Neutron and High Energy X-ray Diffraction Characterization of Materials Under Simulated Manufacturing Conditions

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Bio: Don Brown received his BS in Physics from Bowling Green State University in 1993 and PhD in Physics from the Penn State University in 1998. His dissertation focused on using x-ray and neutron scattering techniques to characterize materials confined to nano-voids. He began his professional career as a postdoc working at the neutron scattering center at Los Alamos National Laboratory. He has been the co-instrument scientist of the Spectrometer for Materials Research at Temperature and Stress (SMARTS) since the commissioning in 2003. SMARTS was the first neutron scattering instrument designed for the study of engineering materials and is based on a philosophy of studying materials response to conditions simulating operation and/or processing. Don has extended this philosophy to include large scale x-ray scattering facilities such as the Advanced Photon Source at Argonne National Lab. His work has focused on the study of nuclear weapons and energy materials, but includes components of aerospace, automotive, and functional materials as well. Most recently, his research has included in-situ processing and performance of additively manufactured materials. He is now a Senior Scientist at LANL and Materials Scattering Team Leader in the Materials Science and Technology Division with roughly 250 co-authored publications and an h-index of 42.

Abstract

Neutron and High Energy X-ray (> 30 keV) diffraction provide the opportunity to quantitatively probe the microstructure of materials at bulk depths under extreme environments. Recent interest in advanced manufacturing techniques have driven coupled experimental/theoretical studies focused on accelerated science-based qualification of materials under manufacturing conditions. Diffraction experiments can be imagined under many different manufacturing conditions, but as metal Additive Manufacture (AM) has garnered so much interest lately, our work and this talk will focus on conditions relevant to AM. In particular, we will focus on designing scattering experiments to extract quantitative microstructural information, e.g., phase fraction, texture, internal stress, solute chemistry and dislocation density during manufacturing processes. The desire for microstructural information, that is phase fraction rather than peak intensity for example, often forces sacrifices either in the fidelity of the experimental environment to the actual process, or in the maximum rate of data collection. Thus, it is necessary to carefully select the probe, X-rays or Neutrons, to match the data rate to the kinetics of the specific process of interest. In this work, we have collected diffraction data during in-situ AM and during post-build processing of several relevant metal alloys to monitor the microstructural evolution of the material, expressly for the purpose of developing and validating microstructure-aware process models. The observed microstructure evolution for each case will be presented, and the necessary assumptions made in extracting the microstructural information from diffraction data will be critically examined.