

## Building nanocomposite materials for sensing applications

Construction of nanoscale devices is a crucial step toward the application of nanotechnology in a variety of fields. Although construction by addition of individual building blocks might appear impossible without using nanomachines, it can actually be carried out by simply exploiting the different magnitude of attractive and repulsive interaction forces at the nanoscale. For example, gravity is negligible for nanoparticles, which can thus “float” in a solvent, but other forces become dominant and require the nanoparticles to be coated with selected molecules. Numerous strategies are based in the concept of *self-assembly*, i.e. the spontaneous organization of tiny components into patterns or structures without human intervention. Among many available techniques, one can simply let the solvent evaporate and hope that the floating nanoparticles will get organized into ordered structures.

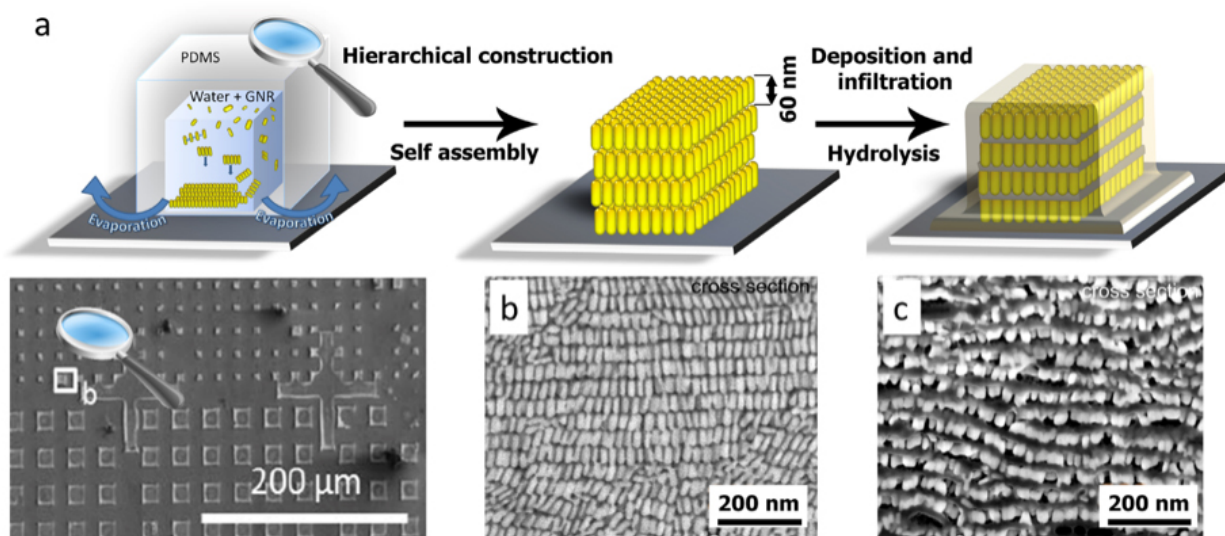


Fig. 1. a) Schematic representation of the process used to assemble gold nanorods at specific locations and subsequent coating with silica. Electron microscopy images of the structures are displayed below. b) Uniform organization of gold nanorods in multilayers. c) Organization after coating and infiltration with silica.

We developed a method that allows organizing nanoparticle building blocks into ordered structures at desired locations, thanks to a mold with suitable templating cavities. The building blocks get confined in the cavities and form organized assemblies upon solvent evaporation, which resemble the shapes in the templating mold (Fig. 1). The so-obtained 3D structures can be several orders of magnitude larger than the initial building blocks. Advanced electron microscopy tools were used to investigate the internal structure of the assembly, which comprises rod-shaped nanoparticles with a preferential orientation over many consecutive layers (Fig. 1). The uniform organization of the

building blocks confirms the role of the coating molecules as a mortar to fix the assembly.

Our rod-like building blocks are made of gold, which shows optical and electronic properties that are characteristic of the nanoscale dimensions. In particular, these “nanorods” can interact with light and enhance an optical signal that can be used to identify molecules in extremely low amounts. The structures we built are particularly interesting because the 3D organization increases the nanorod density, in turn improving the sensitivity of the sensor. We additionally found a chemical process that leads to silica coating and infiltration of the gold nanostructures, so as to stabilize the structure and provide porosity, which can act as a molecular sieve and improve the selectivity of the sensor (Fig. 1).

Overall, this methodology demonstrates simplicity and reproducibility when building at the nanoscale, which is thus far easier than construction at human scale.

**Cyrille Hamon<sup>1</sup>, Andrey Chuvilin<sup>2,3</sup>, Luis M. Liz-Marzán<sup>1,3,4</sup>**

*<sup>1</sup>Bionanoplasmonics Laboratory, CIC biomaGUNE, Spain.*

*<sup>2</sup>Electron Microscopy Laboratory, CIC NanoGUNE Consolider, Spain*

*<sup>3</sup>Basque Foundation of Science, IKERBASQUE, Spain*

*<sup>4</sup>Biomedical Research Networking Center in Bioengineering, Biomaterials, and Nanomedicine (CIBER-BBN), Spain*

## Publication

[Hierarchical organization and molecular diffusion in gold nanorod/silica supercrystal nanocomposites.](#)

Hamon C, Sanz-Ortiz MN, Modin E, Hill EH, Scarabelli L, Chuvilin A, Liz-Marzán LM  
*Nanoscale*. 2016 Apr 14