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The introduction of helium (He) into metal components is a major concern in nuclear energy applications. In fission reactors, it causes embrittlement of load-bearing components, especially ones made of nickel-base alloys. In future fusion reactors, He is expected to severely degrade the surfaces of plasma-facing materials. In both cases, the deleterious effect of He may be traced back to its insolubility in metals, leading to its precipitation into nano-scale bubbles. Metal nanocomposites provide opportunities for mitigating He-induced damage by providing greater control over where He bubbles form and how they interact with other defects.This talk will summarizeexperimental and modeling work on the behavior of He in multilayer metal nanocomposites.

While He bubbles are approximately uniformly distributed within grain interiors of polycrystalline alloys, in nanocomposite metals they show a distinct preference for growth in one of the constituent phases. Moreover, while both grain boundaries in polycrystalline alloys and heterophase interfaces in metal nanocomposites are preferential trapping sites for He bubbles, the latter exhibit a distinct asymmetry in bubble formation, with bubbles preferentially growing into one of the adjacent phases. We explain these differences in terms of the properties of the composite constituent phases as well as the internal structure of the interfaces between them.

Next, we compare a series of layered composites with different interface structures and layer thicknesses. We show that, with decreasing layer thickness, the critical He concentration needed to form bubbles is reduced in all of these materials. The rate of reduction is shown to depend on the structure of the heterophase interfaces found in these materials, in particular the areal density of interfacial He trapping sites.The distribution of such trapping sites within any given interface is directly related to the distribution of interface misfit dislocations, in particular the density of intersections between these dislocations within the interface plane. Such sites have high local interface energy, giving rise to preferential wetting by He bubbles and, therefore, preferential He bubble nucleation.

Finally, we examine the effect of confinement on bubble morphology in layered composites where the layer thickness is reduced to ~5nm. In such cases, there is dramatic shift in bubble shape, from relatively equi-axed to high aspect ratio, linear channels. The formation and stability of these channels is again explained based on the structure of the interfaces between constituent phases in the composite. Upon aging, these channels are shown to transform into wide, faceted plate-shaped voids, which nevertheless remain confined within individual layers in the composite. I conclude with a discussion of how insights gained from this fundamental research may translate into strategies for developing novel, He damage-resistant materials for future nuclear energy applications.