Researchers design transistor that can adhere to internal organs like tape

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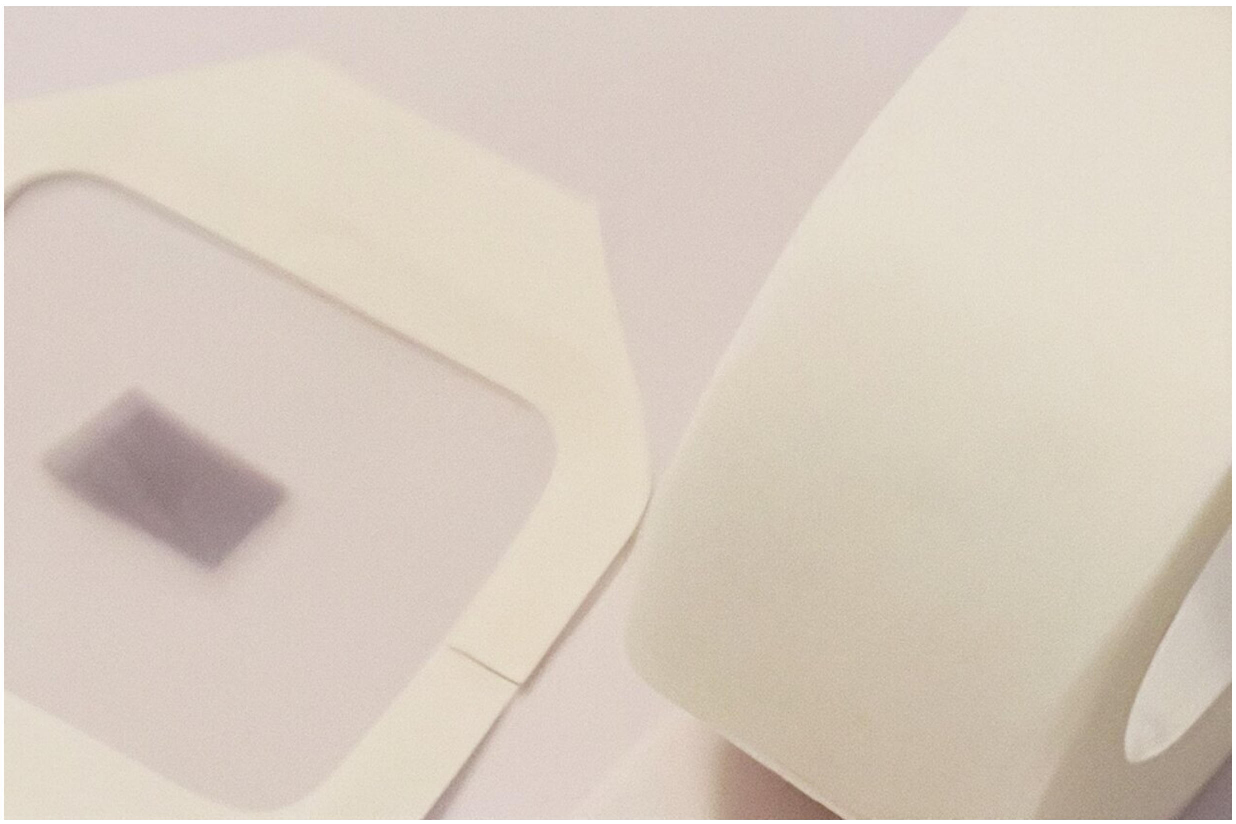

The semiconductor adheres tightly to the surfaces of living organs, making it an ideal component for implantable biosensors. Credit: Wang Group

Sticking an implantable sensor to the surface of a beating heart usually requires suturing around the periphery of the sensor or copious amounts of adhesive layered between the sensor and the heart. In both cases, such a sensor rarely has tight, uninterrupted contact with heart tissue, limiting the data that clinicians can collect on a patient's heart function.

To solve this challenge, researchers at the University of Chicago's Pritzker School of Molecular Engineering have designed a new adhesive semiconductor that can stick tightly to the moist, pliable surfaces of living tissues, including the heart. The semiconductor, described in the journal *Science*, allows tissue-adhesive properties for transistor-based biosensors.

"This is the first semiconductor and transistor that has bioadhesion as an intrinsic property—you don't need organ-invasive stitches, staples, or glue to stick this onto a tissue," said Sihong Wang, assistant professor at Pritzker Molecular Engineering, who led the research. "This is going to open up all sorts of new possibilities for biosensing." Wang also holds a joint appointment at Argonne National Laboratory.

Wang's lab at PME focuses on developing new materials to underpin a full suite of devices that interface with the human body for health monitoring. Some of their prior research has led to stretchable, flexible computer chips that can analyze health data, as well as stretchable displays to integrate into wearable electronics.

But Wang thought more work was needed to revolutionize the biosensors that carry out the first step in this workflow: collecting information from internal organs to send to the chips and displays.

Previously developed biosensors, he said, were not very good at adhering tightly to living organs. This meant the data they provided was inconsistent or spotty.

"A key step for getting information from anywhere inside the human body is transducing the signal from a tissue to a device, and the more closely your device can conform and adhere to a tissue surface, the more effective that signal transduction will be," explained Nan Li, a Ph.D. student in Wang's lab, who is the first author of this work.

In addition to constantly moving and having the ability to grow or shrink, most human organs are constantly moist.

"Everyone knows from their own life experience that if you try to stick a piece of tape onto a dry surface, it can adhere strongly," said Wang. "But try to stick the same tape onto a wet surface and it becomes much harder."

Wang's group overcame these challenges by developing a new polymer that soaks up liquid on the surface of a moist tissue and then adheres to its surface. They combined the polymer with the kind of stretchable, flexible semiconductors they had designed in the past. The resulting sensor is a "double network" of the two materials: one bioadhesive and one semiconducting. The researchers designed the new material so that the properties of neither material, when combined, diminished.

To test the utility of the new adhesive polymer, Wang and his colleagues used the material to create devices that could collect data on the electrical activity of hearts.

"The devices could be attached to any location on the surface of the heart with less than a minute of very gentle pressure," said Wang.

The devices, they showed, stuck to one area of the heart without drifting, and collected more reliable and higher-quality data than devices that are stapled or glued to the heart. For researchers who want to map data to many areas of an organ like the heart, such stable and intimate tissue-adhesion can greatly benefit the spatial resolution of a long-term recording.

But Wang says the possible uses of the new bioadhesive material go far beyond recording electrophysiological signals. The same material could be used to make adhesive sensors that collect data inside the body on the levels of immune molecules, electrolytes, or metabolites.

"This has really great potential for biochemical sensing," said Wang. "It can open up a broad spectrum of implantable sensors that collect data directly from tissues inside the human body."

Wang's group also is studying how to tune the adhesion properties more precisely so that devices using the new polymer can be more controllably removed from the body. For long-term recording of health data, they are also developing new material design strategies to ensure that the human body's immune system accepts the material, and it remains functional over a long time period.

Their overall goal is to realize and maintain intimate tissue interfaces during any length of time.

More information: Nan Li et al, Bioadhesive polymer semiconductors and transistors for intimate biointerfaces, *Science* (2023). DOI: 10.1126/science.adg8758

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