Crystal plasticity finite element investigation of deformation of single crystal copper during cold spray

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Over the past few years, cold spray (CS) process has been applied as an additive manufacturing technology to fabricate individual components along with repairing damaged components. In comparison with fusion-based high-temperature additive manufacturing processes, the feedstock remains solid throughout the deposition process which results in low oxidation, minimal microstructural and chemical degradation in the final component. Considering the small size of cold spray particles (10-50 μm), the dependence of plastic behaviour on the crystalline orientation at high-velocity impacts needs to be investigated. In this work, we present a crystal-viscoplastic model with Johnson-Cook type strain-rate and temperature dependence for metals with low stacking fault energy (SFE). Through the numerical study, a dependence of the dominating bonding mechanism on the crystal orientation was observed. Some orientations showed higher localized plastic deformation than others thereby emphasizing the role of particle microstructure on the bonding mechanisms. This new mechanistic study provides important insight into orientation-dependent bonding mechanisms during cold spray additive manufacturing.

Keywords: Cold spray, Crystal Plasticity, Bonding, Finite Element Analysis

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