Colloidal building blocks for advanced materials

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High-quality monocrystalline materials and nanostructures are key to high-efficiency optoelectronic devices, plasmonic materials and metasurfaces. A large variety of materials can be synthesized at low temperature in solution as colloidal single crystals, combining the advantages of high-quality material and low-cost fabrication, but the potential for large area integration into nanophotonic and plasmonic devices via nanoparticle assembly techniques still remain elusive. The two major bottleneck are:

-Difficulty to achieve defect-free colloids self-assembly in truly arbitrary patterns;

-Poor optical and electronic properties resulting from the discreetness of individual building blocks.

In this invited talk I will present recent breakthroughs from our team tackling both challenges with a new approach that we have introduced based on nanocube assembly and epitaxy. In the first part I will focus on advances on templated-assembly. I will show the fabrication of complex and truly arbitrary organisation of nanocubes on a large surface, with a single nanocube resolution. Examples includes 1D linear assembly[1], 2D nanocube grid arrays for transparent electrodes[2,3], highly dense split-ring resonator absorbers and Pancharatnam–Berry metasurfaces[4]. Then, I will focus on advances on metal nanocube epitaxy, showing a general methodology to transform an arbitrary assembly of nanocubes into defect-free continuous nanostructures and operando mechanistic insights[5,6]. This approach enables to obtain monocrystalline plasmonic and nanophotonic surfaces that can be readily printed on any substrate (flat, microstructured), but also to make nanocrystals with unconventional (à la carte) geometries, that can be used as colloids to go beyond Platonic solids, or into continuous nanostructured grids with record conductivity.

Finally, I will present recent results on a new paradigm on gap-selective crystal growth. In these context, growth takes place in sub-nanometer gaps, enabling to obtain unconventional monocristalline nanostructures.

References

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