Method of Production of a Mixture of Pure Copper and Carbon Nanotubes and Additive Manufacturing of a Metal Matrix Nanocomposite Material based on Pure Copper and Reinforced with Carbon Nanotubes by means of this Mixture

KEYWORDS

- ADDITIVE MANUFACTURING
- COPPER
- CARBON NANOTUBES
- SELECTIVE LASER MELTING
- METAL MATRIX COMPOSITE

AREA

- NANOTECHNO-LOGIES & MATERIALS

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Patent Type
Patent for invention

Co-Ownership
Sapienza University of Rome 50%, INFN 50%

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Industrial & Commercial Reference
Aerospace, Aeronautics, Telecommunications, Automotive, Naval, Rail Transport, Electric Motors

Time to Market
The technology was validated in the laboratory (TRL: 4). It is expected to be released on the target market within one year

Availability
Cession, Licensing, Research, Develop-ment, Experimentation, Collaboration, Start-up and Spin-off.

Fig. 1 MYSINT100, 3D selective laser melting printer for metal powder employed for the fabrication of Cu/CNTs nanocomposites.

Fig. 2 Optical images of Cu/CNTs tensile specimens realized according to the ASTM E8 standard.

Abstract
Development of a process for the production of an advanced composite material based on two steps:

A. mixing of pure copper spheroidal powder with fine grain size and carbon nanotubes (CNTs);
B. Additive manufacturing (AM) of pure copper metal matrix nanocomposites reinforced with CNTs.

The result of this process consists of a copper solid inside which the CNTs are finely dispersed, characterized by advanced performances and, unlike the parts realized using traditional subtractive methods, with an already finished geometry and the possibility of immediate use of the produced part.

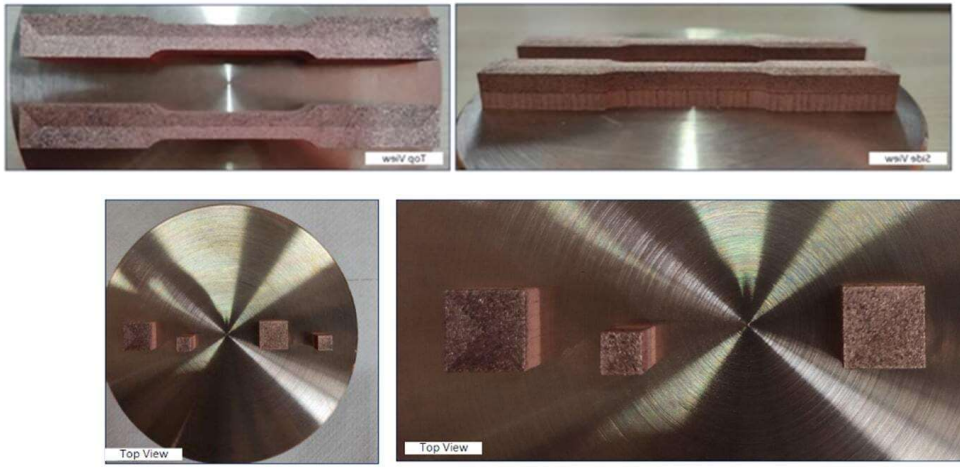

Fig. 3 Optical images of Cu/CNTs cubic samples (side of 5 mm) and platelets (size of 25 × 25 × 2 mm).

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Technical Description

A new pure copper composite material reinforced with nanomaterials was developed by additive manufacturing. The innovative combination of copper and nanomaterials has allowed the rapid prototyping of components with remarkable mechanical, thermal and electrical properties. The proposed technology allows to overcome the limits associated with traditional production methods of metal matrix composite materials and to develop advanced multifunctional nanocomposites characterized by already finished geometry with the possibility of immediate use of the produced part, without the necessity of further post-treatments and processing. By properly adjusting the process parameters and the concentration of nanomaterials within the copper matrix, the functional properties of these composite materials can be finely tuned.

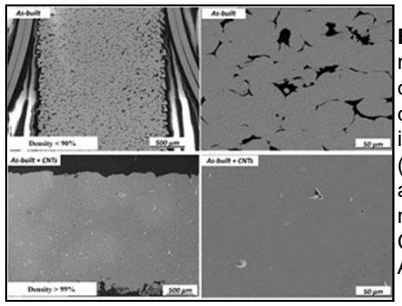

Fig. 4 SEM micrographs of cubic samples cross sections in pure copper (top, As-built) and in copper reinforced with CNTs (bottom, As-built+CNTs).

Technologies & Advantages

Pure copper metal matrix nanocomposites, reinforced with carbon nanotubes (CNTs) and obtained by metal additive manufacturing (AM) combine the advantages of AM technology (i.e., maximal versatility and minimal waste materials, realization of otherwise impossible geometries, parts production ready to use in the as-built version) with the unusual functional properties given by the union of two highly performing materials such as copper and CNTs. The addition of even a small fraction of CNTs (0.1-0.25 wt%) to the pure copper powder allows to overcome the typical limits of metallic AM (i.e., microstructural defects, poor densification of the parts) realizing, with the typical versatility of additive manufacturing, components characterized by remarkable thermal, electrical and mechanical performances. Therefore, the proposed technological approach represents a valid alternative to traditional production methods of metal matrix composite materials capable of overcoming many of the limitations characterizing these synthesis processes, thus paving the way to the development of innovative composites with advanced functionality.

Applications

3D printing of Cu/CNTs composites could be used in the aerospace field for the thermal management of satellites through components such as new generation heat exchangers, intended for installation spaces characterized by complex geometry for which only AM technology would allow their realization.

In the context of telecommunications, a possible application is represented by microwave antennas currently realized with conventional, expensive and difficult to replicate manufacturing processes.

Cu/CNTs composites are excellent candidates for the development of compact heat exchangers necessary for the operation/maintenance of the efficiency of the main hybrid and electric propulsion systems in the naval and automotive sectors, combining excellent thermal conductivity, high mechanical properties and a compact geometry / complex.

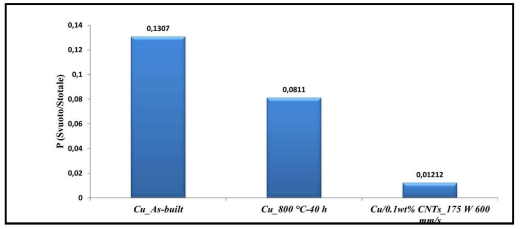

Fig. 4 Porosity of pure copper 3D printed specimens before (Cu_As-built), after thermal treatment performed at 800 ° C for 40 hours (Cu_800 ° C-40 h) and after the addition of 0.1 wt% of CNTs (Cu / 0.1wt % CNTs_175 W 600 mm / s) fabricated by exploiting metallic AM.

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