December 17, 2014

Japan Science and Technology Agency (JST)
TEL: (+81)-3-5214-8404
(General Affairs, Public Relations Division)

The University of Tokyo
School of Engineering
TEL: (+81)-3-5841-1790
(Public Relations Office)

Biometric Information Sensor that directly adheres to the Body like a Compress
～With Adhesive Gel, the Sensor will stay in contact even in motions～

Key Points

- Just by applying to the body like a compress, our novel sheet sensor detects biometric information extremely accurately.
- Adhesive gel applied to a sensor prevents slippage from the surface of a constantly moving living body, and achieved accurate measurement of biometric information.
- Applications of the sheet sensor in health care, sports, medical, are being considered.

Within the framework of the Strategic Basic Research Program of the Japan Science and Technology Agency (JST), Professor Takao Someya, postdoctoral researcher Sung Won Lee et al. of School of Engineering, the University of Tokyo have developed an adhesive gel and succeeded in manufacturing a sheet sensor that can measure biometric information just by applying to the body like a compress.

The technological importance of measuring biometric information is increasing in line with remarkable developments in information technology such as big data. To improve the accuracy of measurements, it is ideal to put the sensor in direct contact with what is to be measured. As such, in order to reduce discomfort of a user when sensors are directly applied to a living body, researchers are actively proceeding to fabricate electronic components on flexible substances such as polymeric film. However, there have been demands to realize a high degree of functionality, such as affinity and adhesiveness with the body, on the machine interface that come into direct contact.

Using limited materials with superior biocompatibility, the research group succeeded in making adhesive gel capable of fabricating patterns with light. Furthermore, they applied the gel to realize sheet sensors that can perform biometric measurement just by applying the gel to the body like a compress. This sensor is made with two different processes.　On top of electronic circuits fabricated on ultra-thin polymeric film, the adhesive gel is patterned only to cover the electrodes that interfaces with the living body. These sheet sensors can detect bioelectric signals, such as strained physical quantities and electrical activities of the heart, by directly applying to surfaces of human skin or the heart of a rat. Adhesive gel prevents the sheet sensor from slipping or falling off the surface during the dynamic movement, and allows stable and long-term measurement.

The compress or plaster-like sheet sensor will evoke the technology in abstracting biological information from an active living body, and applications in health care, sports, medical and public welfare are being considered.

The achievement of this research will be published in ***Nature Communications* on December 19, 2014 (UK time).**

<Research Background and Details>

In line with remarkable advances in information technology such as big data [note1] and the Internet of Things: IoT [note2], the importance of new sensing technology to measure various types of information in real space is increasing. Particularly, research and development of the technology to measure human biometric information is advancing. As a result, there are remarkable developments in biometrics; and biometric information such as a pulses are easily measurable just by putting on a wristwatch-type wearable device [note3].

In order to electronically measure human movement and biometric information with precision, it is necessary for the sensors and electronic circuits to be close in contact to the subject of measurement. Specifically, the reliability of measurement improves when the sensor have good and direct contact with the subject. However, since conventional electronics have been made of hard electronic materials such as silicon, there have been issues such as discomfort when these hard electronic components come into direct contact with living bodies/tissues. There have also been issues that such hard sensors interfere with the dynamic movement of the body.

Amidst this situation, there has been active research and development of technology to form electronic components on flexible materials such as polymeric film and rubber sheets. For example, a flexible electronic switch called organic transistor[note4] fabricated on 1 micrometer thick polymeric film reached a bend radius of 10 micrometers without losing its electronic functionality. When electronic circuits with such flexibility are directly applied to a living body, further contrivance becomes necessary for the surface that directly touches the living body. In short, what we needed to overcome was technology with robust and yet flexible material that improves affinity with the surface of the living body, and that establishes a stable contact with a wet living tissue.

<Details of the Research>

The researchers successfully fabricated sheet-type electronic circuits that enable biometric measurements just by application to the body like a compress. New electronic circuits can measure bioelectric signals such as strained physical quantities and cardio electricity by directly applying to surfaces such as human skin or the heart of a rat. The adhesiveness of the sheet-type electrical circuits prevent the dynamic movement of the body surface to cause the device from slipping or falling off.

The research group first fabricated high-performance organic transistor integrated circuits on 1.4 micrometer extremely thin polyethylene terephthalate (PET) [note 5]polymeric film (image 1), then coated only the electrodes that come into direct contact with the living body with adhesive gel pattern. On their prototype integrated circuits, 144 (12 x 12) sensors are distributed 4mm apart from each other on a surface area of 4.8 x 4.8cm^2. Gel-coated Electrodes function as sensors that measure electronic signals directly from a living body. The integrated circuits stay functional even when the subject moves dynamically. It was proved in the following experiment where integrated circuits were placed on the surface of an inflated balloon. 100% compressive strain was applied, but their electrical performance did not fail.

The decisive factor in the research was the success in making adhesive gel that can fabricate patterns with light using only materials with superior biocompatibility (image 2). This new type of gel material is created by evenly distributing polyvinyl alcohol (PVA) in a rotating gel called polyrotaxane [note6]. Since the pattern can be fabricated by light, this new type of gel can be coated only on the electrodes of sensors arranged in a grid pattern. Good adhesiveness is maintained even with wet living tissue since the new gel itself is adhesive. The adhesiveness of the gel resolves the problem found in the conventional methods where the electrode in contact with the living surface slips or peels off as the living tissue moves.

Their prototype device maintained a good contact for over 3 hours when affixed to the surface of a rat heart due to the astounding flexibility of the organic device and the adhesive gel. This resulted in an electrocardiograph with good quality signals. Since PVA loses flexibility by melting, the device can be easily removed without imposing a burden on the heart after measurement. Furthermore, the team built a supersensitive, flexible strain sensor with the same design method. They were able to measure dynamic body movements such as the moving of fingers by directly applying the sensors to human skin. (image 3).

In 2013, the research group succeeded in making an organic transistor on polymeric film of 1 micrometer in thickness, and applying it to such things as touch sensors and electromyography sensors. In this research, they developed the world’s first adhesive gel that can form patterns with light, which enabled stable, long-term biometric measurement using 1 micrometer thick sensors even if the subject is moving dynamically.

＜Future Developments＞

Application is expected in many directions, including health care, sports, medical treatment and public welfare through the realization of multipoint measurement that can follow dynamic movement just by applying directly to a living body.

Conventional wearable electronics have become increasingly smart through the introduction of electronic circuits into items worn on the body such as wristwatches and eyeglasses. On the other hand, this research has enabled smartness through introducing electrical components even into items directly applied to the body like a compress or plaster. As a result, there are expectations that this will be applied to 24-hour, stress free biometric measurement technology while going about one’s daily life.

Furthermore, although they are at the animal experimentation stage using rats, in this research, this compress-like sensor has been attached even to internal tissues such as a heart tissue. In the future, this technology will be applied to internally implanted electrical systems and the scope of application for electrical devices will increase.

＜Reference Images＞

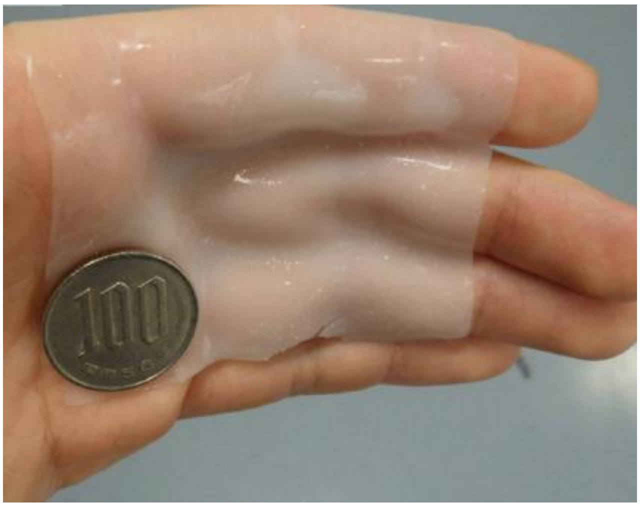
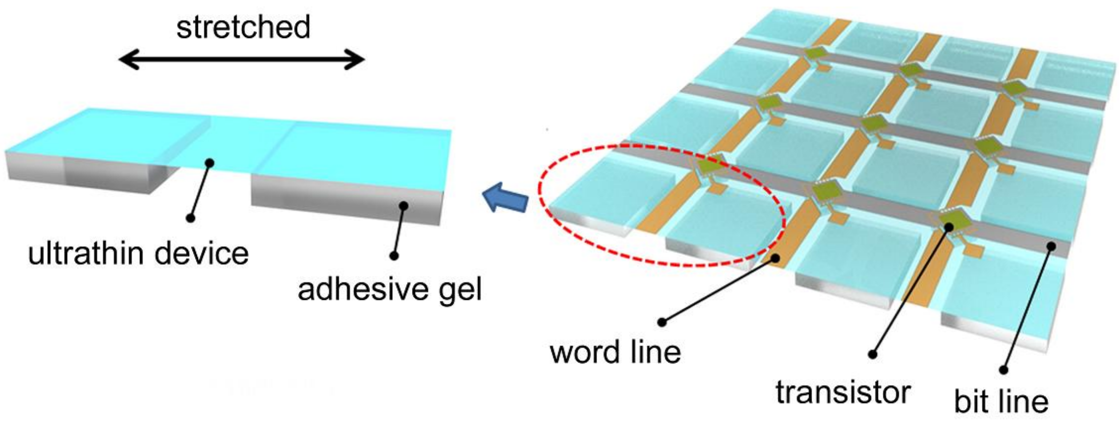


Image 1

Adhesive gel with superior biocompatibility that can form patterns with light

This novel type gel can follow the shtape of fingers when applied to a hand. The gel surface has strong adhesion, and a 100 yen coin does not fall off by shaking.

(a)



(b)

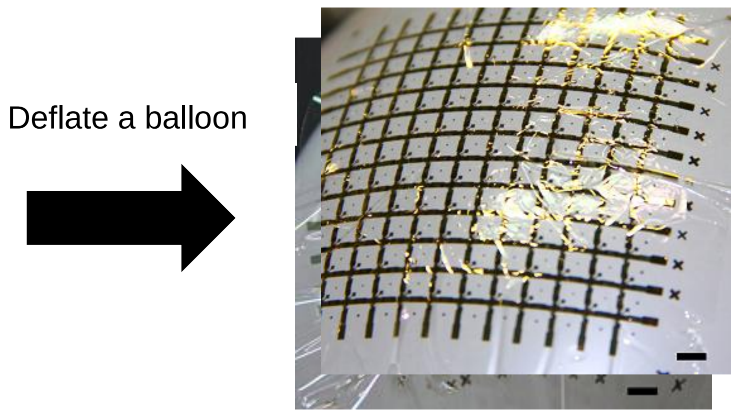


Image 2 New Sheet-type Sensor

Sheet-type sensors are made by forming an adhesive gel pattern only on the electrodes after an organic transistor integrated circuit is made on an extremely thin polymeric film. The sensors did not break even after they were affixed to a balloon and 100% compression was applied.

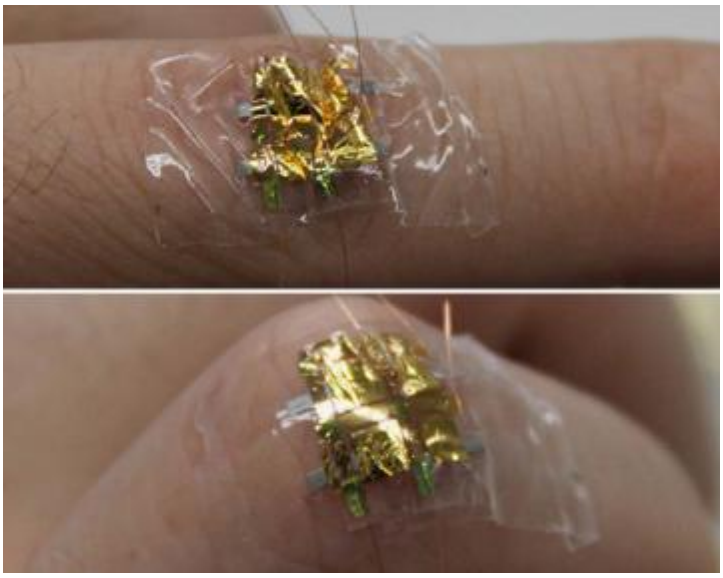


Image 3　Strain sensor applied to a human finger

The strain sensor is thin and flexible and can be comfortably applied to a finger. It will not peel off or break even if great stress such as finger movement is applied.

＜Explanation of Terminology＞

Note 1) Big Data

A large aggregate of information data. The meaning includes technology for collection, analysis and visualization of the data.

Note 2) Internet of Things: IoT

A structure in which a variety of things are connected to the Internet. Everything is digitized and made increasingly smart by connection to the Internet.

Note 3) Wearable Devices

A device worn on the body that can be easily carried around. Wristwatch and eyeglass-type wearable devices are starting to become popular.

Note 4) Organic Transistors

An electronic switch using an organic semiconductor on a transistor channel layer. Since this can be easily made on top of polymeric film by a low temperature process, it has lightweight, thin and easily bendable characteristics.

Note 5) Polyethylene Terephthalate

A type of macromolecule polyester. It is widely used as a base material for such things as plastic drinking containers and magnetic tape.

Note 6) Polyrotaxane

A macromolecule made by linking molecules with a structure in which shaft-shaped molecules pierce holes in ring shaped molecules. There is progress in their application to such things as automobile paint and artificial muscle.

Note 7) Polyvinyl Alcohol（PVA）

A type of plastic showing hydrophilicity in order to have a hydroxy group. It is widely used as such things as adhesives and surfactants.

＜Paper＞

“A strain-absorbing design for tissue–machine interfaces using a tunable adhesive gel”, Nature Communications, December 2014, DOI: 10.1038/ncomms6898

＜Contact Information＞

Regarding this research:

Dr. Takao Someya, Professor
Department of Electrical Engineering and Information Systems
The University of Tokyo
7-3-1 Hongo, Bunkyo-ku, Tokyo 113-8656, Japan
URL：http://www.ntech.t.u-tokyo.ac.jp/

Regarding the JST project:

Tsuyoshi Nakamura
Research Project Group, Tokyo Headquarters
The Japan Science and Technology Agency (JST)
Tokyo Headquarters K’s Gobancho
7 Gobancho, Chiyoda-ku, Tokyo 102-0076, Japan