SiC-ODS Alloy Gradient Nanocomposites as Novel Cladding Materials

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ABSTRACT

Cladding materials are critical to the performance, safety, and long term operation of existing nuclear reactors as well as future advanced reactors and fuel cycles. This project combines nuclear nanomaterial design, processing, testing, and characterization efforts to develop revolutionary materials that can withstand neutron irradiation for long periods of time while offering the promise of dramatically improved performance for both existing and next generation nuclear reactors. The project will design and study gradient nanocomposites that are composed of nanostructured SiC and oxide dispersion strengthened (ODS) steel (9Cr nanostructured ferritic alloy (NFA)) as the most advanced nuclear cladding materials, conduct material testing that most closely resembles nuclear reactor operating conditions, and offer nuclear nanomaterial understanding and prediction abilities based on comprehensive characterization and mechanism studies of these new cladding materials. The ultimate objective is to provide next generation nuclear cladding materials with increased corrosion resistance, strength, and creep resistance in both steady state normal operations and during off-normal and accident conditions.

This project will provide novel and effective SiC-ODS alloy nanomaterials with gradient compositions, understand composite microstructure evolution and performance degradation, and develop lab screening tools to guide future nuclear cladding material activities. More importantly, mechanisms of nuclear cladding material evolution and degradation in actual nuclear irradiation environments will be explored and effective strategies to mitigate/reduce undesirable cladding behaviors will be sought by designing the proposed nanocomposites responsively. The outcomes of this program are as follows: (1) novel and effective SiC-ODS alloy nuclear nanomaterials with gradient compositions and microstructures, (2) nuclear composite microstructure evolution and performance degradation understanding, (3) screening tools to guide future cladding material activities, (4) mechanisms of nuclear cladding material evolution and degradation and effective strategies to mitigate/reduce undesirable cladding behaviors, (5) new directions and replacement guidance for current nuclear cladding materials in operation, and (6) new cladding materials for future nuclear reactor material design and development.