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High-magnesium-content aluminum alloys via wire-based friction stir additive manufacturing

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Al-Mg alloys can be strengthened by additional Mg atoms via solid solution strengthening. However, taking high-magnesium-content aluminum alloys into consideration, the eutectic Al-Mg2Al3 phases, pores and cracks are easily formed during the melted and re-solidification process. As the sever plastic deformation hindered the formation of the eutectic Al-Mg2Al3 phases along the grain boundaries, we tended to utilize a solid-state additive manufacturing technology, namely wire-based friction stir additive manufacturing(W-FSAM) to fabricate Al-Mg alloys with high content of magnesium, avoiding the melted process. The original Mg2Al3 phases were refined and dissolved into the matrix for the severe plastic deformation, and supersaturated solid solution structures were obtained. The refined grains with a diameter of 1.27±0.64 μm were achieved through the dynamic recrystallization process. The fabricated components were significantly strengthened by solid solution and grain boundary strengthening. High contents of Mg promoted the interaction between the solute atoms and mobile dislocation as well as grain boundaries. The ultimate tensile strength and elongation reach 415±11MPa and 31±2%, respectively, exhibiting the high strength-ductility synergy. Components fabricated by W-FSAM performed better mechanical properties than casting and forging products. It showed great potential for fabricating large-scale structures with extraordinary mechanical performances.