Thin-Film Device Laboratory（2024）
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(0) Research fields

CPR Subcommittee**:** Engineering
Keywords: Organic electronics, Organic photovoltaics, Flexible electronics, Stretchable electronics, Next-generation wearable electronics

(1) Long-term goal of laboratory and research background

In recent years, skin-attachable sensors have gained attention as next-generation wearable devices, as they enable high-precision acquisition of biological signals while minimizing the burden of wearing them in daily life. Ensuring water resistance is essential for maintaining stable operation under various environmental conditions. At the same time, thin and flexible sensors are required to improve skin conformity and signal accuracy; however, such structures necessitate thinner encapsulation layers, which compromises their barrier properties against water. Therefore, it is crucial to develop technologies that enhance water resistance without relying on increased film thickness to achieve both water resistance and high flexibility.

(2) Current research activities (FY2024) and plan

Ultrathin organic optical sensors with water resistance and ultra-flexibility for biophysical signal acquisition underwater

A hybrid structure combining an adhesive elastomer with donor/acceptor organic semiconductors was introduced into the active layer, providing strong interfacial adhesion and mechanical stability at both interfaces. This design ensured water resistance and mechanical durability under repeated compression and stretching. By suppressing the dark current while maintaining excellent charge transport properties, the device achieved a high detectivity (D*) of 6.2×10^{11} Jones. Comparable levels of water resistance and performance were also confirmed when using different organic active materials. Notably, stable pulse wave signals were obtained even after immersing the device attached to the skin in water for five hours. We expect this technology facilitates skin-attachable photonic devices as next-generation wearable sensors capable of operating under humid conditions such as bathing or excessive sweating.

Future plan,

1) Large-area fabrication of organic optical devices will be pursued. Optimization of layer deposition processes and device structures will be carried out.

2) High operational stability under light illumination will be addressed. Through improvements in interface design and the introduction of filter layers that suppress ultraviolet components, enhanced operational stability under prolonged light exposure will be achieved.

Fig.1 Photograph of organic optical sensor attached to the finger

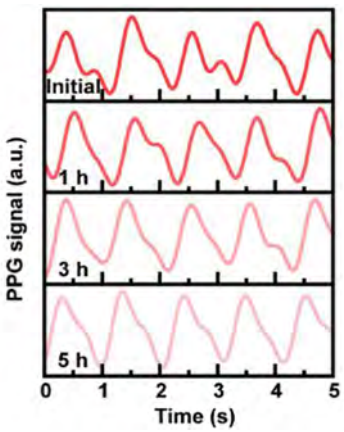

Fig.2 Pulse signals achieved underwater.

(3) Members

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(4) Representative research achievements

1. Kenjiro Fukuda, Lulu Sun, Baocai Du, Masahito Takakuwa, Jiachen Wang, Takao Someya, Lluis F Marsal, Yinhua Zhou, Yiwang Chen, Hongzheng Chen, S Ravi P Silva, Derya Baran, Luigi A Castriotta, Thomas M Brown, Changduk Yang, Weiwei Li, Anita WY Ho-Baillie, Thomas Österberg, Nitin P Padture, Karen Forberich, Christoph J Brabec, Osbel Almora, "A bending test protocol for characterizing the mechanical performance of flexible photovoltaics", *Nat. Energy* **9**, 1335 (2024).
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Supplementary

Laboratory Homepage
https://rikensomeya.riken.jp/index.html
https://rikensomeya.riken.jp/index_en.html