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Commentary

Short Commentary on the Research of Wearable Self-powered Sensor for Limb Sensing or Posture Monitoring

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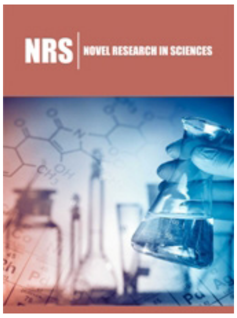

Chengyu Li*

PhD student in Condensed Matter Physics, University of Chinese Academy of Sciences, China

***Corresponding author:** Chengyu Li, PhD student in Condensed Matter Physics, University of Chinese Academy of Sciences, Beijing, China

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Introduction

With the increasing social pressure, a growing number of staff members and students keep a bad posture for a long time. Maintaining such awkward positions continuously often leads to spinal diseases and fatigue for their body. The application of wearable technology can realize the early monitoring and intervention treatment of posture abnormality. Human motions not only provide biomechanical energy, but contain abundant movement information. If the biomechanical energy of limb movement can be effectively collected, and combined with wearable electronics, it is expected to realize active sensing of joint and spinal bending. Fortunately, the self-powered technology based on Triboelectric Nanogenerator (TENG) provides an effective solution to address these problems. Here, we comment, summarize and look forward to the research work about the sensing of limb and spinal joints based on the technology of triboelectric nanogenerator, and describe the potential applications of this innovative study.

Commentary

Recently, based on the grating-structured freestanding mode TENG, a retractable, wearable and self-powered sensor with high precision, high durability and low hysteresis is demonstrated via the processing technology of Flexible Circuit Board (FPCB) and mature 3D printing technology [1,2]. By collecting the biomechanical energy of joint human activities and converting it into electrical signals, it realizes active sensing of limbs and dynamic monitoring of the posture [3]. The rational and efficient utilization of the active, retractable, wearable and self-powered biomechanical sensor based on TENG opens up a new perspective for the field of wearable medical and healthcare, and has great practical significance for promoting the development of wearable electronic technology and human life [4,5].

After the theoretical study on the operation principle and performance characterization of the sensor, the main research contents of this work can be described as follows: (1) The principle, output voltage and a minimum resolution of TENG-based sliding grid structure sensor are studied theoretically. The output characteristics of the sensor with different electrode widths of 0.3, 0.5, 0.7 and 0.9mm are simulated, indicating that the sensor with a wider electrode width has a higher output voltage under the condition of the gap between adjacent electrodes remains unchanged. After the optimized design, the encapsulated sensor exhibiting a high sensitivity of 8 Vmm^{-1}, a minimum resolution of 0.6mm, and excellent robustness (over 120-thousand stretching cycles). (2) The tensile stability test of the device fixed on the optical platform and spinal body surface, the characterization test of electrical performance under different temperature and humidity, and the detection of displacement variation, the above measurement results show that the device has strong anti-environmental interference ability and suitable wearability. Additionally, the peak counting algorithm and semi-digital measurement method are employed to achieve high resolution sensing and optimize the capability of anti-jamming. (3) After measurement and analysis of the subjects' limb activities, demonstrate its capability to sense the motions of the joints in real-time, e.g., wrist, elbow, knee joint, ankle. Through the integration of a potentiometer with high precision and high linearity, the vector posture monitoring system was constructed and the dynamic monitoring of spine curvature was realized. Spinal test results over on tens of participants and full-body joints confirm the effectiveness and feasibility of the developed posture monitoring system.

In summary, a wearable self-powered sensor and system with simple structure, lightweight and similar to badge reel were developed. Applying it to the sensing of joints and the monitoring of the spine will help patients' limb rehabilitation training, and simultaneously reduce the risk of spine diseases caused by long-term bad postures.

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