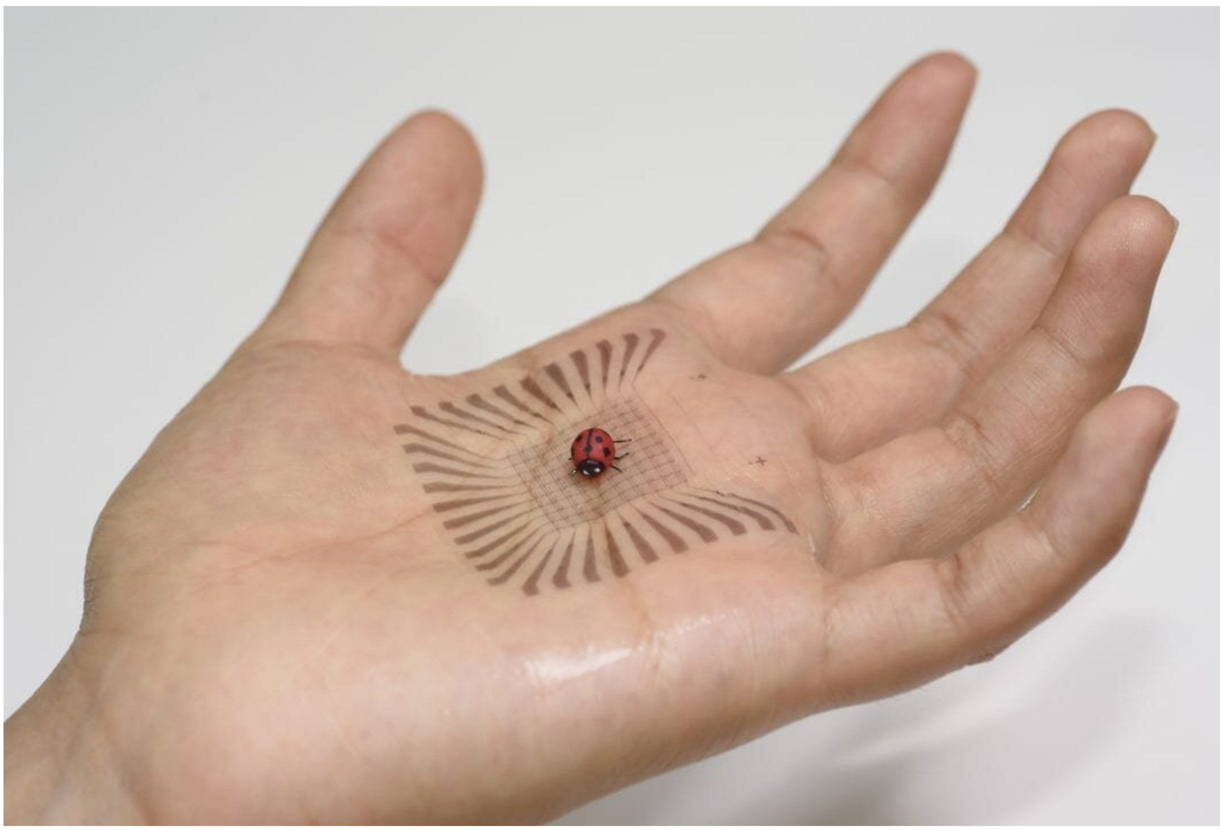
Stretchable, self-powered bioelectronics mimic skin in form and function

September 8 2022, by Melissa Fassbender



The Sihong Wang Research Group focuses on the development of soft polymeric materials and devices that can merge electronics with biological systems. Credit: Sihong Wang

Skin-like electronics could seamlessly integrate with the body for applications in health monitoring, medication therapy, implantable medical devices, and biological studies.

With the help of the Polsky Center for Entrepreneurship and Innovation, Sihong Wang, an assistant professor of molecular engineering at the University of Chicago's Pritzker School of Molecular Engineering, has secured patents for the building blocks of these novel devices.

Drawing on innovation in the fields of semiconductor physics, solid mechanics, and energy sciences, this work includes the creation of stretchable polymer semiconductors and transistor arrays, which provide exceptional electrical performance, high semiconducting properties, and mechanical stretchability. Additionally, Wang has developed triboelectric nanogenerators as a new technology for harvesting energy from a user's motion—and designed the associated energy storage process.

The goal is to combine these advances to develop devices that could be adhered to a user's skin or within the body to detect vital signals in real time "much more" effectively than currently available options, said Wang, adding that this work has been among the most rapidly progressing areas in materials science and electronic engineering.

"Over the past decade, this overall direction of developing electronics that can work more intimately with the human body has really attracted a lot of attention from academia and industry," said Wang. "Because people have seen the big gap and also the big opportunity here to have the electronics that work for the human body in a more intimate way."

Seizing this opportunity, Wang is taking his research in several directions. "We created a new structure and filed a patent through Polsky based on our developments for a new type of pressure sensor, which can stretch similar to skin but doesn't have a shift in performance," Wang explained.

Working with colleagues Stacy Lindau, MD, MA, a professor of obstetrics and gynecology and medicine-geriatrics and director of a research lab in the Biological Sciences Division, and Sliman Bensmaia, James and Karen Frank Family Professor of Organismal Biology and Anatomy, Wang is using this sensor to create a neural-prosthetic system that would be implanted underneath the skin of mastectomy patients. Called the Bionic Breast Project, the aim is to restore sensation to the breast area.

"Such sensors can work similarly to the sensing receptors in the breast for sensing physical contact/movement, by converting it to an electrical signal," said Wang.

These sensors also could be used to develop so-called electronic skin for soft robotics, giving them the ability to sense and perceive in new ways. In the next five years, however, Wang said he expects the most immediate applications of this work would be for a device that extracts several types of signals from the body, such as pulse and blood pressure. And they are doing just that.

Looking ahead, the goal is to detect signals from different biomarkers in sweat.

"In the current medical practice the only way to get a panel of biochemical information is through a blood test, which is not only invasive but not instant," noted Wang. "This would be another big game changer for the way that everyone can get their health status in a much more effective and frequent way." Wang recently published the first two works outlining the strategy to achieve stretchable biosensors with high sensitivity and selectivity.

Stretchable displays and on-body data processing with AI

Another critical component of skin-like devices is a flexible display to communicate with users. For this, Wang and his group have developed another important new type of material: electroluminescent polymers. Highly efficient, the polymer emits light brightly and maintains performance while stretched.

Rounding out the work, the team also is exploring the combination of the devices with artificial intelligence (AI).

"We think toward the future, the success of wearable devices will be in their ability to continuously extract and monitor health information from the human body," said Wang. "Then the data generated will truly be 'big data' compared to now, only having snapshots of a test report."

As with all data sets, the next question is how to effectively and in a high throughput manner analyze and extract useful health information.

"We are trying to develop a new type of computing device and platform that can really efficiently implement AI or machine learning algorithm directly on skin or on the body without relying on shifting or transmitting information wirelessly to a central computing location, like the cloud," explained Wang. "Analysis can be much faster and you don't have the risk of losing very private health information from those wireless transmissions."

The semiconductor-based computing platform is a "neural network computer," inspired by how the brain works.

"Ultimately, we can help achieve precision medicine," said Wang. "For each individual the data the device collects can be analyzed through a personalized program that gives you the most useful and most effective things to do, providing a closed loop intervention to control your health."

Eventually, the goal is to create something that mimics the human brain not only in mechanical properties but also in the way it functions and operates. "Overall, up to now AI has been more a computer science research scope," Wang said. "But for us as materials scientists, we are working on this from a different angle."

The research appears in *Advanced Materials* and *Matter*.

More information: Yahao Dai et al, Stretchable Redox-Active Semiconducting Polymers for High-Performance Organic Electrochemical Transistors, *Advanced Materials* (2022). DOI: 10.1002/adma.202201178

Nan Li et al, A universal and facile approach for building multifunctional conjugated polymers for human-integrated electronics, *Matter* (2021). DOI: 10.1016/j.matt.2021.07.013

Provided by University of Chicago