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Ion beam synthesis of multifunctional Ag nanocrystals embedded in a dielectric matrix

The localized surface plasmon-polariton resonance of noble metal nanoparticles (NPs) is widely exploited for enhanced optical spectroscopies of molecules, photothermal therapy, photovoltaics or photocatalysis. The most efficient metal for electromagnetic field enhancement is silver. The strong antibacterial efficiency of AgNPs makes them also widely used in health-care sectors. Their biological activity is closely related to ionic Ag activity resulting in protein denaturation. Recently, a strategy to design and fabricate hybrid metallic-dielectric substrates for optical spectroscopy and imaging has been proposed. Different architectures consisting of 3D patterns of AgNPs embedded in dielectrics are conceived to simultaneously exploit the optical interference phenomenon in stratified media and the LSPR of metal NPs. These architectures are fabricated by low energy ion beam synthesis and consist of a delta-layer of AgNPs with controlled characteristics and embedded in dielectric thin films. We will show that these embedded AgNPs are multifunctional objects to be used either as plasmonic antenna or ion reservoirs. Hence, SERS has been demonstrated on 2D sheets (graphene and TMD) deposited on top of the dielectric surface, evidencing strong coupling effects. The same substrates are used for transferring Ag+ and test their biocide activity. For this purpose, we have proposed an original method for assessing the release of silver ions from embedded AgNPs based on the photosynthesis of a green alga used as a sensible sensor of ionic silver. Our results show a physical approach to modulate the biocide activity of silver nanostructured surfaces. These nanocomposites are good candidates as coatings to prevent from development of microbial films. The last part will be dedicated to the synthesis by using out-of-equilibrium processes of alternative plasmonics nanostructures consisting of doped Si-NCs embedded in silica matrix.

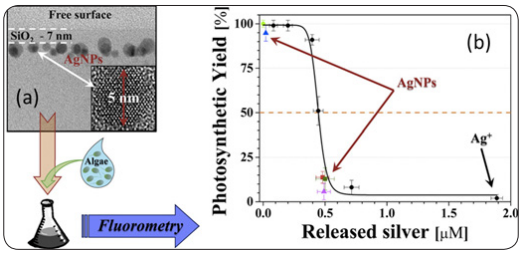

Figure 1: (a) Controlled synthesis of 2D arrays of Ag nanoparticles embedded in silica; **(b)** assessing bio-available Ag release using the green algae as bio-sensors

Recent Publications

1. Carles R et al. (2011) Three dimensional design of silver nanoparticle assemblies embedded in dielectrics for raman spectroscopy enhancement and dark-field imaging. ACS Nano. 5(11):8774–8782.
2. Benzo P et al. (2013) Controlled synthesis of buried delta-layers of Ag nanocrystals for near-field plasmonic effects on free surfaces. Journal of Applied Physics. 113:193505.
3. Bayle M et al. (2015) Ag doped silicon nitride nanocomposites for embedded plasmonics. Applied Physics Letters. 107:101907.

4. Navarro E, Bonafos C, Pugliara A et al. (2016) The use of biosensors for improving the development of nanotechnology under realistic-use scenarios: applications for cheaper and more effective silver nanoparticles and nanostructured surfaces. IEEE Nanotechnology Materials and Devices Conference (2016).
5. Pugliara A et al. (2016) Assessing bio-available silver released from silver nanoparticles embedded in silica layers using the green algae Chlamydomonas- reinhardtii as bio-sensors. Science of the Total Environment. 565:863-871.

Biography

Caroline Bonafos is a Research Director at CEMES-CNRS, Toulouse, where she performs work on synthesis of semiconducting and metallic nanoparticles by low energy ion beam synthesis. She is the author and co-author of over 160 publications in international journals (h index: 28, >2600 citations). She is the director of the research group NACRE (GDR 3531) on “Nanocrystals in dielectrics for electronics and optics” gathering 24 French laboratories on this thematic.

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