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Advancing Microstructure Evolution in Tungsten Through Rolling in Laser Powder Bed Fusion

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Abstract : Tungsten (W), a refractory metal known for its remarkably high melting temperature, offers tremendous potential for use in challenging environments prevalent in sectors such as space exploration, defense, and nuclear industries. Additive manufacturing, especially the Laser Powder-Bed Fusion (LPBF) technique, emerges as a beneficial method for fabricating tungsten parts. This technique enables the production of intricate components while simultaneously reducing production lead times and associated costs. However, the inherent brittleness of tungsten and its tendency to crack under high-temperature conditions pose significant challenges to the manufacturing process. Our research primarily focuses on the process of rolling tungsten parts in a layer-by-layer manner in LPBF and the subsequent changes in microstructure. Our objective is not only to identify the alterations in the microstructure but also to assess their implications on the physical properties and performance of the fabricated tungsten parts. To examine these aspects, we conducted an extensive series of experiments that included the fabrication of tungsten samples through LPBF and subsequent characterization using advanced materials analysis techniques. These investigations allowed us to scrutinize shifts in various microstructural features, including, but not limited to, grain size and grain boundaries occurring during the rolling process. The results of our study provide crucial insights into how specific factors, such as plastic deformation occurring during the rolling process, influence the microstructural characteristics of the fabricated parts. This information is vital as it provides a foundation for understanding how the parameters of the layer-by-layer rolling process affect the final tungsten parts. Our research significantly broadens the current understanding of microstructural evolution in tungsten parts produced via the layer-by-layer rolling process in LPBF. The insights obtained will play a pivotal role in refining and optimizing manufacturing parameters, thus improving the mechanical properties of tungsten parts and, therefore, enhancing their performance. Furthermore, these findings will contribute to the advancement of manufacturing techniques, facilitating the wider application of tungsten parts in various high-demand sectors. Through these advancements, this research represents a significant step towards harnessing the full potential of tungsten in high-temperature and high-stress applications.
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