Generation of Nanomaterials via Spark Discharge: A Rapid, Environmentally Friendly, and Versatile Method for In-Situ Modification of Electrode Surfaces

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Spark discharge is emerging as one of the most promising physical methods for producing various types of nanomaterials, including metals, semiconductors, alloys, or carbon. This process occurs without the need for liquids, chemicals, or templates. It relies on the application of an electric field capable of generating an electric discharge when two conductors, connected to an external power supply, are brought close together. In the context of electrochemical (bio)sensing applications, one of the conductors is the sensing (working) electrode, while the other acts as the source of modifying material, such as a metal, alloy, or carbon (referred to as the electrode tip).

During the dielectric breakdown process, free electrons and ions are produced from ionized molecules of air constituents. These particles then bombard the sparked electrodes. The heat generated by the flow of electricity leads to the formation of air plasma and vaporized particles from each electrode material at the closest points between the conductors. After a natural cooling process, the vaporized material solidifies and deposits onto the surface of the electrodes.

This technique offers a straightforward method for generating template-free (nano)materials of high purity. It allows for the in-situ modification of sensing electrodes, resulting in sensors with enhanced detection capabilities and a wide range of applications. Sparked (single or mixed) metal or graphite nanomaterial-modified electrodes can be prepared on demand, even on-site, within seconds, using a completely green and solution-free method that only requires the respective metal/alloy/carbon wire and a power supply. Data on the generation of bismuth, copper, nickel, and alloyed copper/nickel, tin, gold, iron, molybdenum, carbon, and cobalt sparked nanomaterials on screen-printed, 3D-printed and laser scribed graphite electrodes as well as the analytical utility of the resulting sensors will be presented [1-17].

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