Soft, Stretchable Bioelectronics

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The microelectronics and telecommunications industries have driven important functionality advances across many medical devices, including cochlear implants, pacemakers, catheters and wearable health monitoring devices (e.g. Holter monitors). However, the large size, planar geometry and rigid form factor of standard packaged electronics give rise to important bio-interface challenges for skin coupled and implantable devices. Stretchable and flexible biointegrated electronics overcome many of these limitations of existing medical systems by virtue of dramatic improvements in stretchability and ultrathin form factor, while maintaining high charge mobility and electrical current density. Several studies have reported recent developments in wearable sensors that can be attached on skin for epidermal physiological measurements (skin hydration, temperature, heart rate, and Galvanic skin response). However many of these sensors still rely on tethered electrical connections for data transfer and signal processing. Wired connections along with bulky associated electronics together preclude the adoption of wearable health monitoring systems during normal daily activities and tracking of patients in the home setting.

Here, we present novel mechanics, materials and system integration strategies for a new class of skin-based systems that incorporate physiological and bio-chemical sensors, systems on chip modules, Bluetooth communication, flash memory, and a rechargeable battery configured in stretchable formats at the system level. Quantitative analyses of electromechanical performance and wireless data transmission under mechanical stress highlight the clinical utility of these systems in tracking patients with movement disorders and heart disease. As demonstrations of this technology, we present representative examples of bio-integrated systems that highlight functionality and performance coupled with extreme mechanical flexibility.

These examples demonstrate the capabilities of soft epidermal systems to perform continuous, high fidelity monitoring of motion and electrophysiological signals. These systems have the potential to limit discomfort to the patient and improve compliance, thus enabling new classes of biosensors and electronics for use in the home environment.