
AI-driven optimization of heterogeneous structures in LPBF-fabricated Al-Cu-Mg aluminum alloys for enhanced mechanical performance

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Abstract

The use of artificial intelligence (AI) to regulate the heterogeneous structure of materials in order to enhance mechanical properties has become a critical area of research in materials science and engineering. By integrating machine learning (ML) and deep learning (DL) techniques, a quantitative relationship can be effectively established between manufacturing process parameters, heterogeneous microstructural features, and mechanical properties. This study proposes a method based on a conditional generative adversarial network (cGAN) to regulate the heterogeneous structure of a new high-strength aluminum alloy, Al-Cu-Mg, using laser powder bed fusion (LPBF) process parameters. The method generates the desired microstructure and further optimizes the mechanical properties, thereby demonstrating the potential of AI in additive manufacturing. This study provides a foundational framework for systematically linking additive manufacturing parameters with microstructure and mechanical properties through AI-driven models. This work not only promotes process optimization and material design but also lays the groundwork for precise microstructure control in a wide range of metal additive manufacturing applications.

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