Infrastructure Support for In-Situ High Temperature Dynamic Nano-mechanical Testing System for Mechanical Testing of Irradiated Structural Materials at University of Nevada, Reno

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Collaborators: Name – Organization *[N/A if none]*

Program: Infrastructure

ABSTRACT:

The objective of this proposal is to establish a new in-situ depth sensing nanomechanical testing infrastructure system – using the Alemnis SEM Indenter – designed to work in conjunction with a scanning electron microscope (SEM), which will allow the in-situ mechanical characterization of a variety of irradiated materials with unique micro/nano structures at University of Nevada Reno (UNR).

The Department of Chemical and Materials Engineering (CME) at UNR has a number of current Nuclear Science and Engineering programs such as determining the stress-strain response of irradiated metallic materials via spherical nanoindentation from sub µm-to- µm volumes, in situ Raman spectroscopy for determining actinide speciation and concentration, and development and experimental benchmark of computational models to predict cladding temperature and vapor removal from UNF canisters during drying operations. The department also offers a minors program in Nuclear Materials. The courses offered in the nuclear materials program focus on design, fabrication, mechanical behavior and environmental degradation of nuclear structural materials.

This proposal targets the following specific area of interest: mechanical testing of irradiated structural materials**,** and is aimed towards the ion-beam irradiation nuclear research community. Ion beam irradiation facilities can currently tailor helium concentration to dpa ratios to mimic those found in different reactor conditions. Quantitative measurement of mechanical behavior of ion irradiated materials is currently difficult at best, and at worst, nearly impossible. The primary difficulty stems from the volume of irradiated material, which is limited by the beam energy to depths of fractions of a micron to several microns, making the investigation of bulk mechanical properties very difficult. The addition of the proposed nano-mechanical test system, with its ability to measure activation energies and volumes from sub-µm material volumes, will be highly instrumental in understanding the deformation mechanisms as a function of the radiation dose.

The Alemnis SEM Indenter system was chosen as the best combination of system performance, modular design and cost target. The instrument is specifically designed to leverage the advanced imaging capabilities of scanning electron microscopes and integrated FIB/SEM systems. This is a unique system (and different from other manufacturers) in that it is a depth controlled system. Most nano-mechanical systems are load controlled. Being depth controlled it will allow us to perform high strain rate measurements (up to 100/s strain rates). High strain rate measurements allow us to perform strain rate jump tests, allowing us to measure activation energies and activation volumes from sub-micrometer sized specimens, especially at elevated temperatures. No other manufacturer (US or non-US) has this capability.

We have an exceptional track record of extending important facilities such as TEM, SEM and X-ray diffraction to other institutes and organizations. We will continue to extend this our nano-mechanical testing facility also to other universities and organizations to the extent of about 40% of its utility time. This will help for enhancing the multi-university nuclear research which ultimately will be useful for future collaborative projects. We have a strong commitment to create a multidisciplinary, collaborative educational program to prepare the workforce of the future. The addition of a nanomechanical test system to our existing facilities will contribute significantly to this objective.