Gold Nanoparticles Enhance Clarity of Latent Fingerprints

In the 1941 classic film *The Maltese Falcon*, detective Sam Spade finds out the hard way just how dangerous gold can be—but he never suspects that one day gold might help him do his job better. In an article published in a recent issue of *Chemical Communications* (p. 1142; DOI: 10.1039/b618966k), M. Sametband, I. Shweky, U. Banin, D. Mandler, and J. Almog of The Hebrew University in Jerusalem, Israel, demonstrate a method of using nanoparticles of gold to significantly enhance the intensity and clarity of latent (invisible) fingerprints.

The standard method for capturing latent fingerprints on wet porous surfaces has not changed in decades. Silver physical developer (Ag-PD) is applied to the surface, and the fatty components of the fingerprint residue (sebum) catalyze the deposition of metallic silver, leaving a black residue along the fingerprint ridges. However, Ag-PD is not very stable, and is not always effective at developing faint prints. Previous work has shown that gold nanoparticles applied to latent fingerprints can enhance Ag-PD deposition through an ionic interaction, in a process known as multi-metal deposition (MMD). Sametband and colleagues, inspired by this earlier work, hypothesized that hydrophobic interactions could lead to the adsorption of gold nanoparticles onto sebum-rich fingerprint ridges, and that these nanoparticles would then catalyze the silver reduction from Ag-PD, enhancing the fingerprint images.

To test this idea, the researchers began with a petroleum ether solution of gold nanoparticles (Au-NPs), which were stabilized with alkanethiol chains (i.e., octadecanethiol, tetradecanethiol, or decanethiol) at different concentrations. The spherical nanoparticles were 2–3 nm in diameter, roughly five times smaller than the nanoparticles used in the MMD method. The researchers next produced sebum-rich fingerprint samples on paper strips, and immersed them in the solution for times ranging from 10 s to 5 min, after which they applied Ag-PD. They found that the fingerprint impressions were significantly stronger and clearer than they were for samples without the Au-NP treatment, with optimal results using a 0.04% (w/v) solution and 3 min of immersion time. Samples without the Au-NP treatment took 10–15 min to develop. The method also worked for sebum-rich fingerprints on silicon surfaces, which are not porous. The Au-NPs stabilized with octadecanethiol aggregated better than the Au-NPs stabilized with tetradecanethiol which in turn aggregated better than the Au-NPs stabilized with decanethiol. In a final set of experiments, the researchers examined the effect of CdSe/ZnS nanoparticles on latent fingerprints, and found that aggregates of the nanoparticles adhered to the fingerprint ridges and were clearly visible under ultraviolet illumination, without the need for further chemical enhancement. In light of these results, nanoparticles may someday become a standard part of the forensic toolkit, and the Sam Spades of the future may think that gold is just as useful as it is dangerous.

COLIN MCCORMICK

Suspended Microfluidic Channels Can Weigh Biomolecules and Single Nanoparticles in Fluid Media

Nanomechanical resonators have enabled the measurement of masses as light as 7 zeptograms (1 zg = 10^{-21} g; i. e., the mass of ~4185 protons) in vacuum. In order to resolve such small mass changes, extremely light resonators ringing at very pure tones are required. However, such resonators are severely degraded by viscosity, preventing applications in fluids. T.P. Burg, S.R. Manalis, and co-workers from the Massachusetts Institute of Technology, W. Shen and co-workers from Innovative Micro Technology, and K. Babcock from Affinity Biosensors, in Santa Barbara, California demonstrated, in the April 26 issue of *Nature* (p. 1066; DOI: 10.1038/nature05741), that suspended microchannel resonators in which viscous loss due to the fluid can be neglected with respect to the intrinsic damping of the silicon crystal resonator can weigh single nanoparticles, single bacterial cells, and sub-monolayers of adsorbed proteins in water with sub-femtogram resolution. This result achieved a mass resolution in solution of 300 attograms (1 ag = 10^{-18} g) an improvement of six orders of magnitude over quartz crystal microbalances (mass resolution ~ 1 ng).

The researchers fabricated suspended microfluidic channels with walls 2–3 μm thick and a 3-μm fluid layer in cantilever-shaped resonators by forming buried channels in silicon-on-insulator wafers, followed by wafer thinning and dry etching. They integrated an electrostatic drive electrode under the cantilevers and detected the cantilever vibration optically. The resonance frequency of such suspended microchannels is highly sensitive to the presence of molecules or particles whose mass density differs from that of the solution, and that are absorbed on the surface of the functionalized channels, or suspended in a solution flowing through the resonator—a unique feature of this device.

The researchers measured the binding of goat anti-mouse immunoglobulin-γ molecules to anti-goat immunoglobulin-γ antibodies that were immobilized on the channel walls functionalized with a layer of Neutravidin bound to poly(ethyleneglycol)biotin grafted poly-L-lysine. The

researchers also measured the mass of bacteria and synthetic micro- and nanoparticles in transit through the suspended microchannels by matching pressures at the inlet and the outlet of the resonator, which reduced the flow rate and increased the transit time of the particle through the device, enabling higher resolution measurements of frequency shifts. This mode required no chemical modification of the resonator and was not affected by sensor drift or bulk density changes, allowing the researchers to run a large number of assays without surface regeneration.

The suspended microchannel resonator enables the analysis of precious samples with minimal reagent consumption; can implement differential sensing and temperature control to improve the detection of small signals in the presence of thermal drift, non-specific binding, or bulk density differences; and can be integrated in elastomeric microfluidic systems, which can provide pumps and valves to deliver fluids to the detector with great precision, the researchers said. They envision that flow-through resonant mass sensing could be configured for counting specific cells in a similar way as flow cytometry or for determining the size and mass density of colloidal particles. Mass labelling would enable the specific detection of pathogens such as bacteria, viruses, or toxins with appropriate functionalization of the surfaces of the microchannels.

JOAN J. CARVAJAL

Spontaneous Folding of PDMS Membranes Achieved

Microfabrication can be a difficult and expensive proposition; methods that take advantage of spontaneous, self-assembled processes can potentially simplify microfabrication. C. Py and a team of researchers from The City of Paris Industrial Physics and Chemistry Higher Educational Institution (ESPCI) and the Hydrodynamics Laboratory (LadHyX) of the Ecole Polytechnique in Palaiseau, France have reported in the April 13 issue of *Physical Review Letters* (DOI:10.1103/PhysRevLett.98.156103) a method to shape sub-millimeter objects by wrapping thin films around water droplets. Water droplets deposited on a small, shaped polymeric film induced capillary forces that were strong enough to counteract the elastic energy of the film and distort the shape. The researchers explored the phenomenon experimentally and offer a model for predicting the critical length scales based on an energy balance between the interfacial and elastic energy of the film.

In order to investigate the effects of capillary forces on elastic thin films, the researchers spin-coated polydimethylsiloxane (PDMS) films on glass slides. These thin films (40–80 μm in thickness) were then cut and a droplet of water was deposited. Figure 1 shows films cut into square, triangle, and cross shapes leading to spontaneously formed tubular, pyramidal, and cubic volumes, respectively, as the water droplet evaporates. For films of appropriate dimensions, the film encapsulates the water droplet and then, as the droplet dries, the polymer assumes a three-dimensional shape determined by the two-dimensional cutout. By numerically evaluating the differential elastic and interfacial equations and matching them to experimental data, an elasto-capillary length was determined, $L_{EC} = (Eh^3/[12(1-v^2)\,\gamma])^{1/2}$, where E is Young's modulus, h is the film thickness, v is Poisson's ratio and γ is the surface tension of the liquid. Above this critical length, a shape is successfully folded. Py notes that the $h^{3/2}$ dependence of L_{EC} is beneficial to miniaturization as the critical length scale becomes even smaller as the thickness decreases.

Efforts to create more complex shapes will require more sophisticated models to account for gravitational forces and three-dimensional stresses. The researchers acknowledge the inevitable problem of crumpling, stemming from geometric incompatibilities between planes and volumes described in Gauss's *theorema egregium*, but point out the possible ways this may be overcome. The ability to create complex shapes from planar cutouts will make micro- and nano-fabrication cheaper, easier, and more accessible.

ARTHUR FELDMAN

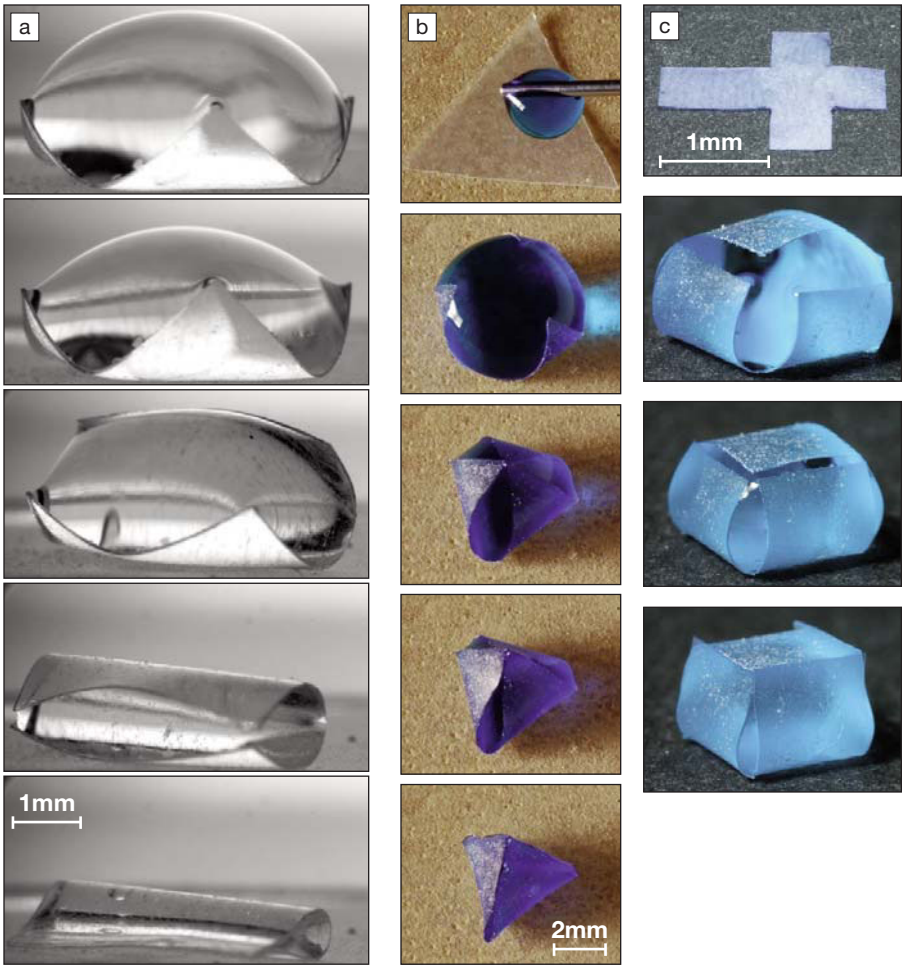

Figure 1. Two-dimensional cutouts of polydimethylsiloxane (PDMS) films assume three-dimensional shapes: (a) square to tube, (b) triangle to pyramid, and (c) cross to cube. Videos of these formations are available at www.aip.org/pubservs/epaps.html. Reprinted with permission from C. Py, P. Reverdy, L. Doppler, J. Bico, B. Roman, and C.N. Baroud, *Phys. Rev. Lett.* **98**, 156103 (2007). ©2007 American Physical Society.