Controlling inter-Nanoparticle Coupling: Highly uniform SERS substrates of plasmonic colloids

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Metallic nanoparticles and especially gold, are in the focus of interest because of their highly depend electric and optical properties on the specific particle size, shape, and surrounding environment. Therefore, they are ideal candidates for their potential use in microelectronic, optical, and biomedical applications. Thus, a big effort has been put in developing new methods which allow a fine control over the particle shape and size. These achievements allow us to fine tune the materials properties in order to use them for a desired application. However, the lack of capability to form organized structures is still a very important challenge in order to use these materials in many applications. In this work we report a novel method to structure, in a macroscale range, arrays of organized gold colloids into 1 and 2D linear parallel arrays which are highly uniform substrates for Surface Enhanced Raman Scattering (SERS). These structures were fabricated through self-assembly of gold nanoparticles upon solution-drying in a periodic confining structure. The technique leads to uniform, parallel linear nanoparticle arrays with the precise arrangement defined through the dimensions of the particles and the grooves. Moreover, the good reproducibility of these structures among big areas, make them perfect candidates as ultrasensitive substrates for SERS due to the controlled formation of arrays of hot spots. Which provide high and uniform SERS enhancement over extended areas. Furthermore, this method, is completely lithography-free so, low cost processing and allows tuneability of the width and spacing of the channels and consequently of the particle patterns between fractions of a micron and many micrometers. Characterization was done by means of transmission electron microscopy (TEM), scanning electron microscopy (SEM), atomic force microscopy (AFM), UV-vis, dark field, and SERS spectroscopy.[1]

Figure 1. Scanning electron microscopy (SEM) images of two different stamped films, comprising single-line (A) and double-line (B) arrays of gold nanoparticles, upon confinement of a monodisperse gold colloid with wrinkled stamps of varying dimensions. Wrinkle wavelength and depth were determined by AFM to be 340 and 23 nm in A; 500 and 77 nm in B. (C) SEM image of a dried colloidal suspension that was confined between two crossed wrinkled stamps.