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COMPUTATIONAL APPROACH FOR EVALUATING MICROSTRUCTURE-TO-PROPERTY LINKAGE OF ADDITIVE ALUMINUM ALLOYS

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Selective laser melting (SLM) is an additive technology commonly used for manufacturing aluminum components. The SLM is characterized by high-rate and high-gradient thermal processes developing in each subsequent layer of aluminum powder. Rapid melting, remelting and solidification processes give rise to the formation of a complex hierarchical microstructure significantly different from the microstructure of casting alloys. An accurate prediction of the deformation behavior of additive aluminum requires knowledge of the deformation mechanisms developing at the micro- and mesoscales and their contribution to the macroscopic response.

This paper presents a computational approach to investigate the deformation behavior of SLM-produced aluminum alloys with an explicit account of the microstructure. Two approaches to simulating AM microstructures of an aluminum alloy are presented. First approach relies on the mathematical description of the microstructure evolution during AM process, taking into account complex physical processes involved. The numerical solution is based on a combination of the finite difference method for modeling AM thermal processes and the cellular automata method for describing the grain growth. Another approach provides fast generation of artificial 3D microstructures similar to those produced by AM, using the method of step-by-step packing. The microstructure-based constitutive models are then used as input data in the boundary-value problem with the grain behavior being described in terms of crystal plasticity. The combined effects of the grain structure, texture and loading conditions on the evolution of the microscale stress-strain fields in SLM aluminum alloys are analyzed.

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