Toxicity evaluation of silver nanoparticles embedded in silica matrix to photosynthesis in *Chlamydomonas reinhardtii*

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The strong antibacterial efficiency of silver nanoparticles (AgNPs) made them widely used in health-care sectors. The small size and huge surface-volume ratio of AgNPs facilitate the silver release, compared to the bulk material, leading to an increased toxicity for organisms sensible to silver [1,2]. The toxic effect of small AgNPs (diameter < 20 nm) embedded in silica layer on algal photosynthesis is assessed in this work.

Two approaches were used to elaborate the nanocomposite structures (figure 1): (I) Low Energy Ion Beam Synthesis (LE-IBS) using a modified implanter to work in the low energy range (0.65 ÷ 20 keV) [3]; (II) combined silver sputtering and Plasma Enhanced Chemical Vapor Deposition (PECVD) by using the plasma of axially asymmetric RF (13.56 MHz) discharge. The discharge was maintained in hexamethyldisiloxane (HMDSO)-oxygen-argon mixtures at low gas pressure (< 7 Pa) [4].

Both techniques allow fabricating a single layer of AgNPs embedded in silica films at different nanometric distances from the free surface. On one hand, the AgNPs structural and optical properties were studied by transmission electron microscopy (figure 2) and by ellipsometry, optical reflectance or Raman spectroscopy [5]. On the other hand, the short-term toxicity of AgNPs to photosynthesis in *Chlamydomonas reinhardtii* was studied using fluorometry and silver release was measured through Inductively Coupled Plasma Mass Spectrometry (ICP-MS). Results from the used analyses show a relation between toxicity effect and silver oxidation and reveal that embedding AgNPs into a silica layer protect them from fast oxidation [6]. In addition, these nanocomposite structures allow modulating the silver release by changing the distance between the AgNPs and the free surface. Correlations between the design of these new specific coatings and their toxicity efficiency are finally presented.

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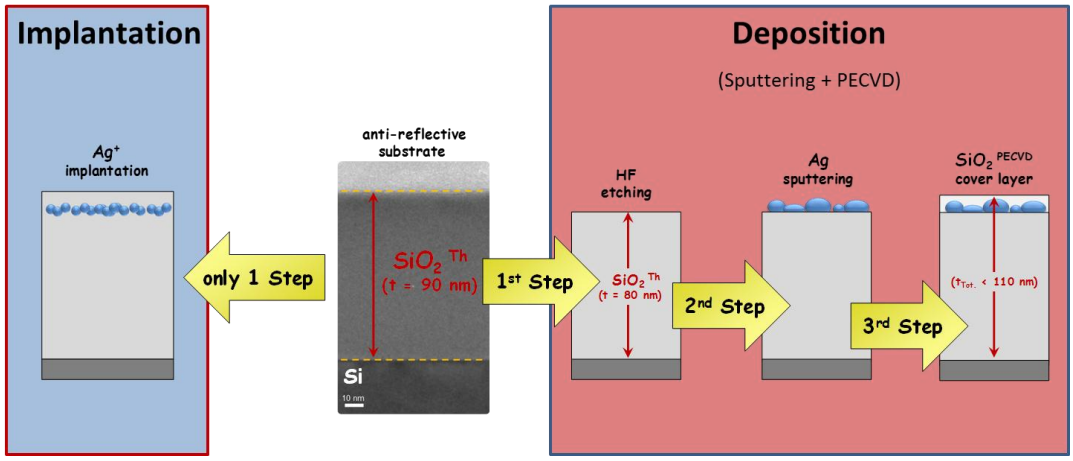

Figure 1: Pathway of the techniques used to fabricate the layers containing silver nanoparticles.

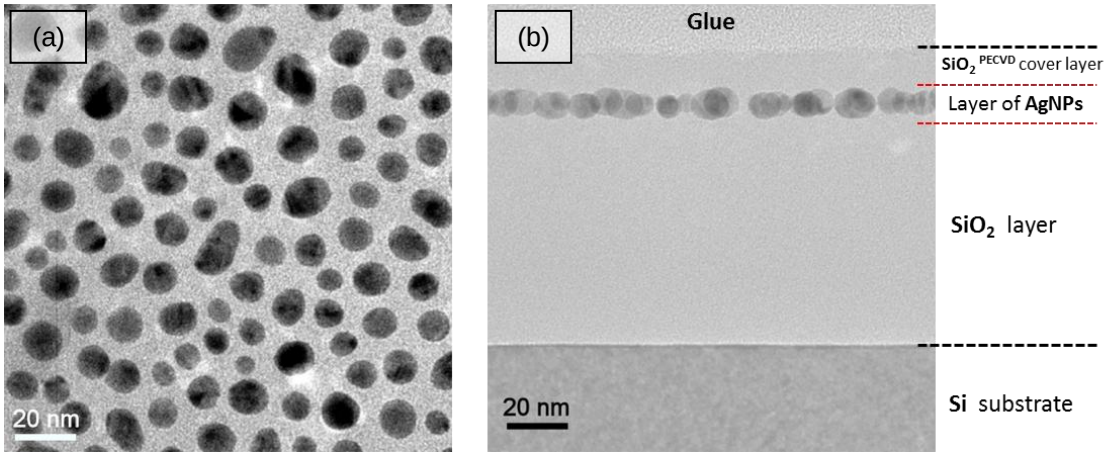

Figure 2: Plan-view (a) and cross-sectional (b) TEM images of a sample elaborated combining silver sputtering and Plasma Enhanced Chemical Vapor Deposition. In the images the dark contrast spherical-like zones are silver nanoparticles (AgNPs).