Technology

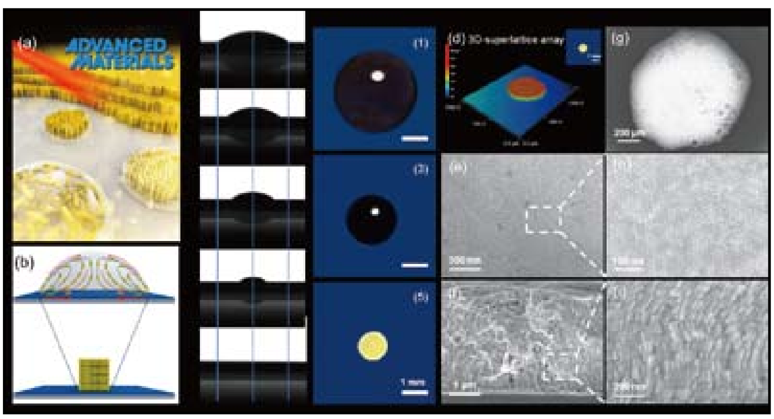
Anti-Coffee-Ring Effect Method Gives Potentials in Macroscopic 3D Plasmonic Superlattice Array

The buildup of three-dimensional superlattices by ordered self-assembly of nanoparticles has become a cutting-edge technology in nano-materials research. As the ordered structure formed with nanoparticles shows collective electro-optical properties, plasmonic superlattices are regarded as an effective transition from nanometer devices to macroscopic materials, with a wide range of application potentials including the development of solar cells and optical fiber communication.

However, the size of current assembled 3D plasmonic superlattices is only at a few micrometers generally, limiting their use in many macroscopic applications. It is a big challenge to assemble plasmonic nanoparticles into a macroscopic and homogenous 3D superlattice with millimeter dimensions.

The droplet evaporative self-assembly method has been widely used as the most common technique to fabricate superlattice structures. However, the process of drying droplet involves nonvolatile solutes, which normally leaves a ring of solute on the substrate – known as coffee-ring effect. This coffee-ring effect hinders the ordered packing of nanoparticles in their self-assembly, and the complex mechanism makes it difficult to control.

A research group led by Prof. YU Xuefeng from the Shenzhen Institutes of Advanced Technology, Chinese Academy of Sciences and Prof. Paul K. Chu from the City University of Hong Kong has made remarkable progress in the fabrication of SERS (Surface Enhanced Raman Scattering) substrate by the self-assembly of gold nanorods. The group's study demonstrated that the typical coffee-ring effect has been successfully mitigated and even totally reversed with the alteration of the surfactant and surface chemistry of gold nanorods and substrates.



(a) Cover picture of *Advanced Materials*; (b) Schematic illustration of the evaporative self-assembly process; (c) Side and top views showing the drop evaporation process; (d-i) Three-dimensional figure and SEM images of the macroscopic plasmonic superlattice.

The researchers put three-dimensional plasmonic superlattices on a millimeter scale consisting of highly ordered and vertically aligned gold nanorods. And through detailed mechanism analysis, their SERS performance indicated excellent plasmonic property, which is suitable for macroscopic sensing applications. With the high reproducibility and operability of the droplet evaporation method, this strategy can be readily extended to the self-assembly of various plasmonic nanoparticles into macroscopic 3D-superlattice arrays, and to bridge the gap between nanoscale materials and their macroscopic applications.

Their work, entitled Evaporative Self-Assembly of Gold Nanorods into Macroscopic 3D Plasmonic Superlattice Arrays, has been published as the cover story of *Advanced Materials*. This study was supported by the National Natural Science Foundations of China, Guangdong Natural Science Foundation/Doctoral Project, and the Key Science and Technology Program of Shenzhen.