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# An integrated process-structure-property modeling framework for additive manufacturing

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**Abstract**

One goal of modeling for metal Additive Manufacturing (AM) is to predict the resultant mechanical properties from given manufacturing process parameters and intrinsic material properties, thereby reducing uncertainty in the material built. This can dramatically reduce the time and cost for the development of new products using AM. We have realized the seamless linking of models for the manufacturing process, material structure formation, and mechanical response through an integrated multi-physics modeling framework. The sequentially coupled modeling framework relies on the concept that the results from each model used in the framework are contained in space-filling volume elements using a prescribed structure. This framework is implemented to show a prediction of the decrease in fatigue life caused by insufficient fusion resulting from low laser power relative to the hatch spacing. In this demonstration, powder spreading and thermal-fluid flow models are used to predict the thermal history and void formation in a multilayer, multi-track build with different processing conditions. The results of these prediction are passed to a cellular automaton-based prediction of grain structure. Finally, the predicted grain and void structure is passed to a reduced-order micromechanics-based model to predict mechanical properties and fatigue life arising from the different processing conditions used in the process model. The simulation results from this combination of models demonstrate qualitative agreement with experimental observations from literature, showing the appealing potential of an integrated framework.

*Keywords:* Additive Manufacturing, mesoscale models, reduced order