Stretch goals: Elastic conductors reach a new milestone

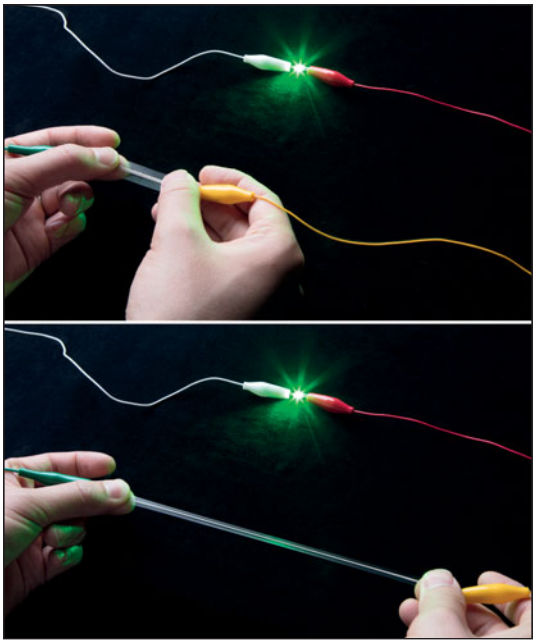
Sensitive elastic conductive materials that can withstand high strains due to stretching are critical for next-generation wearable devices and robotics. Printable elastic conductors are promising candidates for generating large-area, stretchable sensor/actuator networks. These conductors are typically composite materials comprising elastomers laced with metal nanoparticles. Although these composites can deliver high performance, their widespread use has been hampered by various processing challenges.

Now, researchers at The University of Tokyo have fabricated a new elastic composite material that retains its high conductivity even when stretched to five times its original length. This new material is made by printing an ink containing fluorine rubber, fluorine surfactant, silver flakes, and methylisobutylketone as the solvent. It can be printed in various patterns on textiles and rubber surfaces, and can be used as stretchable wiring for wearable devices with sensors.

Remarkably, the silver flakes—which are used as a low-cost conducting filler—transform into silver nanoparticles upon printing and heating of the ink (temperatures between 80°C and 150°C were studied). Electron microscopy revealed silver nanoparticles between two and ten nanometers in diameter, about 1000 times smaller than the original flakes. “We did not expect the formation of Ag nanoparticles,” says lead researcher Takao Someya.

As reported in *Nature Materials* (doi:10.1038/NMAT4904), these printable elastic composites exhibit conductivity higher than 4000 S cm^{-1} at 0% strain, and 935 S cm^{-1} when stretched up to 400%—the highest conductivity reported to date for this amount of stretching.

The high performance of the conductor resulted from self-formation of silver nanoparticles one-thousandth the size of the Ag flakes that were formed after the conductive composite paste was printed and heated. The researchers say that the *in situ* formation of silver nanoparticles in the elastomer matrix improves the conductivity due to enhanced percolation between the silver flakes and the suppression of crack formation through nanoparticle reinforcement. Furthermore, by adjusting the molecular weight of the fluorine rubber, the team could control the distribution and population of nanoparticles, while the surfactant and heating accelerated particle formation and influenced their size.



A new elastic composite conductor demonstrates high conductivity that is maintained even while the material is stretched. For example, a light-emitting diode (top) continues to shine brightly even when stretched to five times its original length (bottom). Courtesy of Takao Someya, The University of Tokyo.

To test the viability of the elastic conductors, the researchers fabricated fully printed stretchable pressure and temperature sensors to sense weak forces and measure heat close to the body and the temperature of the room. These sensors were wired with the printable elastic conductors on textiles by laminating onto surfaces using a hot-pressing technique. The team showed that the sensors took precise measurements even when stretched by 250%.

This is enough to accommodate high-stress flexible areas, such as elbows and knees on conformable, form-fitting sportswear, or joints on robotic arms that have been designed to surpass human capabilities and thus undergo higher strain, the researchers say. The team is now exploring substitutes for silver flakes to reduce the cost, such as copper, and alternative polymers.

“We saw the growing demand for wearable devices and robots and felt it was very important to create printable elastic conductors to help realize the development of products,” Someya says.

Aditi Risbud

2D electrocatalytic MOF sets efficiency record for water splitting

A two-dimensional nickel/iron metal–organic framework (2D NiFe-MOF), fabricated by researchers at the University of New South Wales in Sydney, Australia, has established a new record for efficient electrocatalytic water splitting. Published recently in *Nature Communications* (doi:10.1038/ncomms15341), this work expands the capabilities of MOFs to new applications in energy conversion and storage.

Scientists have only recently begun to develop MOFs, which are structures formed by linking metal clusters in a porous network using organic ligands, for applications such as electrocatalysis. “MOFs are generally believed to be poor electrocatalysts,” says Chuan Zhao, whose group published the work. Traditional MOFs are usually insulating, lack diverse pore sizes to facilitate the transfer of materials, and degrade in water. Researchers must engineer MOFs that allow for the movement

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