Optothermophoresis-induced patterning of gold nanoparticles on solid substrates

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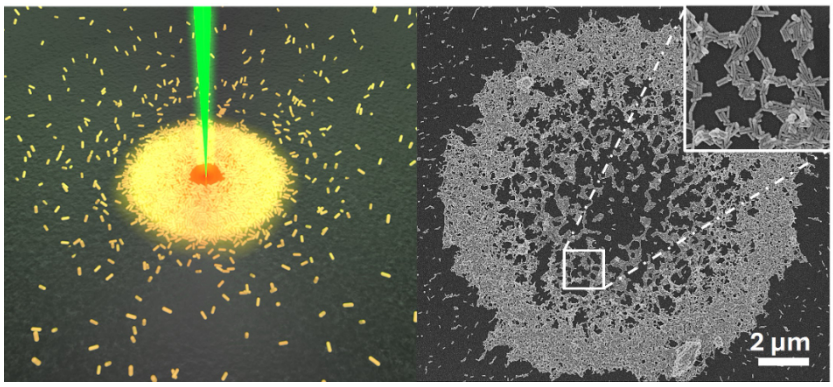
Colloidal assembly of nanomaterials into defined patterns is critical for integration of nanotechnology with solid-state devices. Optical control provides a simple and template-free means of patterning colloids into submicron features. In this talk, a rapid and versatile strategy for the assembly of gold nanoparticles on unmodified glass substrates driven by opto-thermal gradients will be presented [1,2].
By using both gold nanospheres and nanorods capped with cetyltrimethylammonium chloride (CTAC), we demonstrate rapid nanoparticle deposition within seconds at surfactant concentrations up to an order of magnitude below the critical micelle concentration (CMC). Rather than conventional depletion mechanisms, the assembly is consistent with a bridging flocculation mechanism governed by polymer-mediated particle-particle and particle-substrate interactions. The resulting structures can be tuned by varying solvent composition or nanoparticle shape. While spheres assemble in water, gold nanorods require the addition of a co-solvent, highlighting the influence of particle morphology and surface chemistry on the assembly process.
We further extend this approach by replacing polymer ligands with small thiol molecules capable of forming self-assembled monolayers (SAMs). The thiol chain length strongly influences the morphology of the assemblies, with longer chains promoting highly ordered hexagonal arrangements and shorter chains leading to more disordered structures. These findings provide new insight into opto-thermally driven colloidal assembly under non-equilibrium conditions and establish a simple route for the rapid fabrication of tunable plasmonic substrates with potential applications in surface-enhanced Raman scattering (SERS).

Keywords:
optothermophoresis, plasmonic nanoparticles, assembly, SERS



Patterning of gold nanoparticles using laser-induced thermal gradients

References:

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[2] A. J. Amaya, C. Goldmann, M. Haidasch, C. Hamon, E.H. Hill, *Adv. Opt. Mater* . **2025** , 13(34), 2500375

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