Biodegradable and Skin-Conformal Graphene-Based Sensor for Health Monitoring and Human-Machine Interaction

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Abstract

With the development of electronic information technology as well as the arrival of Big Data Era, wearable technology for health monitoring, medical testing and human-machine interaction is also ushering in a new era. Herein, a facile double-transfer technique is applied to fabricate sensors by utilizing nontoxic water-soluble polymer PVA as the substrate and graphene as the active materials, which exhibit conformal contact with skin, stretchable and biodegradable. These sensors have potential in many fields including human vital signals monitoring and human-machine interaction.

The traditional electrode (such as Ag/AgCl electrode) has a couple of disadvantages such as high cost, material waste and heavy metal pollution. Hence, a flexible, biodegradable ECG electrode is designed and fabricated as shown in Figure 1 a,b. The Young's modulus of this flexible sensor is 8.598MPa, and the maximum strain variable is 135%. The resistance fluctuates little when the strain is less than 20%. With the employment of this ECG electrode, the signal processing circuit and a smart phone, the measurement and display of ECG signal in real time is achieved (Figure 1 c,d).

Moreover, these characteristics are also leveraged for monitoring other human vital signals including vocal cords movement, jugular venous pulses (JVPs) and radial artery waves as shown in Figure 1 d,e. Furthermore, this high sensitivity (gauge factor: ≈502) and fast response (≈54 ms) sensor can be implemented in human-machine interaction (Figure 1 f,g). Due to the intrinsic nature of the substrate, this flexible sensor can be disposed by simply spraying deionized (DI) water on the sensors as displayed in a series of photographs in Figure 5 h. The whole sensor disposed completely after 150s. In addition, the dissolution rate can be tailored by changing the water temperature and the thickness of the substrate.

These characteristics including ultra skin-conformal, biodegradable and stretchable make this sensor an effective potential candidate for application in future wearable electronics.

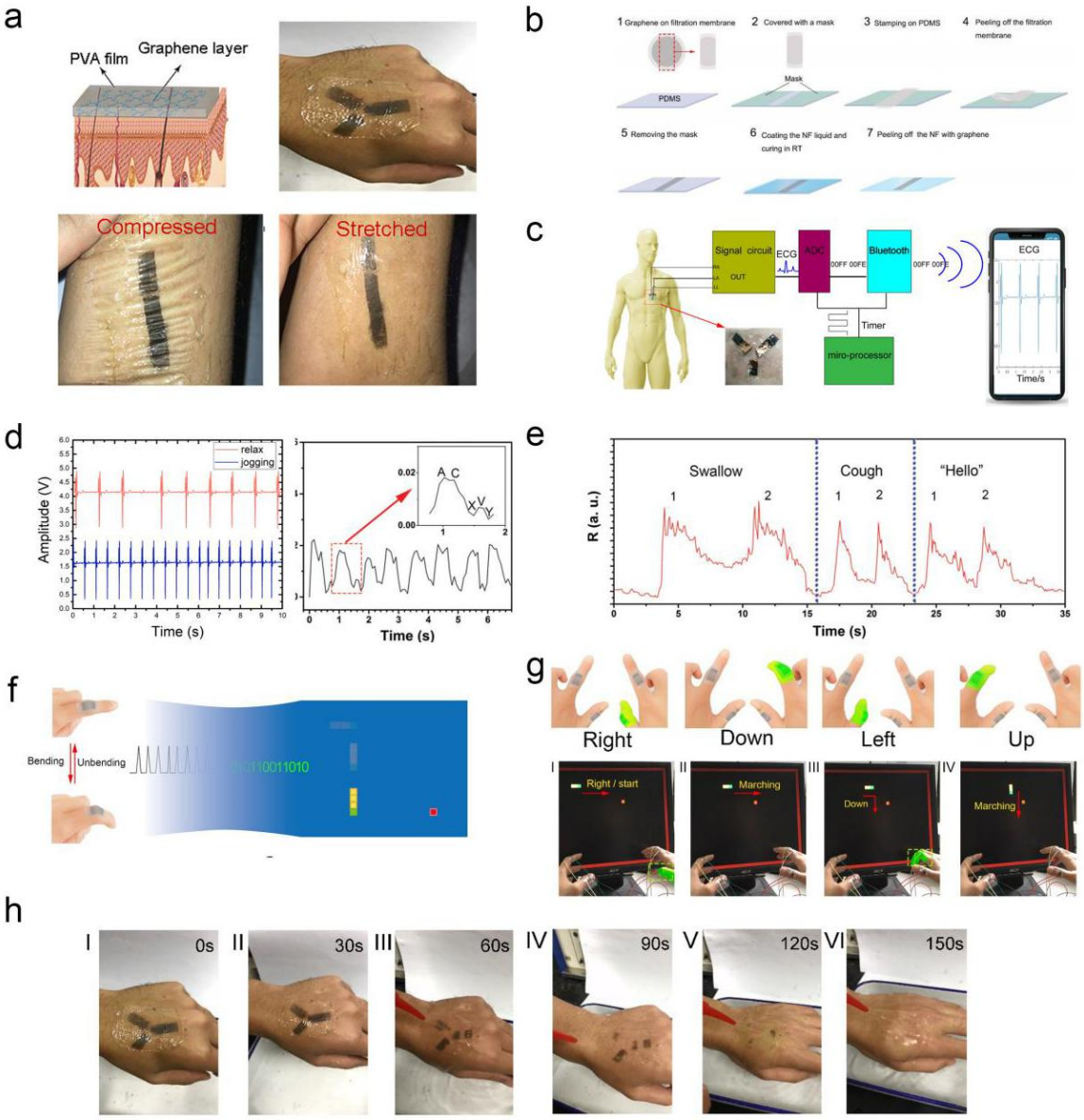

Figure 1: Fabricated graphene-based sensor and its applications. (a) The schematic and photograph of the flexible graphene-based sensor. (b) The schematic of double transfer method (c) Schematic illustration of the ECG measurement system. (d) ECG measurement under different conditions (left) and detection of waveforms corresponding to JVPs (right). (e) The resistive responses of different throat movements. (f) Schematic illustration of human-machine interaction and (g) the set of commands consisting of bending different fingers for controlling the movement of the bar. (h) The disposing processing of the biodegradable sensor, the whole sensor disposed completely after 150s by spray DI water on the sensor.

References

[1] Wan S.; Zhu Z.; Yin K.: A Highly Skin-Conformal and Biodegradable Graphene-Based Strain Sensor. Small Methods, Vol. 2, No. 10, 2018.