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Deformation mechanisms and strain partitioning in WE43 Mg alloy with heterogeneous microstructure processed by additive friction stir deposition

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Abstract

A WE43 Mg alloy with heterogeneous microstructure, featuring grain sizes ranging from 25 μm to 1 μm arranged in alternating bands, was manufactured via solid-state additive friction stir deposition technique. The alloy exhibits excellent mechanical properties, with a yield strength of 201 ± 13 MPa, an ultimate tensile strength of 270 ± 5 MPa, and a uniform elongation of 17.1 ± 2.0% in tension, surpassing most additively-manufactured Mg alloys reported to date. The dominant deformation mechanisms were ascertained at different length scales, and involve <a> basal slip, extension twinning, and limited <a> non-basal slip, which operates across all grain size populations, but their relative activities are sensitive to grain size. The gradual yielding of grains with different sizes—from coarse to fine—induces pronounced strain partitioning and dislocation accumulation at their interfaces. This synergistic interaction sustains strain hardening during deformation and effectively alleviates the conventional strength-ductility trade-off. These findings provide multiscale mechanical insights into the deformation behaviour and strain-distribution mechanisms of heterogeneous Mg alloys processed by additive manufacturing.

Keywords:

Magnesium alloy Deformation mechanism Heterogeneous grains Additive friction stir deposition Strain partitioning