Surface lattice resonances in self-assembled plasmonic gold nanoparticle arrays

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Plasmonic nanoparticles of gold or silver are known for supporting localized surface plasmon resonances (LSPRs) due to their interaction with electromagnetic waves [1]. Encapsulating these metal nanoparticles into soft cross-linked hydrogel shells allows the large area preparation of periodic, non-close packed monolayers. Core/shell particles spontaneously self-assemble at an air/liquid interface where they form hexagonally ordered superstructures. The interparticle distance can be easily varied in a large range by adjusting shell size or swelling state of the hydrogel shells at the interface. The structures can be transferred on a glass substrate. Due to the periodicity of the array, LSPRs can couple to diffractive modes and thus support surface lattice resonances (SLRs). The coupling regime strongly depends on the distance between the metal cores [2]. Furthermore, SLRs can be enhanced by homogenizing the refractive index environment. To achieve this, monolayers on glass are embededded in a polymer-matrix that closely machtes the refractive index of the supporting glass substrate [3, 4].

In this contribution we focus on the correlation between the interparticle distance in gold nanoparticle arrays and the strength and wavelength position of SLRs, i.e. the strength of electromagnetic coupling. To do so, we used UV-vis extinction spectroscopy to analyze the optical response of the self-assembled monolayers. Absorbance spectra show a red-shift and decreasing intensity of the SLRs with increasing distance between particles (Fig. 1). Moreover, monolayers with large spacing possess a pronounced resonance peak at lower wavelength. This peak is related to a purely plasmonic contribution from the single-particle LSPR of the particles. Additionally, we used theoretical simulations to support the experimental data.

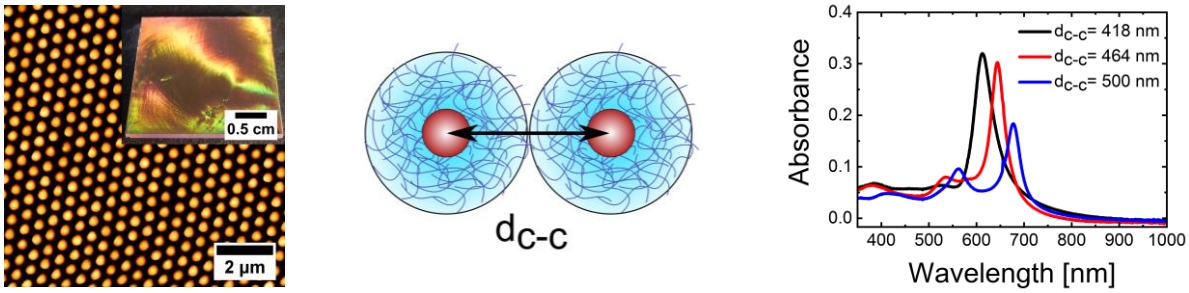

Figure 1. Left: Atomic force microscopy image of a representative ordered gold array. The inset shows a digital photograph of gold monolayer on a glass substrate. Middle: schematic view of core-shell particles with their nearest neighbor center-to-center distance d_{c-c}. Right: SLRs resonances of coated monolayers with varying d_{c-c}.

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