Understanding the cause of suppressed void swelling in additively manufactured steels

Alec Pfundheller
Advisor: Lin Shao
Department of Nuclear Engineering, Texas A&M University
acpfundheller@gmail.com

Abstract:

Our recent study has shown that additively manufactured 316L stainless steels exhibit less swelling in comparison with their wrought counterparts. By applying proton irradiation and cross-sectional transmission electron microscopy characterization, the safe analysis zone for void swelling was identified and compared between the two variants. The AM steels not only show fewer voids but also fewer dislocation loops. A void nucleation theory was proposed to explain the dramatic effect due to the presence of impurities such as carbon on void nucleation and growth. Impurities temporarily trapped vacancies and reduced their effective diffusivities. The mobility changes of vacancies affect the vacancy flux towards a void and also the ratio of defect arrival rates between vacancies and interstitials. The latter is one key parameter to determine whether stable void nuclei can form or not. The modeling shows that even one appm (atom per million) of carbon can effectively reduce void nucleation density and also narrow the void nucleation temperature window. Such void swelling behavior and ultra-high swelling sensitivity are proposed as characteristic features to identify differences between AM and batch processes.