Researchers create 'rubber-band electronics'

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For people with heart conditions and other ailments that require monitoring, life can be complicated by constant hospital visits and time-consuming tests. But what if much of the testing done at hospitals could be conducted in the patient's home, office, or car?

Scientists foresee a time when medical monitoring devices are integrated seamlessly into the human body, able to track a patient's vital signs and transmit them to his doctors. But one major obstacle continues to hinder technologies like these: electronics are too rigid.

Researchers at the McCormick School of Engineering at Northwestern University, working with a team of scientists from the United States and abroad, have recently developed a design that allows electronics to bend and stretch to more than 200 percent their original size, four times greater than is possible with today's technology. The key is a combination of a porous polymer and liquid metal.

A paper about the findings, "Three-dimensional Nanonetworks for Giant Stretchability in Dielectrics and Conductors," was published June 26 in the journal *Nature Communications*.

"With current technology, electronics are able to stretch a small amount, but many potential applications require a device to stretch like a rubber band," said Yonggang Huang, Joseph Cummings Professor of Civil and Environmental Engineering and Mechanical Engineering, who conducted the research with partners at the Korea Advanced Institute of Science and Technology (South Korea), Dalian University of Technology

(China), and the University of Illinois at Urbana-Champaign. "With that level of stretchability we could see medical devices integrated into the human body."

In the past five years, Huang and collaborators at the University of Illinois have developed electronics with about 50 percent stretchability, but this is not high enough for many applications.

One challenge facing these researchers has been overcoming a loss of conductivity in stretchable electronics. Circuits made from solid metals that are on the market today can survive a small amount of stretch, but their electrical conductivity plummets by 100 times when stretched. "This conductivity loss really defeats the point of stretchable electronics," Huang said.

Huang's team has found a way to overcome these challenges. First, they created a highly porous three-dimensional structure using a polymer material, poly(dimethylsiloxane) (PDMS), that can stretch to three times its original size. Then they placed a liquid metal (EGaIn) inside the pores, allowing electricity to flow consistently even when the material is excessively stretched.

The result is a material that is both highly stretchable and extremely conductive.

"By combining a liquid metal in a porous polymer, we achieved 200 percent stretchability in a material that does not suffer from stretch," Huang said. "Once you achieve that technology, any electronic can behave like a rubber band."

The graduate student Shuodao Wang at Northwestern University is a co-author of the paper.

Provided by Northwestern University