Generation of nanoparticles by spark discharge: In-situ tailoring of the electrode surface with a 3D positioning device

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One of the most promising physical techniques for the generation of various types (metal, semiconductor, alloy or carbon) nanomaterials in the gas phase is spark discharge. The sparking process is conducted in the absence of any electrolyte, or template and relies on the application of an electric field capable of producing an electric discharge when the two conductors, being connected with an external power supply, are brought into close proximity (Fig. 1). The ensuing dielectric breakdown produces free electrons and ions originating from ionized molecules of air constituents, which in turn, bombard the sparked electrodes. Heat, introduced due to the flow of electricity leads to the formation of air plasma and vaporized (nano)particles by each electrode material at the closest points between the conductors.

In a straightforward electrode-to-pin approach between a low-cost graphite electrode and a metal, alloy or carbon tip (Fig. 1), the vaporized electrodes' material, eventually transformed by the reactions with the environment, e.g. oxidation in the presence of air, is positioned in the space between the two electrodes and upon the termination of the discharge, solidifies and deposited on the surface of the electrodes.

Results demonstrated an extremely simple technique for the generation of template-free nanoparticles of high purity that enables the in-situ tailoring of low-cost screen-printed electrodes while offering sensors with enhanced detection capabilities and a wide-scope of applicability. Sparked (single or mixed) metal or graphite nanomaterial-modified SPEs can be prepared on-demand, even on-site, within a few minutes or even seconds, through a totally green and solution-free methodology that requires only the respective metal/alloy/carbon wire and a power supply. Data on the generation of bismuth [1,2], copper, nickel and alloyed copper/nickel [3], tin [4], gold [5,6], iron [7], molybdenum [8] and carbon [9] nanomaterials as well as on the analytical utility of the resulting sensors will be presented.

References

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Figure

Figure 1. Setup for the in-situ tailoring of electrode surface with spark-generated nanoparticles