Corrosion behavior and corrosion-resistant design of additive manufacturing metals

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Abstract Corrosion of additive manufacturing (AM) metal with non-equilibrium solidified metastable microstructure deserves critical attention as a growing industrial technology in the decades. Dislocation cell structures decorated with elemental segregation introduced by the periodic plastic deformation facilitate the rapid formation of passivation film at the boundaries, and local micro-galvanic couples accelerate the formation of the passive layer at the intracellular. The Cr/Mo enriched dislocation cell structure elevates the passivation and pitting ability of the AM 3l6L stainless steels. Followed by directly aging heat treatments, the bulk austenite impedes crack propagation, while the thin austenite releases hydrogen much faster and is rather a shallower trap than the bulk austenite in the AM martensite stainless steel. The thin austenite film to martensite transformation near the crack accelerates hydrogen-induced cracking. Furthermore, multi-physical field simulation proves that the scanning strategy optimization contributed to the reduction of the inherent AM defect, such as irregular large pores, which greatly domain the mechanical properties of as-built components. A wide solidification temperature range, localized high strain levels, and incomplete inter-dendritic liquid filling during the late stages of solidification contribute to cracking in AM nickel-based superalloy. Through optimized C and Si element content, the new alloy demonstrates a 40% reduction in the cracking sensitivity index, and the refined grain enhances its room temperature/high-temperature strength and plasticity, and pitting re-passivation capability. Our investigations can be used as a guide for the design of corrosion-resistant additive manufacturing alloys in the future.

Keywords Additive manufacturing, Corrosion, Stainless steel, Nickel-based superalloy