Title: Investigations of Helium Accumulation in Materials through Accelerated Aging

Abstract: Understanding helium behavior over long timescales is necessary for predicting lifetimes of nuclear materials. This is particularly true for nuclear waste storage materials, tritium storage materials, and nuclear weapon components, each of which will potentially accumulate helium over much longer timescales than nuclear reactor materials. This talk will overview work aimed at understanding helium accumulation, bubble nucleation, and bubble coarsening in the pyrochlores $Gd_2Ti_2O_7$ and $Gd_2Zr_2O_7$, $LiAlO_2$, and palladium. Pyrochlores have been extensively studied for the immobilization of actinides, which will undergo radiation damage and helium gas build-up due to α-decay over hundreds of thousands of years. Ion implantation was used in conjunction with heavy-ion irradiation to simulate the synergistic effects of gas accumulation and displacement cascade damage (as well as accompanied phase transformations) that would be expected in these materials over geological timescales. Helium bubbles were characterized in materials implanted under various conditions using transmission electron microscopy (TEM), grazing-incidence x-ray diffraction (GIXRD), and thermal desorption spectroscopy (TDS). $LiAlO_2$ is a component of Tritium Producing Burnable Absorber Rods (TPBARs), which are designed for placement inside nuclear reactors where they breed the tritium necessary for sustaining the nation's strategic stockpile. $LiAlO_2$ is enriched with the ^6Li isotope, which absorbs neutrons from the reactor and subsequently decays, releasing $^3H + {}^4He$ into the material. Most of the tritium is gettered by the outer layer of Zircaloy-4, but not as much as simulations predict. In an effort to understand how the tritium released inside $LiAlO_2$ might be interacting with the surrounding microstructure, the synergistic effects of hydrogen, helium, and displacement cascade damage were explored using in-situ TEM single, dual, and triple ion irradiation. We found that the 200 keV electron beam induces its own damage on $LiAlO_2$, which significantly complicated these experiments. Tritium storage materials, such as palladium, pose unique challenges for studying with accelerating aging techniques because the β-decay of tritium releases ^3He with too little energy to induce displacement damage in the material. In this work, in-situ TEM 10 keV ^4He implantation was utilized gain some fundamental understanding of bubble nucleation and coarsening in palladium with as little displacement damage as possible. Resulting microstructures were compared to literature studies on aged tritides.

Bio: Caitlin A. Taylor is a currently a Senior Member of the Technical Staff at Sandia National Laboratories where she uses electron microscopy and x-ray diffraction to characterize various microstructural properties of materials. Previously she was a Postdoctoral Appointee at Sandia under Khalid Hattar, using in-situ ion implantation, gas cell, and liquid cell TEM to study helium bubble nucleation and growth kinetics under different conditions, microstructural changes in metals due to hydriding, and electron beam induced nanoparticle synthesis. Caitlin obtained her Ph.D. in Materials Science & Engineering from the University of Tennessee, Knoxville in December of 2016, during which she studied helium accumulation and bubble formation in the pyrochlores $Gd_2Ti_2O_7$ and $Gd_2Zr_2O_7$. In May 2012, she obtained a B.S. in Physics with a Math minor from Hope College in Holland, MI, where she worked in two research groups, one in theoretical astrophysics and one in nuclear physics.

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