

Powder Engineering for Controlled Cold Spray Additively Manufactured Microstructures: Process-Structure-Property Relationships

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Solid-state additive manufacturing processes, such as cold spray additive manufacturing (CSAM), enable direct retention of feedstock microstructural features, allowing materials design to be shifted upstream to the powder. Ultrasonic atomization (UA) produces highly spherical powders with tunable solidification conditions, enabling controlled manipulation of microstructure prior to deposition. Together, UA and CSAM establish a framework for predictable, feedstock-driven materials design.

Rotating detonation engines (RDEs), characterized by extreme, directionally biased thermomechanical loading and direction-dependent failure mechanisms, present a compelling application space for such an approach. GRCop-42, a high-conductivity, precipitation-strengthened copper alloy with demonstrated performance in conventional liquid-rocket engines, is a candidate material for these environments.

This work investigates the synthesis of GRCop-42 powders via UA with systematic variation of sonotrode amplitude, plasma torch power, and gas recirculation conditions to control droplet breakup, melting, and cooling rates during solidification. Powders are characterized in terms of particle size distribution, oxidation state, internal microstructure, and precipitate morphology, with select micromechanical testing at the particle scale. These powders are subsequently deposited via CSAM to evaluate retention of feedstock features and their influence on bulk thermomechanical performance.

The objective is to establish process–structure linkages spanning atomization and deposition, enabling the design of powder microstructures tailored for CSAM across application-specific requirements. Microstructural evolution, deposition behavior, and resulting thermomechanical properties will be discussed in the context of feedstock-informed materials design for extreme, directionally biased detonation environments.