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Design oriented modelling for the synthesis process of copper nanoparticles by a radio-frequency induction thermal plasma system

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Radio-frequency inductively coupled plasma (RF-ICP) technology has proven to be a viable means for continuous production of nanoparticles (NP), thanks to its distinctive features, such as high energy density, high chemical reactivity, high process purity, large plasma volume, precursors long residence time and the high cooling rate (10^4 –10^5 Ks^{-1}) in the tail of the plasma, and its large number of process variables, e.g. frequency, power, process gases, phase of the precursor and system geometry [1]. Nonetheless, this high versatility comes at a price, as process optimization (in terms of yield and size distribution of the NP) is a challenging process that can hardly rely on try and fail experimental approaches due to equipment costs and to the limited amount of information that can be obtained from conventional diagnostic techniques. Therefore, process optimization of the NP synthesis process in RF-ITP systems has to rely extensively on modelling techniques [2-3].

In this work, we report on design-oriented modelling for the optimization of an RF-ICP synthesis process of Cu NP starting from a solid precursor. In particular, the effect of i) the geometry of the reaction chamber (the volume downstream the plasma source, where NP are formed and grow) and of ii) the quenching strategy (injection of gas in the reaction chamber that affects flow fields, temperature distributions, cooling rates and particle deposition at the chamber walls, which must be minimized) will be investigated. The adopted simulative model can describe plasma thermo-fluid dynamics, electromagnetic fields, precursor trajectories and thermal history, and nanoparticle nucleation and growth [4]. Radiative losses from Cu vapour and their effect on the precursor evaporation efficiency have also been taken into account in the model.

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