HIGHLY LOADED SILVER AND COPPER(II) OXIDE NANOPARTICLE INKS FOR ADDITIVE MANUFACTURING OF ELECTRONICS

E. Dimitriou[1,2], N. Michailidis[1,2,*]

[1]Physical Metallurgy Laboratory, Mechanical Engineering Department, School of Engineering, Aristotle University of Thessaloniki, 54124, Thessaloniki, Greece

[2]Centre for Research & Development of Advanced Materials (CERDAM), Center for Interdisciplinary Research and Innovation, Balkan Centre, Building B', 10th km Thessaloniki-Thermi Road, 57001, Thessaloniki, Greece

(*nmichail@auth.gr)

ABSTRACT

In recent years, significant progress has been made in the additive microfabrication of electronic components, transforming experimental laboratory prototypes to industrial manufacturing procedures. With the increasing demand for miniaturization of electronics, there is a growing need for efficient patterning methods and novel materials [1,2]. Metal nanoparticle-based conductive inks represent the most popular functional material for printing of electronics. Conductive inks comprise colloidal suspensions of metal nanoparticles in an aqueous or organic solvent [3,4]. The inks are printed into patterns, which are then sintered to become conductive tracks that can be introduced to a variety of electronic components [3]. Silver nanoparticle inks dominate in terms of abundancy, stability and electrical conductivity [4]. Although copper nanoinks appear to be a less expensive alternative, copper nanoparticles are easily oxidized [5]. Therefore, efforts are focusing on using copper precursor (i.e., copper oxide) nanoparticles, which require an additional post-printing step to be reduced to metallic copper [4]. This work focuses on the preparation of highly loaded silver and copper(II) oxide nanoparticle inks for additive manufacturing of electronics. Nanoinks with particle loadings of 20-60 % wt. in glycol-water co-solvent media have been successfully prepared. Rheological measurements on ink samples revealed non-Newtonian, shear thinning behavior and viscosity greater than 10 Pa·s. Transmission Electron Microscopy images revealed spherical particles, smaller than 35 nm, with unimodal, narrow size distributions. UV-Visible Spectroscopy verified the colloidal stability of the particles in the course of a few months. Thermogravimetric Analysis and Differential Scanning Calorimetry shed light on the evaporation of the ink media and reduction of Cu(II) to metallic Cu, necessary for printing and post-printing processing, respectively. The sintering behavior of the nanoparticles was investigated via thermal treatment and Scanning Electron Microscopy.

KEYWORDS: Additive Manufacturing, Conductive Inks, Nanotechnology, Silver Nanoparticles, Copper Oxide Nanoparticles

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