Supplementary Material

Wearable self-driven (In,Ga)N sensor for biosensing application

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Section S1: Supplementary Notes

Preparation of (In,Ga)N film

In Fig. 1a, the GaN-based epitaxial structure on a Si substrate was achieved using metal-organic chemical vapor deposition (MOCVD). Along the growth direction, the epitaxial structures included an AlN nucleation layer (~330 nm), an (Al,Ga)N multilayer buffer layer (~600 nm), an undoped GaN layer (~800 nm) and a Si-doped n-GaN layer (~2,800 nm, [Si] ≈ 8×10^{18} cm^{-3}). These were followed by a 9-cycle (In,Ga)N/GaN (3/10 nm) multiple quantum well (MQW), an Mg-doped p-(Al,Ga)N ~30 nm electron barrier layer (EBL) ([Mg]≈1×10^{20} cm^{-3}), an Mg-doped p-GaN layer (~60 nm, [Mg] ≈ 3×10^{19} cm^{-3}), heavily Mg-doped p-GaN contact layer (~20 nm, [Mg] ≈ 2×10^{20} cm^{-3}).

Characterization and Measurement Methods

To assess the photoelectric response, measurements of the properties were conducted utilizing a semiconductor parameter analyzer (Agilent B1500A). For the purpose of detection, a light-emitting diode (LED) served as the light source. The responsivity (R) of the sensor, being a crucial parameter, was derived using the given equation.

$$R = \frac{I_{\mathrm{ph}}}{S_{\mathrm{device}} \times P_{\mathrm{inc}}}. \quad \text{(S1)}$$

The effective area of the device (S_{device}) is 0.03 cm^2.The incident optical power density is denoted as P_{inc}, while I_{ph} represents the current in response to the optical input. The rise time (T_{rise}) is characterized as the duration during which the photocurrent increases from 10% to 90%, whereas the decay time (T_{fall}) refers to the period in which the photocurrent decreases from 90% to 10% of its peak. To characterize both the morphology and elemental distribution, we employed spherical aberration-corrected scanning transmission electron microscopy (AC-STEM, Talos F200X, FEI) alongside high-resolution energy dispersive x-ray (EDX) imaging techniques. The electrodes of the devices protected with high temperature tape were exposed. An appropriate amount of liquid was placed on the electrodes with a pipette gun and the relevant tests were performed using an EC workstation.

Section S2: Supplementary Figures

The experimental data in Figure S1a can be fitted with the following equation:

$$I = 3.8693 \times 10^{-9} + 1.43401 \times 10^{-10} C - 3.09334 \times 10^{-13} C^2. \quad \text{(S2)}$$

I is the output current and C is the electrolyte concentration. The experimental data in Figure S1b are fitted by the following equation:

$$I = 2.96353 \times 10^{-8} + 1.61014 \times 10^{-10} V. \quad \text{(S3)}$$

V is the volume of artificial sweat.

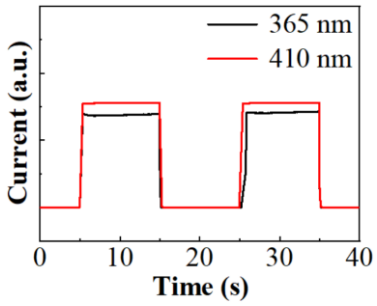

FIG. S1. Optical switching characteristics of the device irradiated at the same incident power density.

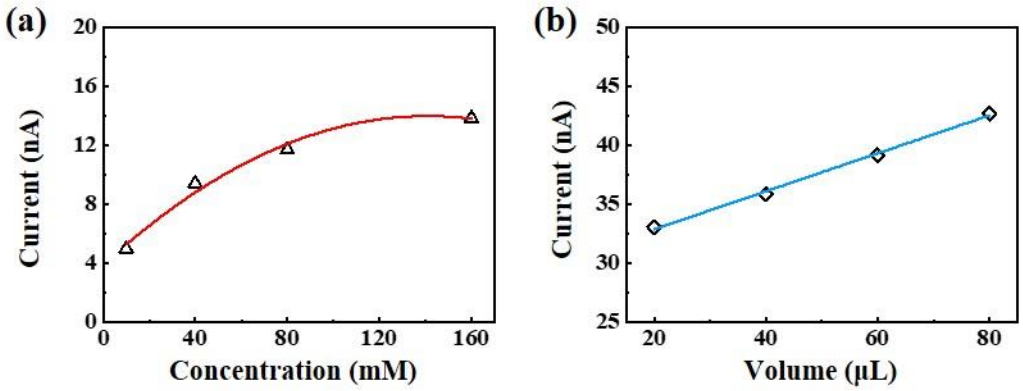

FIG. S2. Photocurrent densities of the sensor with different (a) concentrations (b) volumes of artificial sweat electrolyte.

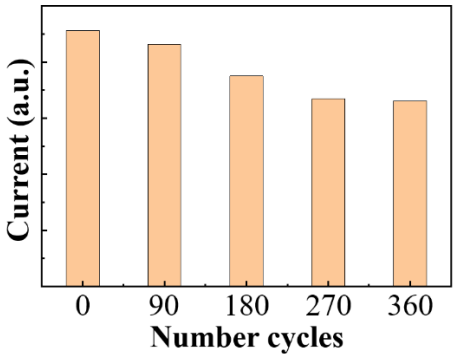

FIG. S3. Long-time stability testing of the sensor.

Conflict of Interest

The authors declare no competing financial interest.

Author Contributions

S.Y.H. and B.B.H. completed all experiments in device fabrication. S.Y.H. completed all device measurements and the corresponding data collections and analyses. Y.K.Z. conceived the idea. Y.K.Z., Y.L.H. and J.Y.Z. guided the work. S.Y.H., B.B.H. and J.Y.Z. completed the mechanism study. S.Y.H. and Y.K.Z. wrote the original draft of this work. Y.K.Z. and J.Y.Z. carried out the funding acquisition and project administration. Y.K.Z. carried out all MBE experiments. S.Y.H. and B.B.H. performed the investigation. All authors reviewed this manuscript.

Data Availability

The data that support the findings of this study are available from the corresponding authors upon reasonable request.