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Flexible Printed Arrays and Their Use in Wearable Medical Devices

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Fabrication of wearable medical sensors heavily relies on conventional semiconductor vacuum processing. We have adopted the unique manufacturing capabilities of printed electronics and designed wearable medical devices that are soft, lightweight, and skin-like. These soft and conformable sensors significantly improve the signal-to-noise ratio (SNR) by establishing a high-fidelity sensor-skin interface. Over the past 8 years we have used different printing techniques for fabricating wearable medical sensors in two sensing modalities: bioelectronic and biophotonic. In bioelectronic sensing, we have designed and fabricated flexible and inkjet-printed gold electrode arrays which were implemented in a smart bandage for early-detection of pressure ulcers. Recently, the efficacy of the electrodes is demonstrated on conformal surfaces and on the skin to record electrocardiography (ECG) and electromyography (EMG) signals. Hybrid systems that combine flexible sensors with rigid computational components on a separate substrate provide a real-time analysis of physiological signals, with the implementation of machine-learning models for signal processing. In biophotonic sensing, we have demonstrated a flexible and printed sensor array composed of organic light-emitting diodes and organic photodiodes, which senses reflected light from tissue to determine the oxygen saturation. We use the reflectance oximeter array beyond the conventional sensing locations. The sensor is implemented to measure oxygen saturation on the forehead with 1.1% mean error and to create 2D oxygenation maps of adult forearms under pressure-cuff–induced ischemia. In addition, we present mathematical models to determine oxygenation in the presence and absence of a pulsatile arterial blood signal.