FABRICATION OF COPPER OBJETCS THROUGH LITHOGRAPHY-BASED METAL MANUFACTURING

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Lithography-based Metal Manufacturing (LMM) is a new and attractive 3D technology for the printing of structured metal parts. The process consists of curing layer by layer a photosensitive resin highly loaded with metallic particles. After the photopolymerization process, the fresh 3D-printed object is further heat-treated in order to remove the cured polymer and sinter the metallic particles. This technological approach ensures the generation of high resolution dense structures with complex forms in shorter time compared to other metal additive manufacturing technologies [1]. In this work, LMM has been applied to copper. This metal is easily recyclable and presents a high thermal and electrical conductivity, which makes it suitable for applications in the energy and telecommunication fields.

The manufacture of 3D functional parts depends on both the photocurable formulation, and the characteristics of the metallic fillers. Copper particles absorb differently at the writing wavelength regarding the particle size distribution and chemical composition, which might change under air because of an easy oxidation of the powder. These two factors directly affect the penetration of the actinic light within the cured layer. A selection of the most suitable copper particles, appropriate photoinitiator and monomers allow to tackle these issues. Moreover, copper is a high-density metal that leads to phase separation. Rheological additives that do not affect the light penetration are mandatory to stabilize the formulation. Finally, 3D printed metal objects need to be heat-treated under neutral or reducing atmosphere to avoid further oxidation. Nevertheless, under these conditions, carbon residues might be generated. Specific debinding conditions (atmosphere, heating rate and temperature dwell) have to be developed to reduce the residual carbon content in the final object and achieve similar electrical and thermal properties as in raw copper powder [2]. The influence of the most impacting parameters on the characteristics of the 3D printed objects will be highlighted.

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[1] J.W. Lee, I.H. Lee, D.-W. Cho, Development of micro-stereolithography technology using metal powder, Microelectronic Engineering. 83 (2006) 1253–1256. https://doi.org/10.1016/j.mee.2006.01.192.

[2] M. Roumanie, C. Flassayer, A. Resch, L. Cortella, R. Laucournet, Influence of debinding and sintering conditions on the composition and thermal conductivity of copper parts printed from highly loaded photocurable formulations, SN Appl. Sci. 3 (2021) 55. https://doi.org/10.1007/s42452-020-04049-3.