

Soft Bio-integrated Sensors for Skin-Based Wearable Devices

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Standard wrist-based and chest-strapped wearable health monitoring devices have the potential to capture movement, activity and electrophysiological data from patients in the home setting. However, these devices contain conventional electronics, which consist of bulky and packaged components, which typically do not bend, stretch or conform to the curvilinear shapes of the human body. These limitations pose a serious challenge for patients with cardiac or movement disorders, which require continuous tracking of health symptoms to monitor compliance or efficacy of drug regimens. Devices that achieve intimate mechanical coupling with the body may thus help to prevent medical problems in high-risk neurological and cardiac diseases.

Here we describe new mechanical and electrical design strategies for wearable devices with physical properties that approach that of soft biological tissue. These ‘epidermal electronics’ have enabled emerging stretchable wearable systems that can monitor motion, physiology and electrophysiological activity in the hospital and home settings. The sensors (i.e. electrodes, temperature sensors, gyroscope and accelerometers) and associated circuitry (i.e. microcontroller, memory, voltage regulators, rechargeable battery, wireless communication modules) and spring-like interconnects are all contained as embedded components within an ultrathin, stretchable elastomeric substrate. Quantitative analyses of systems mechanics during cyclical exposure to stress illustrates the ability of the epidermal electronics to mechanically couple with soft tissues, in a way that is mechanically invisible to the user. These results highlight the soft and stretchable form factor achieved and multimodal sensing, which is ideally suited for monitoring physiological signals from different regions of the body in patients.

These wearable systems may provide quantitative feedback to patients and physicians in a continuous manner, with implications for clinical trials and home monitoring as a powerful alternative to self-reporting and qualitative clinical assessments.