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Cold Spray Additive Manufacturing of Al–Fe Bimetallic Composites with Tailored Properties

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Cold spray is becoming a strong option for multi-material additive manufacturing because it deposits material at low temperature. This helps reduce intermetallic formation and thermal residual stresses that are common in fusion-based processes. In this study, Aluminium–Iron (Al–Fe) bimetallic composites were made by high-pressure cold spray using in-flight mixing of as-received powders, which allows real-time control of the composition. The feedstock was varied from 0 to 100% Fe, and the deposits were studied for their microstructure and mechanical behavior using micro- and nano-hardness tests, uniaxial tensile testing, and profilometry-based indentation plastometry (PIP). The mixed deposits formed a dense Al matrix with Fe splats spread through it, and the porosity decreased (from ~0.79% in Al to ≤0.25% in the composites). This improvement is linked to peening-assisted densification caused by the impact of hard Fe particles. At higher Fe levels, the final deposit composition differed from the starting feedstock because Al and Fe do not deposit with the same efficiency. Fe retention was close to the target value at low Fe content (23.0% in Al-25Fe), but it dropped as more Fe was added (28.7% in Al-50Fe and 45.4% in Al-75Fe), showing stronger Fe–Fe rebound and more clustering. The mechanical properties could be adjusted by changing composition. Young's modulus increased from 32 GPa (Al) to 55 GPa (Al-75Fe), and the yield/ultimate strengths rose from ~40/55 MPa (Al) to ~77/94 MPa, with the increase becoming limited beyond ~23–28 vol.% Fe in the deposit. Ductility did not change in a straight line: it reached the highest value at an intermediate Fe level (Al-25Fe, ~4.7% fracture strain) because cracks were forced to change direction and the Al matrix could tear in a more ductile way. At higher Fe content, ductility decreased because weak bonding at Al–Fe interfaces made brittle fracture more likely. Overall, these results show that online-mixed CSAM can be used to adjust Al–Fe composite structures in a controlled way and helps guide the choice of composition, process settings, and mechanical performance for Al–Fe deposits.

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