Microscale additive manufacturing of high-surface area nanoporous copper: towards hierarchical structures and 3D circuits

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Nanoporous metals have been proposed as electrodes for carbon capture and hydrogen production, sensing in bioelectronics applications, current collectors in batteries, catalysts for carbon-based nanomaterial synthesis, or active material in propellants and structural energetics to overcome limitations in reaction kinetics of their bulk solid counterpart. However, their consolidation into large-scale parts via powder metallurgy while maintaining its mechanical performance is limited by the nanoporous metal's thermodynamic instability during sintering and their poor flowability in powder-based feedstocks. In this work, the synthesis of spherical nanoporous copper micron-sized powders (PCu) is undertaken via dealloying of Cu-Al gas-atomized precursors with high-throughput, moderate flowability, moderate-oxygen content, high-surface area and free of precipitates. PCu is sintered with powder mixtures containing Cu nanoparticles at temperatures as low as a third of its melting point to overcome its thermodynamic instability and preserve its high-surface area. As an example, open-die casting and micro-projection stereolithography were employed to produce conductive copper parts with low-to-moderate strength with preserved nanoporosity (i.e., pore size 24 – 36 nm), and hierarchical features sizes spanning 50 μm and 5 mm. As demonstration of its unique applications, architected 3D printed PCu lattices are designed as transient elements with programmable self-disintegration and self-destruction.

Refs:

1. [1] Niauzorau et al, Applied Materials Today, 2023 [2] Hasib et al, Composites Part B: Engineering, 2023.