Additive manufacturing of copper-based nanocomposites

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Additive manufacturing (AM) is a disruptive approach to fabricate innovative components with peculiar characteristics, especially for high demanding applications, as for aerospace and automotive sectors. However, not all metals and alloys can be easily processed mostly due to the metal-laser interaction. Copper is a typical example, but a proper development in the AM field can address several technical issues, regarding heat exchange, and allow to design specimens characterized by high thermal conductivity and the design freedom of 3D printing.

Copper alloys and composites can overcome those limitations (e.g., powder high reflectance and high surface tension) that make the 3D printing of pure copper particularly tricky. Alloying copper with other elements, to deal with, e.g., a precipitation-strengthened alloy, implies a delicate trade-off: mechanical properties are generally improved, but copper conductivity is extremely sensitive to even low amounts of different materials in solid solution. Concerning the resulting conductivity, most alloying elements lead to a negative output with few notable exceptions (i.e., silver). A different approach can be considered by combining copper with a nano-reinforcement; although ceramic fibers and nanoparticles can increase the mechanical properties of copper-matrix composites, the electrical and thermal conductivity are generally decreased. However, this latter result is much less critical than that related to the introduction of solid solution elements.

This report presents the activity of Consorzio di Ricerca Hypatia regarding the optimization of the selective laser melting process to fabricate pure copper samples and composites, including carbon nanoparticles. The resulting composites provided a clear evidence to suitably tailor the AM process, also showing improved mechanical properties. Specimens were characterized in terms of reflectance measurements, density evaluation, scanning electron microscopy, Raman spectroscopy and mechanical indentation.