Synthesis of metal/polymer nanocomposite thin film through interaction of a gold salt solution aerosol with a Dielectric Barrier Discharge

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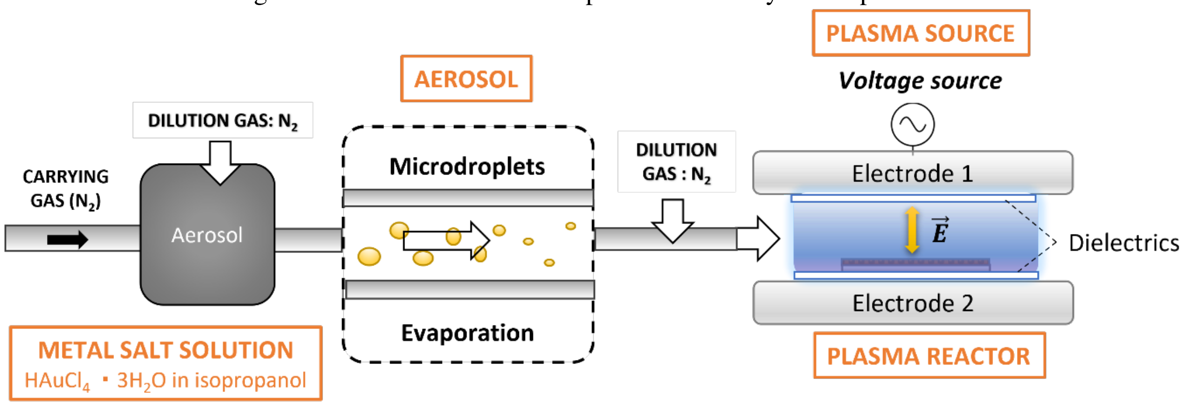
Low-temperature atmospheric pressure plasma technologies offer unique opportunities for the synthesis of hybrid nanocomposite thin films consisting of inorganic nanoparticles (NPs) embedded into an organic matrix. Some studies have shown that it is possible to deposit them by combining plasma processes with an aerosol of either a dispersion of preformed gold NPs or a solution of a gold precursor in a suitable solvent. [1] . In our work, as suggested in a previous publication [2], a dielectric barrier discharge (DBD) in nitrogen is associated with an aerosol of solution of gold salt (tetrachloroauric(III) acid trihydrate, $HAuCl_4{\cdot}3H_2O$) in a polymerizable solvent (isopropyl alcohol). The process is schematically shown in Fig 1. The novelty of this process mainly resides in the fact that it enables the synthesis of the NC thin films in a single step, avoiding the direct handling of NPs.

Fig. 1: Overview of the nanocomposite thin film synthesis process



For synthesis of nanocomposite layers with a DBD at atmospheric pressure, a dual-frequency excitation is typically used to control independently the growth of the matrix and the transport of the nanoparticles [2,3]. In our study, a high frequency excitation (above 10 kHz) is necessary for the gold salt reduction to form gold NPs and the organic matrix growth, while a low-frequency excitation (typically below 1 kHz) is needed to avoid nanoparticles being trapped in the gas gap and, therefore, to favor their transport to the surface of the substrate.

Preliminary results have shown that we are able to synthesize nanocomposite thin films with the inclusion of gold nanoparticles in an organic matrix, deriving from plasma polymerization of isopropyl alcohol. Chemical composition, morphology and optical properties of the resulting nanocomposite layers have been investigated using various characterization techniques, such as Fourier-transform infrared spectroscopy, X-ray photoelectron spectroscopy, scanning electron microscopy and UV-visible absorption spectroscopy (Fig. 2).

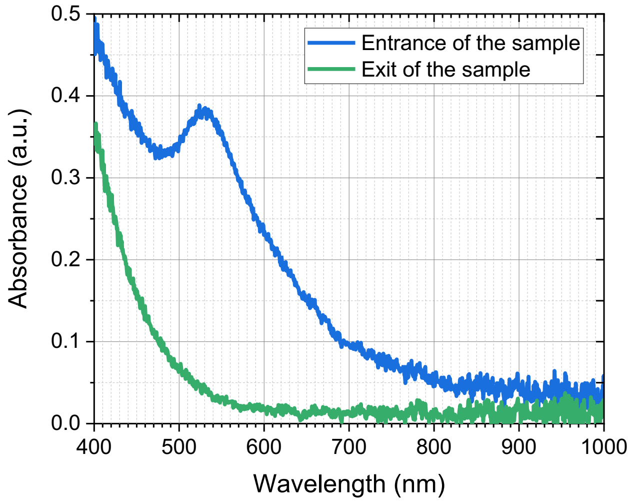


Fig. 2: UV-visible spectroscopy spectrum of a nanocomposite coating

Overall, these results provide new insights into the possibility of using a single-step aerosol-assisted plasma process based on a dielectric barrier discharge at atmospheric pressure to deposit hybrid nanocomposite coatings.

[1] A. Uricchio and F. Fanelli, Processes 9, 2069 (2021).
[2] E. Nadal *et al*., Nanotechnology 32, 175601 (2021).
[3] P. Brunet *et al*., Langmuir 34, 1865 (2018).