

Preparation and characterization of gold nanocubes two-dimensional monolayers

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I. Introduction

Gold nanoparticles assembled in dense 2D monolayers have shown improved optical properties than stand-alone nanoparticles due to plasmon coupling. Plasmon coupling is the combination of plasmonic modes of two or more nanoparticles when these are in close proximity each other, that can result in a red-shift of plasmonic band and an increase of the electric field in the interparticles gap. This leads the way to new applications in various fields like sensing, electro-optical and optothermal devices. [1] Self-assembly at water-oil interface represents a quick and low cost strategy to obtain highly ordered closed-packed gold nanoparticles arrays. [2] Gold nanocubes, with their planar surface morphology and a strongest localized plasmonic field in proximity of their sharp edges are interesting candidate as building blocks for the preparation of 2D monolayers. A water dispersion of gold nanocubes coated with CTAB (AuNC@CTAB) was synthesized using a seed mediated growth protocol. [3] The obtained AuNC was self-assembled in close-packed 2D array at water-hexane interface and transferred on ITO glass using a drain-to-deposit approach. [4] The obtained film was characterized by Uv-Vis spectroscopy and electronic microscopy (SEM).

IIa. Monolayer Preparation

Water/hexane interface, created between a dilute solution of 1-dodecanethiol and the water dispersion of AuNC, represent an ideal and defect-free surface where AuNC could self-assembly under an appropriate driving force. The driving force is the reduction of the surface charge of AuNC due to the injection of ethanol in the aqueous phase, that destabilize the colloidal dispersion. Then, AuNC starts to migrate to the interface and assembly, forming a gold shining layer.

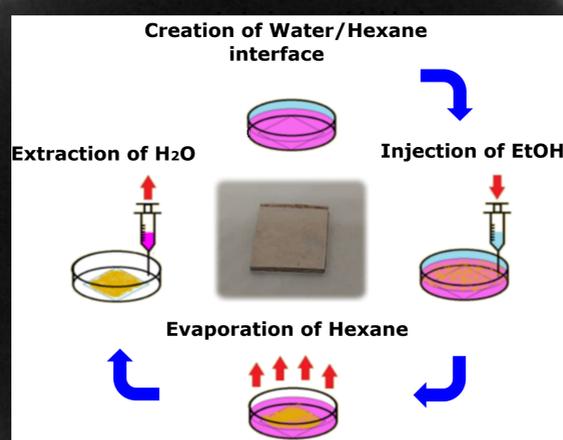


Fig. 1: Illustration of the preparation process of AuNC monolayer.

IIb. Monolayer preparation

At this point the 1-dodecanethiol will start to functionalize the AuNC surface increasing the Van der Waals attractive forces between nanoparticles at the interface. This united to the slow evaporation of hexane favour the assembly and further compact the obtained layer. Finally, extracting the aqueous phase with a syringe the formed layer will stick on the ITO glass below. The deposition was drained, washed and characterized by SEM microscopy and UV-Visible spectroscopy.

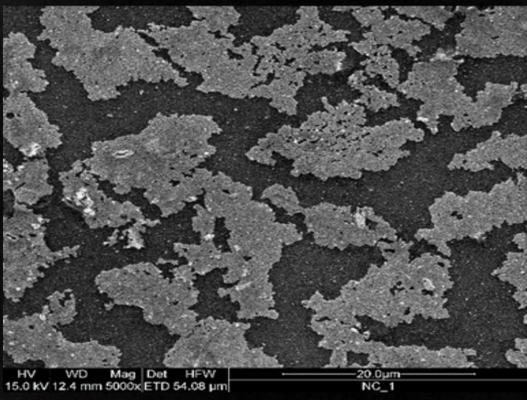


Fig. 2: Low magnification SEM image of AuNC monolayer deposited on ITO glass

III. Morphology

SEM image at low magnification (Fig. 2) show an extended layer constituted by several islands of gold nanoparticles ten of microns larger. In high magnification image (Fig. 3) we see that these islands are composed by a monolayer of gold nanocubes densely packed with very few zones with voids and overlaps.

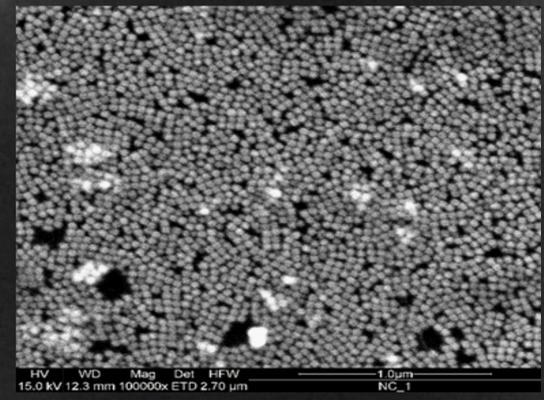


Fig.3: High magnification SEM image of AuNC monolayer deposited on ITO glass.

IV. Plasmonic properties

AuNC@CTAB in H₂O (size 40 nm) presents a sharp plasmonic band centred at 535 nm (Fig. 4, blue line). The formation of a dense ordered layer red-shifts and enlarges the plasmonic band for the strong coupling (Fig. 4, red line). Three different maximums are now visible: the maximum at 548 nm is relative to high orders plasmonic modes while the others centred at 690 and 990 nm are relative to the dipolar modes. The presence of a large band for dipolar plasmonic modes is due to the discontinuities in the film.

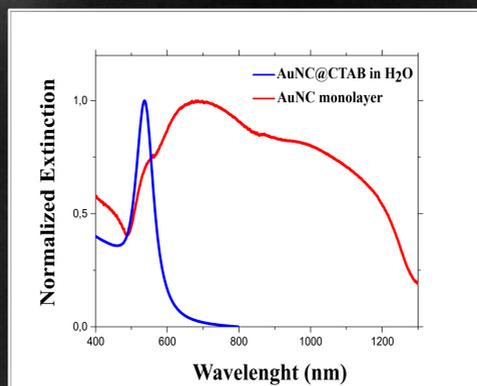


Fig. 4: Extinction spectra of AuNC monolayer on ITO glass (blue) and AuNC@CTAB in H₂O (red).

V. Final Remarks

With the procedure here described a dense monolayer of gold nanocubes on ITO glass could easily be obtained. The films showed a wide plasmonic band that range from Visible to NIR (i.e. 548 to 1260 nm). These films will be tested as substrate for applications in MEF technologies and optothermal devices.

Bibliography

- [1] Song et al. *Nanoscale*, 2020, 12, 7433–7460;
- [2] Park et al. *Langmuir*, 2007, 23, 10505–10510;
- [3] Dovgolevsky et al. *small*, 2008, 4, 2059–2066;
- [4] Yang et al. *Nanotechnology*, 2016, 27, 225604.