VI International Conference on Simulation for Additive Manufacturing, SIM-AM 2027
September 13-16, 2027, Weimar, Germany

PREDICTION OF SOLIDIFICATION MICROSTRUCTURES IN ADDITIVE MANUFACTURING

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ABSTRACT

This invited session brings together researchers working on the prediction of solidification microstructures in additive manufacturing, including dendritic/cellular structures, grain structures, and crystallographic textures. It provides a forum for discussing the mechanisms of microstructure selection, advances in predictive modeling, and opportunities for simulation-guided microstructure control.

Topics of interest include dendritic/cellular growth and its fundamental role in grain competition and orientation selection, including under rapid solidification conditions. Particular attention is given to how melt-pool thermal-fluid behavior and evolving shape influence competitive growth and microstructure selection. Nucleation and fragmentation-induced grain multiplication are also within scope. The session also explores how laser scanning conditions and scan strategies influence microstructure selection and can be designed to achieve desired grain structures and textures, including approaches toward single-crystal growth and microstructure optimization.

The session welcomes physical models and numerical methods that improve the accuracy or efficiency of melt-pool thermal-fluid predictions, dendritic/cellular growth simulations, and grain-scale descriptions of growth, competition, and texture evolution. Relevant approaches include phase-field models for dendritic/cellular growth and rapid solidification; phase-field, cellular automaton, Monte Carlo, and other grain-scale models; and finite-element, finite-volume, lattice Boltzmann, and related thermal-fluid frameworks. High-performance computing, efficient algorithms, multiscale approaches, and reduced-order or data-driven models are of interest where they improve predictive capabilities or extend accessible spatial and temporal scales, from individual melt pools to multi-track and multi-layer processing. Integration of simulation and experiment for model development, parameter estimation, and quantitative validation is also encouraged.

Contributions on other topics related to microstructures in additive manufacturing are also welcome.