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Elucidating Microstructural Evolution Mechanisms in Tungsten via Layerwise Rolling in Additive Manufacturing: An Integrated Simulation and Experimental Approach

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Abstract : In the field of additive manufacturing, tungsten stands out for its exceptional resistance to high temperatures, making it an ideal candidate for use in extreme conditions. However, its inherent brittleness and vulnerability to thermal cracking pose significant challenges to its manufacturability. This study explores the microstructural evolution of tungsten processed through layer-wise rolling in laser powder bed fusion additive manufacturing, utilizing a comprehensive approach that combines advanced simulation techniques with empirical research. We aim to uncover the complex processes of plastic deformation and microstructural transformations, with a particular focus on the dynamics of grain size, boundary evolution, and phase distribution. Our methodology employs a combination of simulation and experimental data, allowing for a detailed comparison that elucidates the key mechanisms influencing microstructural alterations during the rolling process. This approach facilitates a deeper understanding of the material's behavior under additive manufacturing conditions, specifically in terms of deformation and recrystallization. The insights derived from this research not only deepen our theoretical knowledge but also provide actionable strategies for refining manufacturing parameters to improve the tungsten components' mechanical properties and functional performance. By integrating simulation with practical experimentation, this study significantly enhances the field of materials science, offering a robust framework for the development of durable materials suited for challenging operational environments. Our findings pave the way for optimizing additive manufacturing techniques and expanding the use of tungsten across various demanding sectors.

Keywords : additive manufacturing, layer wise rolling, refractory materials, in-situ microstructure modifications
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