Deciphering Irradiation Effects of YH_x through In-situ Evaluation and Micromechanics for Microreactor Applications

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Program: RDO-1: Advanced Reactor Development

ABSTRACT:

Advanced reactor concepts, specifically microreactor designs, allow for portability and flexibility in siting owing to its limited need for refueling, reduced size, and weight. The development of microreactors necessitates the advancement of alternative neutron moderators, such as metal hydrides. Metal hydrides are of interest for their high H densities, moderating potential, and thermal stability at high temperatures enabling higher power conversion efficiency. Yttrium hydride is under consideration for microreactor applications due to its higher temperature stability, with desorption occurring at ~800°C instead of ~600°C in zirconium hydride. This project addresses a critical gap in accelerated testing of metal hydride evolution coupling multi-length scale mechanical testing with ion irradiation and advanced characterization to establish a baseline understanding of yttrium hydride (YH_x) evolution, a candidate metal hydride moderator. Our approach will couple ion irradiation with small and bulk scale mechanical testing to decipher multi-scale impacts on void formation and phase stability. This work will advance understanding of YH_x for future microreactor applications combining *in situ* and *post mortem* experimentation and multi-scale characterization. The objective of this project is to (1) identify the effects of ion irradiation on the YH microstructure and phase stability at elevated temperature; (2) understand how radiation-induced defects, such as voids and dislocation loops, affect mechanical properties; and (3) establish a facility for further ion irradiation studies of YH and nuclear materials under gas exposure. The outcome will couple real-time phase evolution to rapidly evaluate YH_x under irradiation to advance microreactor development. This work will address the stability and micro-mechanical properties of YH_x under irradiation and thermal stimuli to understand the effect of irradiation-induced microstructural changes on properties. The rapid deployment of ion irradiation and associated characterization can reduce the technical risks associated with deployment and testing of YH_x and will supplement on-going, critical neutron irradiation experiments. Yttrium hydride samples will be fabricated to different hydrogen-to-metal ratios and ion irradiated to characterize radiation damage, phase stability under irradiation, and mechanical property changes due to radiation-induced defects (e.g. voids). This work will determine how radiation damage affects mechanical properties in yttrium hydride, addressing a major knowledge gap in determining the feasibility of this material as a moderator material in microreactors.