Ordered array of Au nanostructures: tunable Plasmonic properties and biosensing applications

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A simple and reproducible approach for the fabrication of highly ordered array of metal nanostructures by nano-sphere lithography (NSL) is presented, demonstrating their superior performances for biosensing applications.

Keywords: Plasmonics, Nano-Sphere Lithography

In this work, highly ordered array of plasmonic nanostructures have been fabricated developing a simple and reproducible approach based on nano-sphere lithography (NSL)[1]. This cost-effective method is based on the self-assembling of close-packed polystyrene (PS) particles at air/water interface, and enables the fabrication of colloidal mask characterized by a high quality crystal structure. Periodic array of different metal nanostructures can be easily prepared on large-area by exploiting the interstitial geometry of this cheap lithographic mask. The potentiality to achieve dynamic tunability of the resulting metal NPs arrays is a challenging achievement of a low-cost nanofabrication tools which has not been completely explored so far. A valuable ability is to couple the versatility offered by NSL technique with a post-processing tool for a properly engineering of plasmonic NPs arrays. To this purpose, a thermal post-processing is proposed here as a further engineering step for a fine tuning in terms of size and morphology of nanoparticles array; the versatility of this approach offers the great capacity of ranging from three dimensional nano-prism to zero dimensional nano-dots profiles, while keeping the original periodicity of the array (dictated by the size of the colloidal mask). Related optical properties are monitored by UV-Vis spectroscopy investigations and compared with proper theoretical analysis and numerical simulations.

Realization of periodic plasmonic monolayers, featuring macroscopic dimensions and easily controllable sized and lattice spacing, will allow creation of intense electromagnetic near field distribution upon interaction with light of proper frequency. A rational design of such singular or collective optical properties can be used to focus and optimize the investigated functional features.

Actually metal nano-prism arrays, owing to their proximity and consequently huge electromagnetic field reached at their sharp tips, have been exploited for many applications such as the development of innovative sensing platform, substrates for surface enhanced Raman scattering (SERS) or surface-enhanced fluorescence microscopy, nanopatterning or the realization of new generation plasmonic solar cells. Moreover, their large “sensing volume”, defined as the penetration depth within which changes of the refractive index can be detected, demonstrated their superior performances for biosensing applications. As proof of concept, an optical biosensor based on Localized Surface Plasmon Resonance [2] has been developed for the sensitive detection of Lipopolysaccharides (LPS). Gold nanostructures have been realized, used as optical transducers, functionalized with specific antibodies as sensing elements for the detection of LPS. After a proper functionalization step of the nanostructured transducers, Protein A was immobilized which contains an Fc antibody-binding specific domain allowing an oriented immobilization of antibodies. Each functionalization step have been monitored by optical characterization by measuring the shift of the resonance peak. A good linear relationship between peak shifts and the LPS concentration has been demonstrated with a detection limit down to 10ng/ml. Further applications in quality control of pharmaceutical preparations and medical devices are in progress.

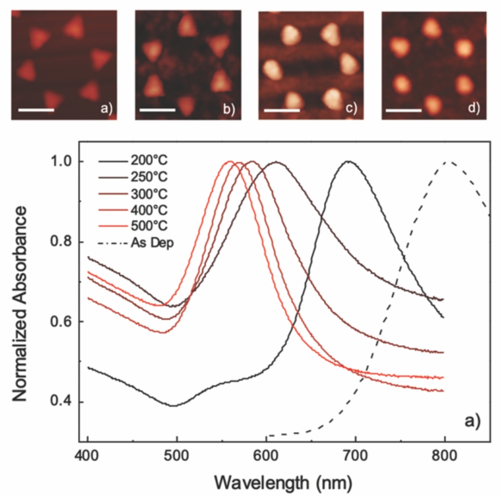

Fig 1. Evolution of the morphology and normalized absorbance spectra upon thermal annealing, for the as-deposited and annealed Au nano-particle arrays

References

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