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Electron microscopic characterization of deformation microstructures in 304L stainless steel forgings for tritium storage reservoirs

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Abstract: High-pressure storage vessels for the containment of hydrogen and its isotopes, including tritium, are often fabricated from austenitic stainless steels. The integrity of these vessels is degraded as the isotopes dissolve into the metal and interact with the microstructure. The deformation behavior and corresponding microstructures in such alloys are sensitive to the presence of tritium, both through the direct influence of hydrogen effects on deformation, and through the effect of internal helium bubbles on deformation as the tritium decays to helium (referred to as tritium aging). Additionally, the evolution of the helium bubble architecture depends on the initial microstructure of the material, which has implications on the deformation and fracture behavior. In order to decouple these complex effects, at Sandia we are conducting a detailed microstructural study of the deformation microstructures in 304L forgings as a function of strain and internal hydrogen concentration. This study is intended to provide a baseline understanding of hydrogen-deformation interactions to inform studies on 304L forgings aged with internal tritium. In this presentation, we will discuss detailed transmission electron microscopy (TEM) and electron backscattered diffraction (EBSD) measurements comparing the microstructures of forged 304L, both with and without internal hydrogen, for different tensile strains. We will focus specifically on the nanoscale evolution of shear-bands in the presence of internal hydrogen and their relationship to deformation-induced twinning and phase transformations forming ε- and α'-martensite. Here, nano-beam diffraction and atomic-resolution observations are providing fundamental insight concerning the interfacial dislocation processes involved in these transformations and the influence of hydrogen on these processes. We will end the talk with a discussion of our plans to extend this work to clarify the role of internal tritium and helium on deformation behavior.

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