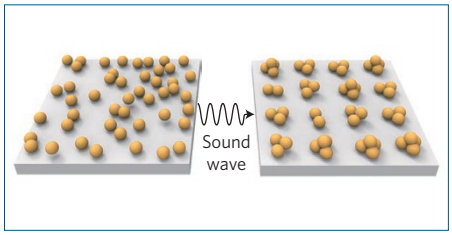
NANOMATERIAL ASSEMBLY

Sounds good

Nano Lett. http://doi.org/bqrx (2016)



AMERICAN CHEMICAL SOCIETY

Two- and three-dimensional periodic arrays of nanomaterials can be exploited to fabricate sophisticated electronic devices or circuits. Engineering such assemblies into specific lattices is, however, challenging because a material's identity typically governs the structure that it will adopt. Now, Wooyoung Shim and colleagues from Yonsei University and Seoul National University in South Korea use low-frequency sound waves to manipulate micro- and nanomaterials into lattices with tunable parameters.

The team apply standing waves to ethanol suspensions of SiO_2 particles or Cu nanowires spread over square silicon surfaces. The surface vibrates at its resonance frequency and the particles are carried by capillary waves in the liquid and repositioned in a symmetric grid-like pattern at the wave displacement antinodes. An enhanced coffee-ring effect — where suspended particles leave a ring-shaped structure on a surface once a liquid has evaporated — is induced at high temperature (~60 °C) to ensure that the particles remain at the lattice points during the drying process. Altering the wave's frequency tunes the spacing between aggregates and the overall area of the lattice is limited only by the size of the surface. Depositing a transparent polymer layer on top of the patterned surface and repeating the process extends the assembly into three dimensions. While lattice spacing is currently restricted to millimetre and micrometre scales, exploring viscous liquids and high-frequency waves may eventually afford denser patterns. *VR*

COMPLEX OXIDE INTERFACES

Long correlated paths

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Lithographic processes based on conductive atomic force microscopy have been exploited recently to generate ultranarrow, quasi-one-dimensional conductive regions with outstanding transport properties at the interface of two oxide materials. This approach provides a novel platform to explore the effects of the reduced dimensionality on a variety of correlated electronic ground states emerging in complex oxide heterostructures. In particular, nanowires patterned on the $LaAlO_3$/$SrTiO_3$ interface have led to the unexpected observation of robust electron pairing without evidence for superconductivity.

Now, Jeremy Levy and colleagues at the University of Pittsburgh and the University of Wisconsin-Madison in the US have demonstrated the ballistic transport of electron pairs over micrometre distances. The researchers used conductive atomic force microscope lithography on $LaAlO_3$/$SrTiO_3$ interfaces to pattern nanowires up to 4 μm in length that are delimited by semitransparent barriers and act as optical cavities. They studied the differential conductance maps of these regions at ultralow temperatures as a function of the external magnetic field and of both source–drain and side-gate voltages. This revealed clear oscillations arising from quantum interference processes. Although appearing at magnetic field values much higher than the upper critical field for superconductivity, these oscillations were synchronous with those arising in the superconducting phase, suggesting an intimate relation between the superconducting and paired regimes. These observations confirm the ballistic nature of transport within a correlated state — a limit unexplored to date. *GP*

PROTEIN SCIENCE

The ring reveals all

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The coffee-ring effect — the formation of a particle corona from an evaporating droplet of a colloidal suspension — is typically a hindrance in printing and patterning applications. While many strategies have been sought to suppress this effect, Damien Baigl and colleagues at the Sorbonne, CNRS and PSL Research University in Paris now report a method that exploits it for protein analysis.

By examining the drying of drops containing polystyrene nanoparticles and proteins (bovine serum albumin, BSA, and haemoglobin), the researchers found a clear relationship between drying patterns and the protein's adsorption and reorganization behaviour. Coffee-ring formation is observed when the protein's (BSA) and nanoparticle's charges match, whereas it is suppressed when they neutralize each other. This behaviour is believed to result from the formation of favourable electrostatic interactions, as well as hydrophobic interactions between the protein surface and unfunctionalized nanoparticle regions, rendering the particle–protein assembly hydrophobic.

The tetrameric protein haemoglobin does not follow as simple adsorption behaviour, suggesting protein reorganization also plays a role in protein–particle interactions. The researchers use their method to detect a single point mutation in a protein, as demonstrated by the distinct patterns of drying drops containing haemoglobin or the mutant responsible for sickle cell anaemia. As well as a way of suppressing the coffee-ring effect, this work offers a simple method for investigating protein folding and screening protein interactions for nanotoxicology and nanomedicine. *BLB*

MOLECULAR ROTORS

Highly viscous confinement

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Much like their natural counterparts, artificial molecular machines are expected to operate in an environment where viscous forces dominate inertial forces (low Reynolds number). However, building machines that have no macroscopic counterpart is conceptually challenging. Now, Hai-Bao Duan, Miguel Garcia-Garibay and colleagues at the University of California, Los Angeles have reported a molecular rotor that works in a highly viscous medium and could be used to study the dynamics of fluids in nanoconfined environments.

The researchers start with an amphidynamic crystal, that is, a crystal composed of a static framework with dynamic elements. In this case, a metal–organic framework (MOF) acts as a scaffold for a triptycene group linked by an alkyne. The triptycene is free to rotate around a three-fold axis, since the alkyne linkage poses a negligible activation barrier and there is enough free volume in the pores of the MOF that the dipole interactions with the scaffold and the steric interactions between adjacent tryptycenes are minimal. The researchers then used solid-state deuterium NMR to measure this diffusion-controlled rotational frequency of ^{2}H-labelled rotors. Moreover, temperature-dependent experiments allowed them to estimate the rotational energy barrier as 15.5 kcal mol^{-1}, about 10-fold higher than in the bulk. This effect is due to the presence of 10 water molecules in the vicinity of the rotor, which makes the viscosity of the MOF cavities four orders of magnitude higher compared with in the bulk. *AM*

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