Computationally Efficient Textured Microstructure Prediction in Additive Manufacturing

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Abstract

Efficient modeling of solidification microstructures and crystallographic texture of additively manufactured metals is essential to modeling mechanical response. Presented here are two efficient 3D texture-inclusive AM models. The first is a modification of the existing SPPARKS Potts modeling package to include preferred growth along crystallographic $< 100>$ directions during solidification. This model is both relatively light and high-speed and shows close matching to experiments when properly calibrated. This first model includes tracking a moving modified Rosenthal heat source that is able to produce non-semicircular melt pools. The second model is an even more efficient option that models entire laser passes and ensuing solidification by the assumption of a generalized growth shape rather than following a solidification front. This model also captures $< 100>$ preferred growth allowing it to predict as solidified crystallographic texture. Comparisons of results, efficiency, and potential modifications to these models will be made. Finally, highly efficient reduced-order methodologies to predict microstructures using machine learning will be discussed. Both generative adversarial networks (GAN) and graph neural network approaches will be covered.

Keywords: Additive Manufacturing, Simulation, Machine Learning, SPPARKS, Solidification Texture

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