Rapid Simulation of Irradiation Damage in PWR Internals

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ABSTRACT:

As Pressurized Water Reactor (PWR) internals are expected to experience high damage doses exceeding 100 dpa by the end of the second license renewal, there is a need for data and validated models to predict the degree of irradiation damage expected in these internals. Test reactor irradiations are impractical because the damage rate is comparable to that in commercial reactors. The only practical means of obtaining irradiated microstructures at high dpa (>25 dpa) in a short amount of time (<6 months) and at modest cost is to use self-ion irradiation. Emulation of the microstructure produced in reactor requires that self-ion irradiation correctly captures both the nucleation processes and the growth processes of each of the relevant microstructure features. However, a less demanding challenge is to use ion irradiation to *grow* the microstructure created by reactor irradiation from a relatively low to intermediate damage level, to reach higher damage levels. This is the idea behind the rapid simulation of high fluence by self-ion irradiation concept. The objective of this study is to demonstrate that self-ion irradiation can *evolve* an existing damage microstructure to higher dose levels such that the doses provided by ion and neutron irradiation produces the same microstructure. This approach hypothesizes that self-ion irradiation after preliminary nuclear reactor irradiations negates the complicated nucleation regime allowing for a pure growth-regime-based damaged-induced microstructural progression resulting in rapid simulation of radiation damage in PWR core internals. Proof of the hypothesis and hence meeting the objective thus depends on using reactor irradiated components and then systematically performing self-ion irradiations followed by thorough characterization of the resulting microstructures including the dislocation loop and network, precipitate type and distribution, void distribution and radiation induced segregation. The necessary self-ion irradiations and characterization efforts will be completed using state-of-the-art Nuclear Science User Facilities (NSUF) partner facilities.