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PROCEEDINGS

Microstructure Mechanism of Stray Grain Formation During Ni-Based Single-Crystal Superalloys Prepared by Laser-Directed Energy Deposition

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ABSTRACT

Ni-based single-crystal superalloys (SX) turbine blades of aeroengines are inevitably damaged during using. Therefore, it is of great significance for commercial aeroengines with high economic requirements to repair SX turbine blades reasonably and continue to realize their value by Laser-Directed energy deposition (L-DED). The repairing of SX must maintain the epitaxial growth of single-crystal, so the microstructure adjustment and the inhibition of stray grains are important for the preparation of L-DED SX.

In this work, the single channel monolayer and single channel five-layers SX have been prepared by L-DED. Based on the columnar transition to equiaxed theory (CET), the macroscopic temperature field simulations in the deposition processing and multiscale characterizations of deposition structure were used to analyze the formation and evolution mechanisms of unique precipitations and stray grains. Results shows that the element segregation results in the unique microstructure, include petal-shaped γ/γ' eutectic and demarcation band with a thickness of single γ/γ' eutectic. With the change of height at deposition region, dendritic orientation deviations affect the uniformity of element segregation in the CET region, and similar solid solution treatments under subsequent temperature cycling lead to the directional coarsening of the γ' phase and then produce γ/γ' eutectic bands, which manifest as grain boundaries at the mesoscale. At the same time, the formation of carbide and adjacent γ/γ' eutectic leads to the misorientations between the dendrite core and the inter-dendrite zone, which also appears as stray grains at the mesoscopic scale.

The revealed microstructure mechanism of stray grain formation contributes to the suppression of stray grains in the middle and bottom of the deposition region and promotes the application of L-DED technology in the repair of commercial aeroengine SX turbine blades.

KEYWORDS

Ni-based single-crystal superalloys; Laser-Directed energy deposition; element segregation; stray grains; γ/γ' eutectic

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