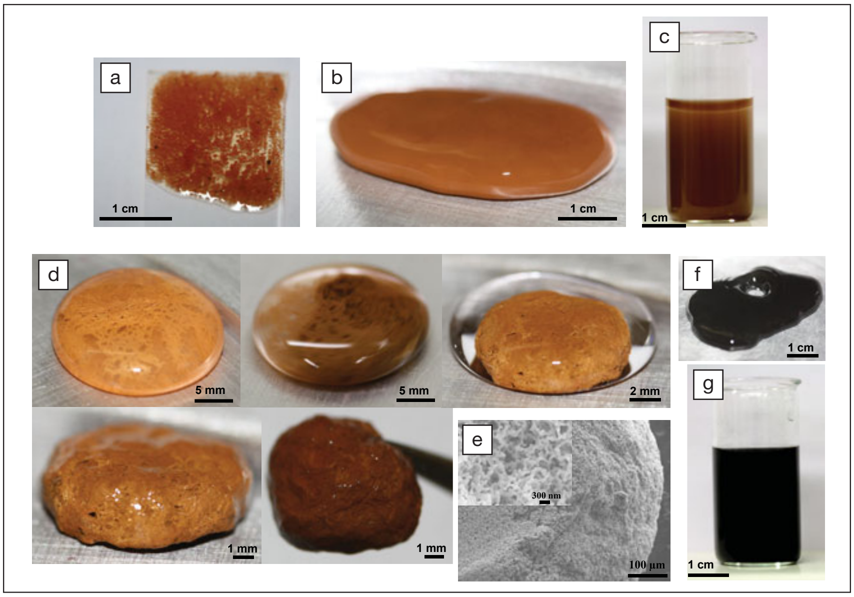
Leidenfrost drops prove to be versatile nanoreactors

The Leidenfrost effect, first investigated over 250 years ago, is well known as the phenomenon that causes water droplets to hover over the surface of a hot frying pan for several seconds while evaporating. This common phenomenon, which creates droplets in a super-heated state, has now been exploited to fabricate a wide range of nanoscale materials. As described in an article published in *Nature Communications* in October (DOI:10.1038/ncomms3400), researchers from several German research institutions investigated the physical properties of Leidenfrost drops in detail and established that overheating, thermal gradients, and electrical charge separation which occur within the Leindenfrost drops create an ideal environment to promote nucleation of functional nanomaterials.

Gold nanoparticles of 4 nm size were synthesized in a 2-mL drop of dilute $HAuCl_4$; however, when the OH^- concentration within the drop was increased by adding NaOH to the reaction solution, macroscopic, spongy three-dimensional (3D) metal nanostructures were formed. Nanoparticle synthesis, clustering, assembly, and fusion all occur within the levitating Leidenfrost drop (see Figure), and preliminary follow-up investigations show that the morphology, shape, and porosity of the resulting nanoporous metal can be controlled by varying the NaOH concentration.



Synthesis of nanoporous gold: (a) photograph of macroscopic spongy gold structure prepared by the Leidenfrost drop synthesis method collected on a glass substrate; (b) Leidenfrost pool of suspended nanoporous brown gold levitating on a hot plate and (c) the same solution inside a glass container; (d) time evolution for synthesis of solid nanoporous gold sphere from initialization to final product as a sponge; (e) scanning electron microscope (SEM) image of the spongy brown gold (inset: higher magnification SEM image); (f) Leidenfrost pool of suspended nanoporous black gold levitating on a hot plate and (g) the same solution inside a glass container.

Alternatively, homogeneous nanostructured coatings can be applied to different substrates *in situ* after the synthesis of nanostructures within the Leidenfrost reactor. To accomplish a uniform coating the substrate is placed inside the drop, which is rotated during the levitation phase. The team led by Mady Elbahri, who holds a joint appointment at the University of Kiel and the Helmholtz-Zentrum Geesthacht, demonstrated that Leidenfrost drops can even be used as nanoreactors to synthesize functional metal–polymer hybrid foams. Such a 3D coating of a complex structure cannot be obtained by conventional immersion synthesis techniques; it requires the unique aspects of a Leidenfrost nanoreactor.

"We understand the chemistry; extending the range of applications for Leidenfrost drop chemistry now necessitates a better understanding of the levitation process. This is the challenge we are working on," said Elbahri. For now, however, the limiting factors to advancing this new type of charge-driven chemistry are the size of the levitated droplet and its stability.

Birgit Schwenzer

Nano Focus

Origin of nickelate stripe phase uncovered

Strongly correlated materials often show unusual magnetic and electronic properties, such as high-temperature superconductivity. An example of such behavior is the formation of self-organized electronically ordered phases, which can cause charges to segregate into atomic-scale patterns and is linked to the emergence of high-temperature superconductivity.

An international research team has now illuminated the origins of the so-called "stripe phase" in which electrons become concentrated in stripes throughout a material.

"We're trying to understand nanoscale order and how that determines materials properties such as superconductivity," said Robert Kaindl, a physicist at Lawrence Berkeley National Laboratory (Berkeley Lab). "Using ultrafast optical techniques, we are able to observe how charge stripes start to form on a time scale of hundreds of femtoseconds."

Kaindl, W.-S. Lee (SLAC National Accelerator Laboratory), T. Sasagawa (Tokyo Institute of Technology), and their colleagues reported the results of

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