While lead-halide perovskites have revolutionized photovoltaics, they have also shown promise for lasers, light-emitting diodes, and transistors. Now, researchers show that perovskite nanocrystals are also highly effective catalysts for organic synthesis.

Reactions that form carbon–carbon bonds are the basis of synthesizing drugs, plastics, and chemicals. But the reaction procedures are complicated and require expensive noble metal catalysts. A team led by Yong Yan at San Diego State University found that colloids of methylammonium lead tribromide and cesium lead tribromide are 1000 times as effective as iridium- and ruthenium-based catalysts for catalyzing the α-alkylation of aldehydes, a valuable and widely used chemical reaction. The perovskites cost approximately 100 times less. For the simple one-pot reaction, the researchers mixed organic starting materials into a suspension of the perovskite nanocrystals. Blue-light illumination triggers reactions that generate several products. By tweaking the reaction condition, the researchers can selectively catalyze other important chemical reactions, the researchers report in the *Journal of the American Chemical Society* (doi:10.1021/jacs.8b08720).

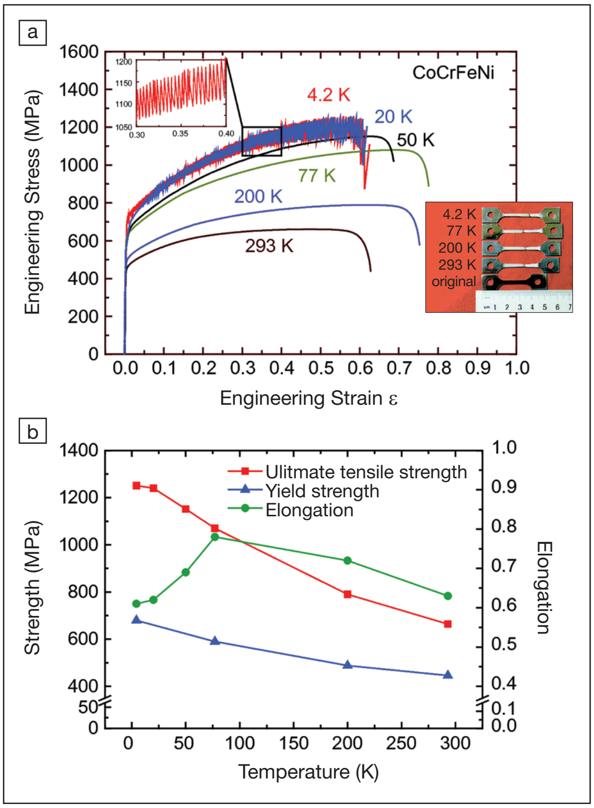
CoCrFeNi increases strength at cryogenic temperatures

An international team of researchers has discovered that the strength of a CoCrFeNi high-entropy alloy increases at the liquid-helium temperature while the sample maintains excellent ductility. These mechanical properties could make this new alloy useful for cryogenic applications, according to the study published recently in *Science China Materials* (doi:10.1007/s40843-018-9373-y).

The CoCrFeNi alloy belongs to an emerging class of materials known as high-entropy alloys (HEAs). Compared to traditional alloys such as steel, which mostly consist of one primary metal with small concentrations of additional elements, HEAs are mixtures of several different elements in roughly equal concentrations. HEA research was ignited in the early 2000s with the simultaneous discovery of two different alloys. Today, research continues on HEAs in particular because they exhibit desirable mechanical and structural properties at extreme temperatures. For example, “HEAs usually have different kinds of defects [compared to conventional alloys], such as stacking faults with lower energy, and can be ductile even at very low temperatures,” says Yong Zhang of the University of Science and Technology Beijing. Zhang is corresponding author of the publication.

Zhang and his collaborators performed a series of challenging experiments on CoCrFeNi, assessing the alloy’s strength and ductility down to temperatures of 4.2 K. “Few places in the world can perform these extremely low temperature experiments,” says Peter Liaw of The University of Tennessee, Knoxville, who is a coauthor on this publication. When subjected to tensile strength testing at extremely low temperatures, the CoCrFeNi alloy deformed in a slip-stick manner, as demonstrated by jagged or serrated stress–strain curves at 20 K and 4.2 K.

Performing mechanical property measurements at “the liquid-helium temperature is really remarkable,” says Richard LeSar of Iowa State University, “It opens up a different realm for thinking about behaviors in these systems.” LeSar was not involved with this study.



Tensile properties of the CoCrFeNi alloy at different temperatures. (a) Engineering stress–strain curves and photograph of the dog-bone-shaped samples, before and after tensile tests. The enlarged stress–strain curve at 4.2 K is displayed in the inset and the jagged serrations are clearly observed. (b) Strength and elongation versus temperature for the high-entropy alloy. The ductility reaches a maximum at 77 K. Credit: *Science China Materials*.

To explain the serrated behavior of the stress–strain curves, images of the CoCrFeNi samples after strain testing were taken using both a transmission electron microscope and a high-resolution scanning transmission electron microscope. The images revealed many small parallel hatched features consistent with the formation of deformation twins, which correspond to boundaries where two different regions of the alloy have shifted relative to one another. In addition to the twinning behavior, a new crystal phase of the CoCrFeNi alloy was also observed.

Theoretical analysis of the serrated stress–strain curves revealed an “unstable dynamic process, which was consistent with the instability caused by the phase transition and twinning,” according to Jingli Ren of Zhengzhou University, China. Ren performed the calculations for this study. Both the deformation twinning and phase transition likely contributed to the low-temperature ductility and strength measured in CoCrFeNi HEAs.

Further understanding is needed of how the observed chaotic behaviors in CoCrFeNi contribute to its serrated stress–strain behavior and mechanical properties at low temperatures. According to Liaw, more in-depth analysis and modeling of this and other HEAs are needed to separate the contributions from deformation twinning and phase transition to the strength and ductility seen at the liquid-helium temperature. Such a study could be challenging because the two behaviors often appear simultaneously in some HEAs.

Zhang hopes these results demonstrate the capabilities of HEAs at cryogenic temperatures, which could be used especially as materials for aerospace and nuclear-reactor applications.

Lauren Borja

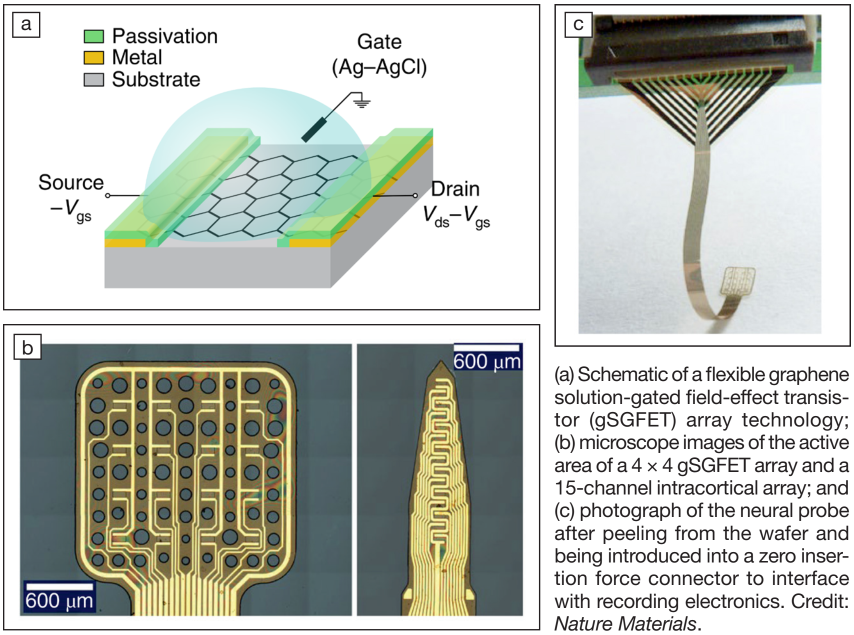
BIO FOCUS

Graphene microtransistors map brain activity

The study of low-frequency brain signals, which is important for the diagnosis of many medical conditions, is limited by the microelectrode materials currently available. Now, researchers have shown that these infraslow brain waves, that is, brain activity that occurs at frequencies less than 0.1 Hz, can be monitored with high spatial resolution using graphene transistors.

From the outside, the brain looks like a colony of neurons that communicate with each other in some sort of bizarre electrical language. Chemical conditions inside and around a neuron decide whether it will respond to or ignore an incoming signal from another neuron. If the conditions are right, a traveling electric potential is generated that moves across the brain. Most neural activity that has been studied so far is fast—greater than 1 Hz. However, infraslow activity (ISA) is becoming recognized for its involvement in a number of electrophysiological states such as sleep, coma, wakefulness, and anesthesia. Among these slow-moving brain murmurs are such ominously named entities as "spreading depolarizations" and "cortical spreading depressions" or CSDs. These slow-moving waves are often called brain tsunamis, which depolarize neurons and shut down large sections of the brain. CSDs are often triggered in cases of stroke or brain injury as well as during migraines and epileptic seizures.

"In humans, terminal spreading depolarization (SD) has been measured within minutes following circulatory arrest and during the development of brain death. Transient SDs have been recorded in 90–100% of patients with severe stroke, 60–80% of patients with brain hemorrhage, and about 50% of patients with severe traumatic brain injury," Jens P. Dreier of the Center for Stroke Research Berlin told *MRS Bulletin*. The study of these low-frequency brain signals are therefore important for diagnosis and cure in neurocritical care.



(a) Schematic of a flexible graphene solution-gated field-effect transistor (gSGFET) array technology; (b) microscope images of the active area of a 4 × 4 gSGFET array and a 15-channel intracortical array; and (c) photograph of the neural probe after peeling from the wafer and being introduced into a zero insertion force connector to interface with recording electronics. Credit: *Nature Materials*.

In a recent issue of *Nature Materials* (doi:10.1038/s41563-018-0249-4), Eduard Masvidal-Codina and colleagues, led by Anton Guimerà-Brunet at the Institute of Microelectronics of Barcelona (IMB-CNM, CSIC) and Jose A. Garrido at the Catalan Institution for Research and Advanced Studies (ICREA), reported their study of graphene microtransistors for studying low-frequency brain signals. The unique geometry of these devices allows good integration with the tissue of the brain and can cover a significant area, allowing for comprehensive monitoring. The research team developed a graphene solution-gated field-effect transistor (gSGFET) that used a graphene sheet to mediate the conduction between the source and the drain. The potential of the neural tissue changes the resistance of the graphene channel that is then read from the current variation. These graphene transistors not only have a high surface-to-volume ratio—enabling greater coverage of the brain tissue than was possible previously—but also function as signal amplifiers, boosting the signal-to-noise ratio.

"Mapping infraslow activity with high-fidelity and spatial resolution simultaneously with local field potentials with non-cytotoxic materials was not previously possible and is a technological advance