Using High Energy X-Ray Diffraction to Probe Additively Manufactured Metals over a Range of Length and Time Scales

John Carpenter [1], D.W. Brown[1], B. Clausen[1], J.C. Cooley[1], M. Strantza[2], A. Losko[3], N. Johnson[4], J.S. Park[5], P. Kenesei[5], J. Almer[5]
[1] Los Alamos National Laboratory
[2] Lawrence Livermore National Laboratory
[3] Heinz Maier-Leibnitz Zentrum
[4] Colorado School of Mines
[5] Argonne National Laboratory

Email: carpenter@lanl.gov

This talk will present our efforts to characterize the processing / microstructure / properties / performance relationship of additively manufactured materials across many length and time scales utilizing high-energy x-ray scattering techniques at the Advanced Photon Source. As an example of studying the effect of processing on microstructure, high energy x-ray diffraction has been used to monitor microstructural evolution in-situ during additive manufacture of 304L stainless steel and Ti-6Al-4V with sub-second time resolution and sub 0.1mm spatial resolution. Both material feedstocks are wire and deposited using a metal inert gas welding set-up. The intent is to study this additive technique as it pertains to the repair of existing objects. Specifically, the evolution of phase fractions, liquid and multiple solid phases, is monitored immediately following deposition, during solidification, and during cooling. This information can be utilized in current process – microstructure models in order to inform and validate the appropriate kinetics which lead to the resultant microstructure after deposition.