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Procurement of a micro-autoclave for X-ray Diffraction Measurements

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ABSTRACT: There is a general lack of fundamental understanding of oxidation and associated corrosion mechanisms that occur in current nuclear materials such as zirconium alloy fuel claddings, nickel alloys steam generator tubes, and stainless steels internals, as well as in advanced nuclear materials such as SiC and coated zirconium alloys for ATF cladding applications under extreme conditions of temperature, pressure, and corrosive environments. For most metal-oxide systems, the relationships between the oxidation conditions and the resulting oxide-film growth kinetics and microstructure are poorly understood. This lack of understanding has led to models that are empirical at best and do not provide a physical description of the corrosion mechanism. In addition, although it is well known that water radiolysis is preponderant in nuclear materials and significantly affects corrosion, satisfactory radiolysis effects on corrosion-coupled models are still lacking. These knowledge gaps can be addressed by developing a state of the art autoclave where material interactions and behavior at the surfaces and interfaces can be studied in situ under corrosive conditions relevant to nuclear applications. Such understanding is vital to predict the performance of existing nuclear materials and to design and develop materials with long-lived stability under extreme conditions. High synchrotron X-ray energy and brightness available at the Materials Research Collaborative Access Beamline (MRCAT) at the Advanced Photon Source, coupled with advanced high temperature/high pressure equipment technology, present an exceptional opportunity to understand the fundamental interfacial processes involved in the degradation of nuclear materials in extreme environments. The goal of this proposal is to procure and install a state of the art micro-autoclave at the MRCAT beamline (sector 10) at the Advanced Photon Source (Argonne National Laboratory) in collaboration with the Department of Physics at the Illinois Institute of Technology and the Department of Engineering Physics at the University of Wisconsin-Madison. The proposed equipment will allow in-situ micro-scale characterization of oxide microstructure of nuclear materials under corrosion in various environments as well as the in-situ investigation of primary water radiolysis effect on corrosion. Thanks to this new equipment, the capabilities of the NSUF partner beamline will be greatly improved in the high pressure, higher temperature region. This will allow the user community to better characterize nuclear materials degradation phenomena in well-controlled environments relevant to nuclear applications. Consequently, the experimental data generated by the users will maintain the strict quality assurance, better serve multiscale and multiphysics model validation currently developed by the Department of Energy and help understanding complex degradation mechanism occurring in nuclear materials.