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Synthesis of alloy nanostructures by discharges in liquids

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High-rate and low-cost synthesis of nanoparticles can be achieved by plasmas in liquids. When spark discharges are ignited in a dielectric liquid, a strong heating of the electrode material occurs, producing a metallic vapor from which nanoparticles grow by condensation. This process can be conveniently used to synthesize core-shell nanoparticles. Indeed, by processing between two metallic electrodes formerly synthesized nanoparticles, it is possible to coat them and produce core-shell nanostructures.
By contrast, producing alloy nanoparticles by discharges in liquids is much more complicated. To understand the reasons that explain this behavior, several experiments were done in order to understand the elaboration of CuZn and CuAg alloys by discharges in liquid nitrogen. A pin-to-pin configuration was adopted for all our study.
We used metallic copper, zinc or α-brass ($Cu_{63}Zn_{37}$) electrodes on the one hand and metallic copper, silver or copper-silver alloy ($Cu_{28}Ag_{72}$) electrodes on the other hand. These systems were chosen because of the large difference of melting points between copper (1084˚C) and zinc (419˚C) and the small difference between copper (1084˚C) and silver (961˚C). Furthermore, the high solubility of zinc in copper and of copper in silver makes of both systems an excellent choice for comparison.
High-resolution transmission electron microscopy (HRTEM), energy-dispersive X-ray spectroscopy (EDX), electron energy loss spectroscopy (EELS) and electron micro-diffraction analyses were carried out to characterized the formed nanoparticles. Time-resolved optical emission spectroscopy measurements were also performed to improve our understanding of synthesis mechanisms.
We will show that the main difficulty associated with the synthesis of nanoparticles is due to the differential melting of elements. Once evaporated, metallic vapors never recombine in the plasma but produce separated nanoparticles of each type of metal.

Keywords
Nanoparticles synthesis
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