

- Apply IPD to prepare surface-modified steel samples and perform further *in-situ* and long term static tests using the best candidate materials.