Material Fabrication/Modification using Atmospheric Pressure Plasma

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Abstract

Atmospheric pressure plasma (APP) has emerged as a versatile and efficient tool for material fabrication and surface modification across a wide range of applications. Due to its unique ability to operate under ambient conditions without requiring vacuum systems, APP enables cost-effective and scalable processing of materials. Keeping in view the advantages, we have developed a few locally fabricated APP set-ups. These set-ups facilitate the synthesis of Ag, Au, Cu, Ni, Zn, etc. nanoparticles (NPs), Gold, silver, and gold–silver bimetallic colloids stabilized with fructose were successfully synthesized, where $HAuCl_4 \cdot 3H_2O$ and $AgNO_3$ served as the metal precursors. These NPs turned out to be effectively counteracting the surface activity of Avian Influenza Virus [1]. Nano diamonds (NDs) fabrication is another area where APP is being utilized. Experiments have been carried out to enhance thermal, optical, mechanical and antibacterial activities of the Polyvinyl alcohol–Nanodiamonds (PVA-NDs) composite required for the food packaging industry. Multiband Luminescence in Nanodiamond via Voltage-Controlled Atmospheric Pressure Micro plasma have been investigated. The luminescent NDs offered emerging applications in optoelectronic devices, bioimaging, biosensing, photosensitizers, drug testing, quantum computing, and magnetic sensing [2,3].

These set ups have also been utilized for the growth of nanosheets, like BN, AgBN, etc. Hexagonal boron nitride (h-BN) nanosheets were synthesized on aluminum substrates using borazine as the precursor. Hexagonal boron nitride nanosheets show promise as coatings for a range of aluminum-based products, including coinage, fuselage materials, optical mirrors, solar energy concentrators, and bearings [4]. These facilities are also being widely employed for surface modification, surface nitriding, DLC deposition, spray coating. In addition, the APP set up has demonstrated its significant potential in the development of nano agrochemicals, offering new possibilities for sustainable agricultural technologies. Nano particles of Polyvinylpyrrolidone (PvP) encapsulated Emamectin Benzoate (EB) have been fabricated by using a hybrid technique comprising of Flash Nano precipitation (FNP) and APP.

A highly reactive environment created by plasma at atmospheric pressure provides an energy-efficient platform for tailoring material properties with precision, making it a promising approach for both industrial and research-based innovations.

References

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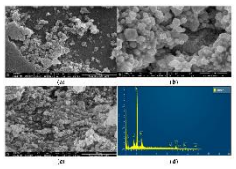

Fig. 1: FE-SEM images of (**a**) Au-10, (**b**) Ag-10, (**c**) Au–Ag-10 and (**d**) EDX of Au–Ag-10 [1].

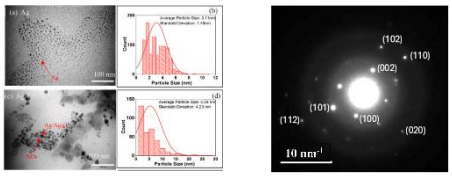

Fig. 2: TEM images of (a) Ag NPs and (c, e, g, i) Ag NDs composite at different NDs concentrations [2] and SAED patterns of synthesized NDs [3]