2D MXene Heterojunctions for Real-Time Wearable Health Monitoring

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Abstract

The rapid evolution of wearable medical technologies is increasingly driven by the growing demand for real-time, non-invasive health monitoring in home healthcare applications [1]. Photoplethysmography (PPG)-based biosensing has emerged as a cornerstone for tracking vital physiological parameters such as heart rate, blood oxygen saturation, and arterial stiffness. However, Conventional PPG sensors require high-intensity LEDs, causing high power, frequent recharging, and higher costs, limiting wearable biosensors adoption [2, 3].

Addressing these limitations necessitates the development of energy-efficient, self-powered sensors with enhanced sensitivity and low-noise performance. Here, an advanced class of flexible van der Waals heterojunction (vdWH) photosensor is introduced, leveraging a 2D/1D $Ti_3C_2T_x$ MXene/SbSI heterostructure. The strong built-in electric field at the vdWH interface facilitates efficient photocarrier separation (Fig. 1a), significantly improving responsivity while suppressing noise current. Optimized light–matter interactions further contribute to ultrafast response times, high sensitivity, detectivity and quantum efficiency, enabling the reliable detection of weak optical signals in low-light conditions (Fig. 1b). Moreover, the mechanical flexibility of the device ensures stable operation under diverse power densities, making it ideally suited for wearable applications (Fig. 1c). Seamless integration of this self-powered photosensor into next-generation wearable health monitoring systems enables continuous, real-time biosignal acquisition without external power sources, substantially enhancing user comfort and device longevity (Fig. 2). This innovation establishes a new paradigm for flexible optoelectronics, offering a scalable, cost-effective, and energy-efficient solution for autonomous healthcare monitoring, biomedical diagnostics, and human–machine interfaces.

References

[1] Ghorpade, U.V., et al., Chem. Rev. 2023, 123, (1), 327-378. [2] Du, Z., et al., Adv. Mater. 2024, 36, (9) 2310478. [3] Kim, J., et al., Adv. Funct. Mater. 2017, 27, (1), 1604373.

Figures

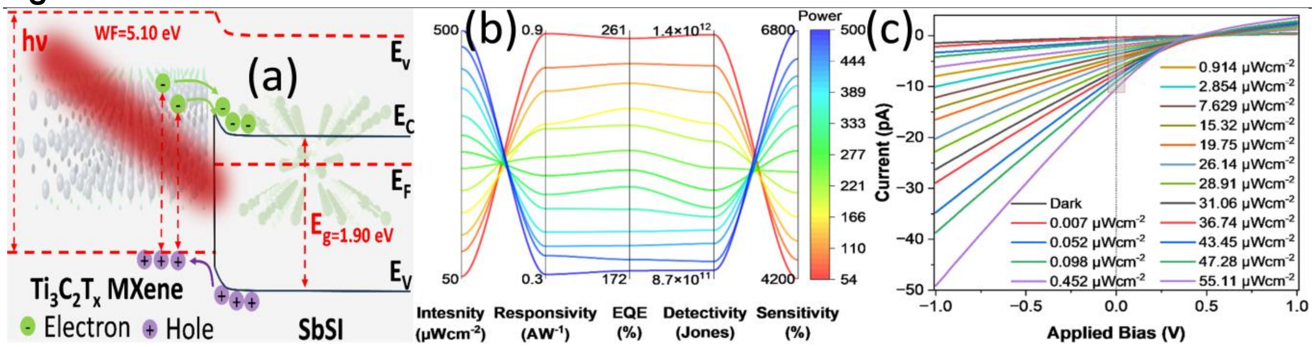

Figure 1: (a) Energy band alignment (b) Performance parameters variation. (c) I-V curves of sensor.

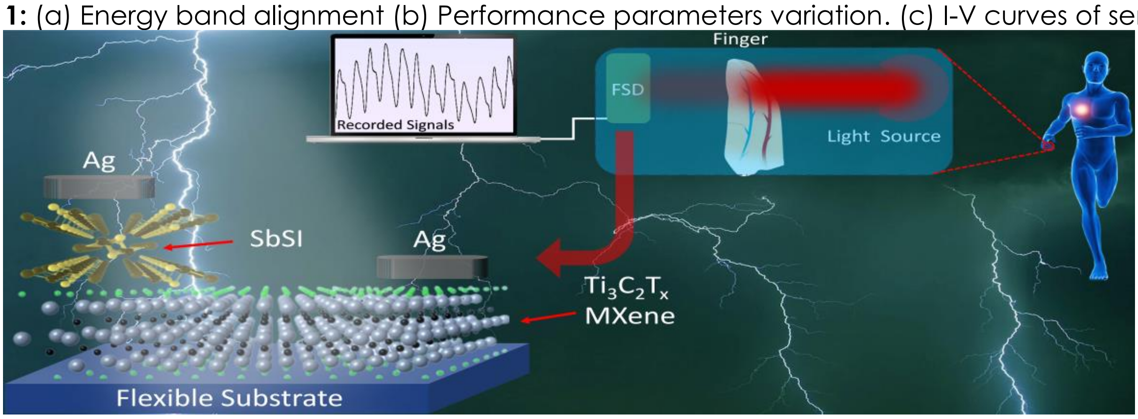

Figure 2: 2D/1D MXene/SbSI Heterojunction wearable flexible sensor working model and schematic.