Next generation healthcare, Agriculture IoT, Construction tech

# Research on creation of ultra-flexible and highly transparent electronics

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## Abstract

We create multifunctional advanced materials by designing nano- and micro-materials to construct novel electronic devices and to explore the mechanisms of device characteristics. In addition, flexible electronics that is integrated and packaged with the novel electronic devices is studied and applied to solve issues in social communities. We are actively promoting interdisciplinary research to create completely new values and electronics systems, and to unravel the mechanisms that cause the transformation in social system (health care for people/agriculture/infrastructure fields, etc.). We are challenging to develop a wide range of applications from electronics packaging of advanced materials to their implementation in society.

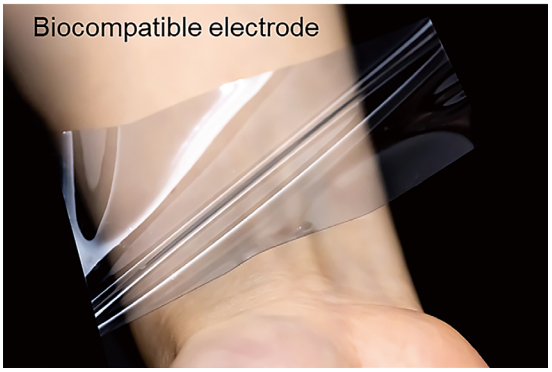
## Background & Results

In recent years, stress-related diseases are estimated to affect more than 4 million people in Japan, and wearable sensor technology to quantify stress in daily life is in high demand. To realize imperceptible sensors, this research field has developed thin-film, stretchable, transparent conductors that can wirelessly measure low-noise potential signals (approximately 0.1 uV) equivalent to those of medical materials by utilizing biosafety conductor materials. One of the key materials, a bio-dry electrode, is composed of an elastomer and a conductive polymer, which form a nano- to micrometer-sized phase-separated structure in the material. Furthermore, by using an inorganic (metallic) material consisting of Ag/Au core-shell nanowires, which are invisible to the naked eye, as the wiring material, we have constructed highly conductive and transparent stretchable wiring. The transparent sensor sheet, which is composed of a bio-dry electrode and a stretchable wiring layer, exhibits high electrical conductivity, making it an important probe for low-noise potential measurement equivalent to that of medical materials (Fig. 1). We have also developed a new technology for low-damage multilayer patterning of metallic and organic nanomaterials described above, and developed "thin-film, flexible, and transparent electrochemical transistors" (Fig. 2).

On the other hand, we have succeeded in on-site measurement of aqueous solution concentration using only a simple process of attaching a sensor sheet (Fig. 3). By focusing on the broadband infrared radiation emitted from the liquid solvent itself and its local absorption by the substance, a sample-less and label-free liquid quality measurement has become possible. This liquid quality measurement uses a highly sensitive, broadband, and stretchable thin-film optical sensor sheet newly developed by our research group. The sheet can be attached to soft materials such as plants, vinyl chloride pipes, serpentine pipes, and rubber tubes, and can stably follow the expansion, contraction, bending, and other deformations of the pipes caused by liquid flow. The results of this research, which demonstrate a fundamental technology that contributes to ubiquitous water quality testing, are expected to contribute to the construction of safety nets for infrastructure and agriculture in the future.

## Significance of the research and Future perspective

Through our research and development of multifunctional and high-performance printed circuit boards required for flexible hybrid electronics (FHE), we carry out research on their application to healthcare sensor systems for the human/agriculture/infrastructure fields. In particular, we focus on the construction of thin-film, flexible, and transparent sheet-type sensors by integrating stretchable conductor materials, mainly organic and inorganic nano-materials, into organic devices. By developing electronic devices that are as flexible as human skin and as transparent as water, and that can be clearly observed even by non-experts, a fundamental technology is being created for next-generation personal sensors that can seamlessly fit into our daily lives.

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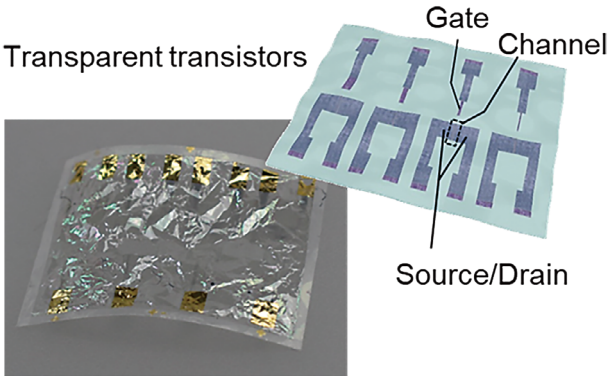


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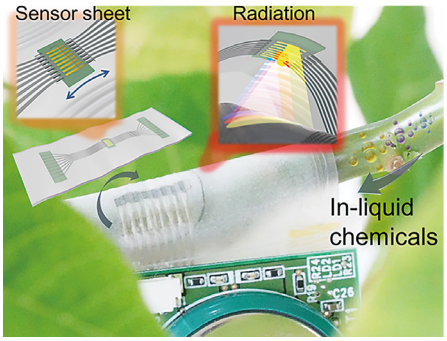


Fig. 3 (Copyright permission from Sci. Adv.)

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| Keyword | nano & micro materials, flexible electronics packaging, sensors & systems |