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Emerging Soft Bioelectronics

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Bioelectronics can transduce signals across the tissue and device interface to measure and regulate biological activities for healthcare monitoring and diseases treatment. Currently, a variety of bioelectronic devices are widely used, such as glucose sensors, cardiac pacemakers, and electrocorticalgrams. However, due to the diverse mechanical strains and complex biofluids within the body, conventional rigid electronics cannot effectively meet the requirements of long-term comfort, precision, and stability. Over the last few years, there has been growing interest in flexible and stretchable bioelectronics in the form of wearable textiles, attachable to skin and implantable inside the body, that aim to comply with nonplanar and dynamic tissues. It is thus our great pleasure to organize this special issue on bioelectronics for *Advanced Functional Materials*. We here highlight materials, structures, functions, and interfaces for soft bioelectronics with a collection of 6 reviews, 1 progress report, and 11 articles from this exciting field.

Traditional electronic devices are typically rigid, planar, dry, and static, while biological tissues are soft, curvilinear, ionic, and dynamic, so new materials should be designed to reduce these differences to establish effective and reliable interfaces. Pooi See Lee and co-workers (article number 1907184), Xiaodong Chen and co-workers (article number 1909540), and Moumita Kotal and Ilkwon Oh and co-workers (article number 1910326) discuss the basic requirements and material designs for both epidermal and implantable bioelectronic interfaces, ranging from metallic and carbonaceous nanomaterials, to conductive polymers and hydrogels. The challenges involving long-term stability of the bioelectronics in vivo are also addressed. Besides materials, device structures and implementation techniques are widely studied to reduce tissue damage and provide long-term signal stability, and the main advances and representative examples are carefully highlighted by Fei Pei and Bozhi Tian (article number 1906210) and Kyung-In Jang and Taeyoon Lee and co-workers (article number 1910026).

Sensors are one type of the most explored bioelectronic devices. For tactile sensors, Darren J. Lipomi and co-workers (article number 1906850) report the development of stimuli-responsive organic materials for haptic devices. Zhenan Bao and co-workers (article number 1903100) present an effective method for tunable, consistent, and reproducible capacitive pressure sensors by using a pyramid microstructured design.

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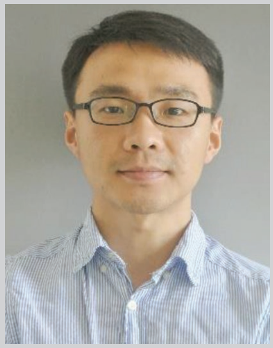

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Huisheng Peng and co-workers (article number 1902971) demonstrate a compression-sensing supercapacitor based on gradually crosslinking carbon nanotube arrays. Seung Hwan Ko and co-workers (article number 1909171) show a stretchable thermo-haptic device for the re-construction of artificial thermal sensation in virtual reality. Wei Gao and co-workers (article number 1906713) review the advancements of portable and wearable bioaffinity sensors involving material screening, sensing mechanisms, and system-level integration technologies. Dion Khodagholy and co-workers (article number 1909165) review organic electronic devices for high-resolution electrocorticography of the human brain.

Bioresorbable devices that can biodegrade or dissolve on demand are also emerging to eliminate the removal process of implantable devices. Xian Huang and co-workers (article number 1905024) present a room-temperature spontaneous sintering method by using bioresorbable inks that contain zinc nanoparticles and anhydride. Peiyi Wu and co-workers (article number 1908018) have designed edible, renewable, and reconfigurable skin-like iontronic devices though the use of traditional dough. Tae-Il Kim and co-workers (article number 1909707) report biocompatible and biodegradable organic transistors by using solid-state electrolyte.

On-body power-supply devices are necessary for various bioelectronic facilities and have been also extensively studied in the recent decade. To meet the requirements of both high safety and flexibility in biomedical applications, Ye Zhang and co-workers (article number 2000077) highlight gel electrolytes for energy-storing devices to guide the future design of high-performance devices. Joseph Wang and co-workers (article number 1906243) review the recent progress on wearable biofuel cells for bioenergy harvesting and self-powering biosensors. It helps to understand the mechanisms of biofuel cells and enzyme immobilization techniques to realize efficient and stable bioenergy harvesting. Takeo Miyake and co-workers (article number 1906225) report a bioabsorbable metal-air primary battery for smart contact lenses, where a Zn loop serves simultaneously as the anode and antenna for wireless power transfer, providing a multifunctional direct current and/or alternating current output. Besides high flexibility, Soonmin Seo, Qijun Sun, and co-workers (article number 1909652) further demonstrate the importance of the development of stretchable power-supply devices.

In general, wearable electronics has been studied with various functions, especially biochemical sensing based on sweat and power source. However, most functions are still rare for implantable devices. Materials and devices should be further designed to ensure stability inside the body to efficiently sense biochemicals and harvest bioenergy. Besides, more attention should be focused on material screening and device design aimed at repeatability and dependability for real applications. Finally, bioelectronics is interdisciplinary, involving material science, chemistry, physics, microelectronics, biomedicine, and neuroscience, and thus its development relies on the combined effort from all of the above fields.

We really appreciate the work of all authors and their significant contributions to this special issue. We also greatly thank Dr. Irem Bayindir-Buchhalter for her strong editorial support. She is enthusiastic, careful, and warm-hearted, and we are so happy to have worked with her to organize the issue. We sincerely hope that this special issue will help the readers of *Advanced Functional Materials* to gain new knowledge and generate new ideas in the field of bioelectronics.

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