First fully integrated flexible electronics made of magnetic sensors and organic circuits

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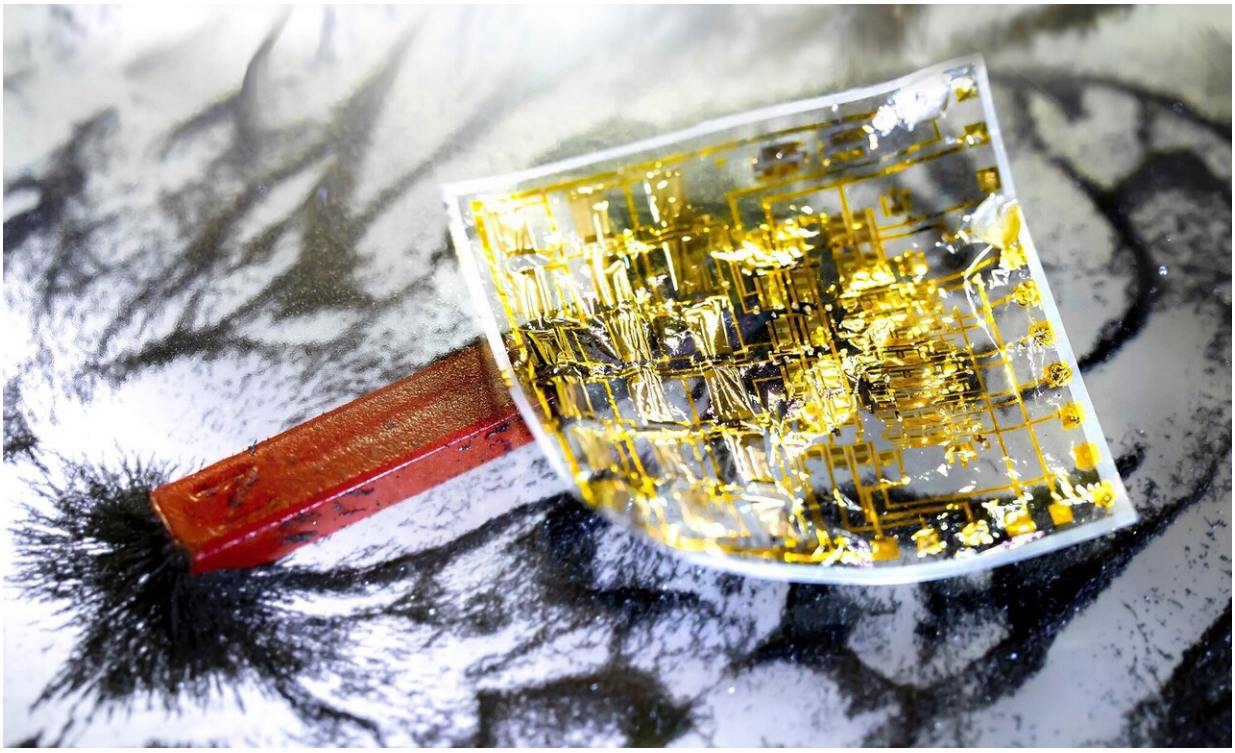

Flexible electronic skin equipped with an array of giant magneto resistance sensors and complex electronics circuit designed and developed for sensing distribution of magnetic field. Credit: Masaya Kondo

Human skin is a fascinating multifunctional organ with unique properties

originating from its flexible and compliant nature. It allows for interfacing with external physical environment through numerous receptors interconnected with the nervous system. Scientists have been trying to transfer these features to artificial skin for a long time, aiming at robotic applications.

Robotic systems heavily rely on electronic and magnetic field sensing functionalities required for positioning and orientation in space. Much research has been devoted to implementation of these functionalities in a flexible, compliant form. Recent advancements in flexible sensors and organic electronics have provided important prerequisites. These devices can operate on soft and elastic surfaces, whereas sensors perceive various physical properties and transmit them via readout circuits.

To closely replicate natural skin, it is necessary to interconnect a large number of individual sensors. This challenging task became a major obstacle in realizing electronic skin. First demonstrations were based on an array of individual sensors addressed separately, which unavoidably resulted in a tremendous number of electronic connections. In order to reduce the necessary wiring, important technology had to be developed—namely, complex electronic circuits, current sources and switches had to be combined with individual magnetic sensors to achieve fully integrated devices.

Researchers from Dresden, Chemnitz and Osaka have now presented a pioneering active matrix magnetic sensor system in a recent article published in *Science Advances*. The sensor system consists of a 2 x 4 array of magnetic sensors, an organic bootstrap shift register required for controlling the sensor matrix, and organic signal amplifiers. All electronic components are based on organic thin-film transistors and are integrated within a single platform.

The researchers have demonstrated the system's high magnetic

sensitivity, and it can acquire the two-dimensional magnetic field distribution in real time. It is also very robust against mechanical deformation, such as bending, creasing or kinking. In addition to full system integration, the use of organic bootstrap shift registers is a very important development step toward active-matrix electronic skin for robotic and wearable applications.

Prof. Dr. Oliver G. Schmidt, director at the Leibniz Institute for Solid State and Materials Research Dresden, says, "Our first integrated magnetic functionalities prove that thin-film flexible magnetic sensors can be integrated within complex organic circuits. The ultra-compliant and flexible nature of these devices is an indispensable feature for modern and future applications such as soft robotics, implants and prosthetics. The next step is to increase the number of sensors per surface area as well as to expand the electronic skin to fit larger surfaces."

More information: Imperceptible magnetic sensor matrix system integrated with organic driver and amplifier circuits. *Science Advances* (2020). DOI: 10.1126/sciadv.aay6094

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