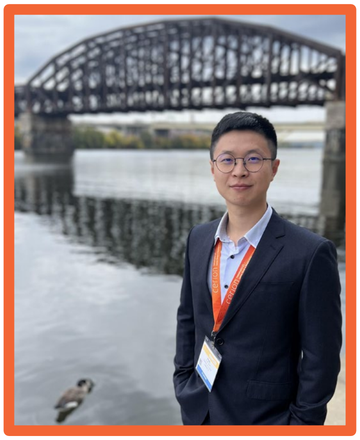
Graduate Student Research Seminar

Spring 2023

Rapid Solidification Kinetics During Additive Manufacturing



Yitao Wang (PhD student)

Advisor: Dr. Fadi Abdeljawad

Monday, April 10th

3:00 pm (EST) – 132 Fluor Daniel Building

Abstract

Recent advances in additive manufacturing (AM) techniques have enabled the development of novel materials with unique microstructural features. Laser powder bed fusion (LPBF) is one of the most widely used AM techniques to fabricate metallic systems. With LPBF, a concentrated laser beam selectively melts a layer of metal powder, and the resultant melt pool solidifies rapidly by various mechanisms. Solidification physics has received considerable attention in recent years for its direct relevance to nearly all AM technologies. Microstructural features, such as the shape and size of crystalline grains and materials interfaces, that emerge during LPBF result from an intricate interplay between thermodynamic forces and kinetic processes involving the transport of chemical species and latent heat of fusion away from solid-liquid interfaces. Further, rapid solidification conditions during LPBF result in solute trapping, which influences solidification morphologies (e.g., dendritic, cellular, and planar) and their characteristic size. Understanding and controlling solidification rates is therefore considered a key aspect of microstructure control during materials processing. In the present work, we employ a mesoscale phase-field modeling framework to examine the impact of various kinetic processes on non-equilibrium solidification in ternary alloys. Analytical and computational studies are used to systematically examine the influence of various mass transport mechanisms and interface permeability on solidification growth rates and solute trapping. Simulation results show that off-diagonal interdiffusion coefficients play an important role in growth rates and solute redistribution in the vicinity of the advancing solid-liquid interface. Our computational studies are used to survey the complete ternary alloy space and quantify associated solidification rates. In broad terms, our work provides avenues to relate LPBF processing and alloy chemistry to resultant solidification morphologies and associated properties.

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