Multiscale, Multifidelity Models for Control and Optimization in Additive Manufacturing

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Program objective: The objective of this proposal is to advance computational mechanics models that permit constructing online models for additive manufacturing to enable real-time process control targeted toward reducing residual stress accumulation during build. As residual stress and strain accumulation is inherently a multiscale process due to the high thermal gradients and cooling rates experienced during solidification, a bottom-up approach to physics-based modeling of the multiscale behavior is pursued. Thermomechanical models based on crystal plasticity finite elements to resolve the effects of grain-scale heterogeneity will be developed along with low-order hyper reduced order and surrogate models derived from a database of simulation results containing parametric analysis of material properties and build conditions. Machine learning-based constitutive law modeling will be pursued to establish a homogenized probabilistic constitutive model that accounts for material property variability and can be used for engineering-scale finite element analysis. If this modeling approach has acceptable prediction capability, then it can be used to drive build condition parameters for targeted, spatially resolved structural material properties without relying on scenario-specific overly calibrated models, which is the present status quo.