Simulation analysis of Electron beam melting using a multi-scale model

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Abstract

Electron Beam Melting (EBM) has become the focus of most concern for fabricating of precision metal parts because of high-efficiency and excellent formability. In recent years, numerous studies showed that $<001>_\beta$ // Nz columnar β grain structure and inward curved β grain structure are observed in EBM metal fabrication, especially for Ti-6Al-4V alloy. The solidification conditions was regarded as the most important factor for leading to these phenomenon. In order to simulate the thermal response and its effect on the meso-structure evolution of grain growth of Ti-6Al-4V alloy during EBM process, a multi-scale model integrating a "Tri-Prism" element (TP6) and a phase-field (PFM) methods was presented. The material deposited process and its temperature field at the macroscopic is modeled by "Tri-Prism" element, which provides favorable applicability for complex geometry, higher precision and less computation time than isoparametric hexahedron element. The grain structure evolution at the mesoscale is performed by temperature-dependent phase-field model. Upon the experimental validation, the $<001>_\beta$ // Nz columnar β grain structure and inward curved β grain structure are reproduced by using this multi-scale model, and the formation mechanism is analyzed in detail. The effect of printing parameters on the β grain structure and texture in Ti-6Al-4V additive manufacturing by EBM are also investigated detailly.

Keywords: Electron Beam Melting, multi-scale model, "Tri-Prism" element, Phase-field method, columnar grain.