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Publication date:
2023

Document Version
Publisher's PDF, also known as Version of record

Dynamic SEM in-situ studies: A tool to investigate microstructural evolution during metal additive manufacturing?

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An anisotropic microstructure is typical of metal components fabricated by plasma arc additive manufacturing (PLAAM) with a site-specific microstructure, due to non-equilibrium cooling conditions and the unique process parameters. Additionally, previously deposited layers are subjected to cyclic heat inputs during the manufacturing process, which can result in element diffusion, phase transitions, or changes in grain morphology.
In this study, in-situ scanning electron microscopy (SEM) methods are developed to better understand the complex spatial-temporal thermal transients that AM components are subjected to during fabrication. Our emphasis is on developing microscopy techniques required to simulate such a temperature profile on a sufficiently large sample compared to a typical grain size in AM components. The temperature distribution in bulk samples on the MEMS-SEM microheaters is predicted using COMSOL simulations. The dynamic changes in the microstructure are analyzed using electron backscatter diffraction (EBSD) and SEM imaging during a cyclic heating experiment. This study will allow to draw conclusions on the feasibility of using SEM-based heating studies to develop a fundamental understanding of microstructure formation during PLAAM processes.