Organic–Inorganic Halide Perovskite-Based Diffusive Memristor and its Application in Artificial Nociceptor

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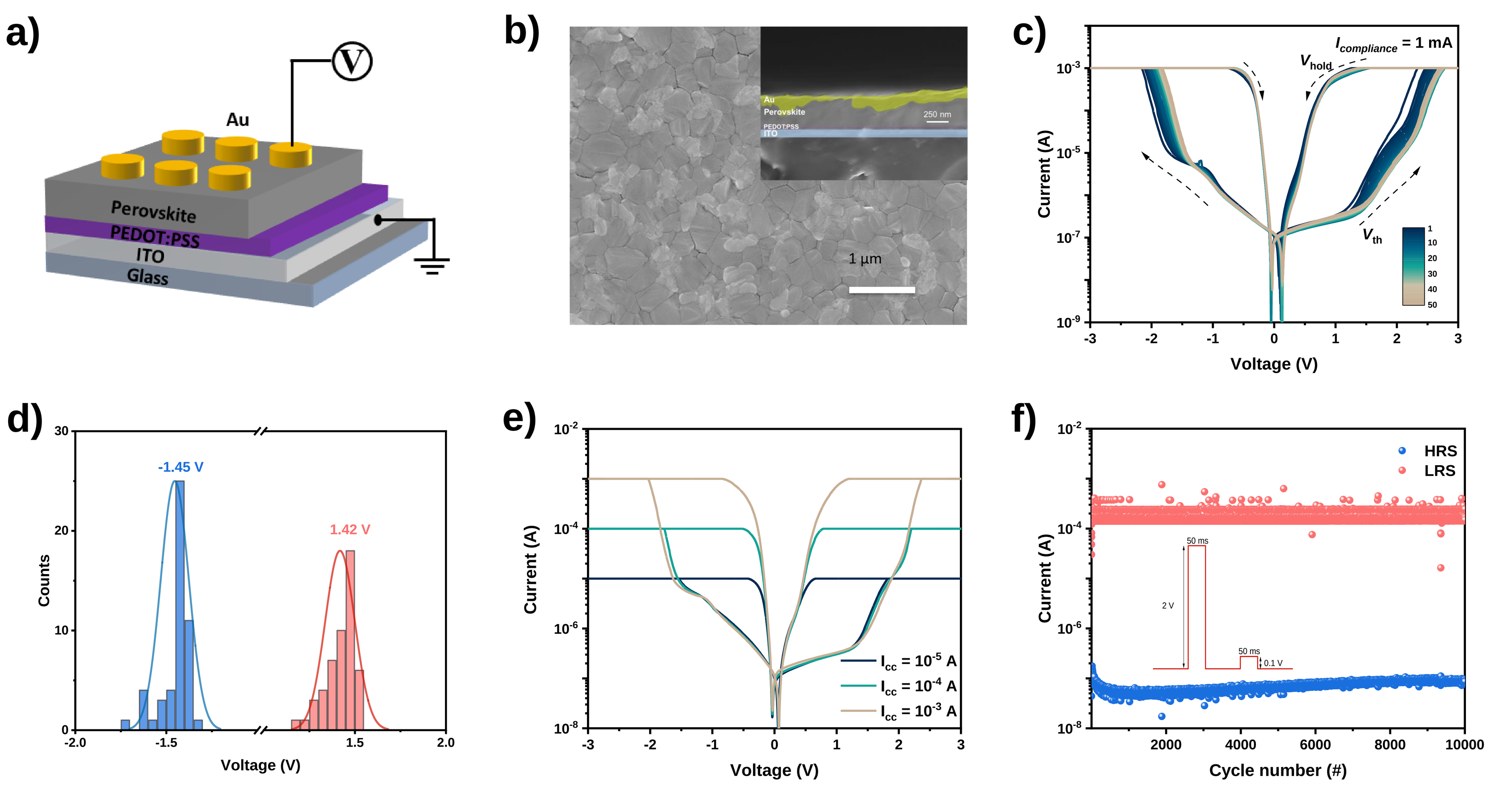
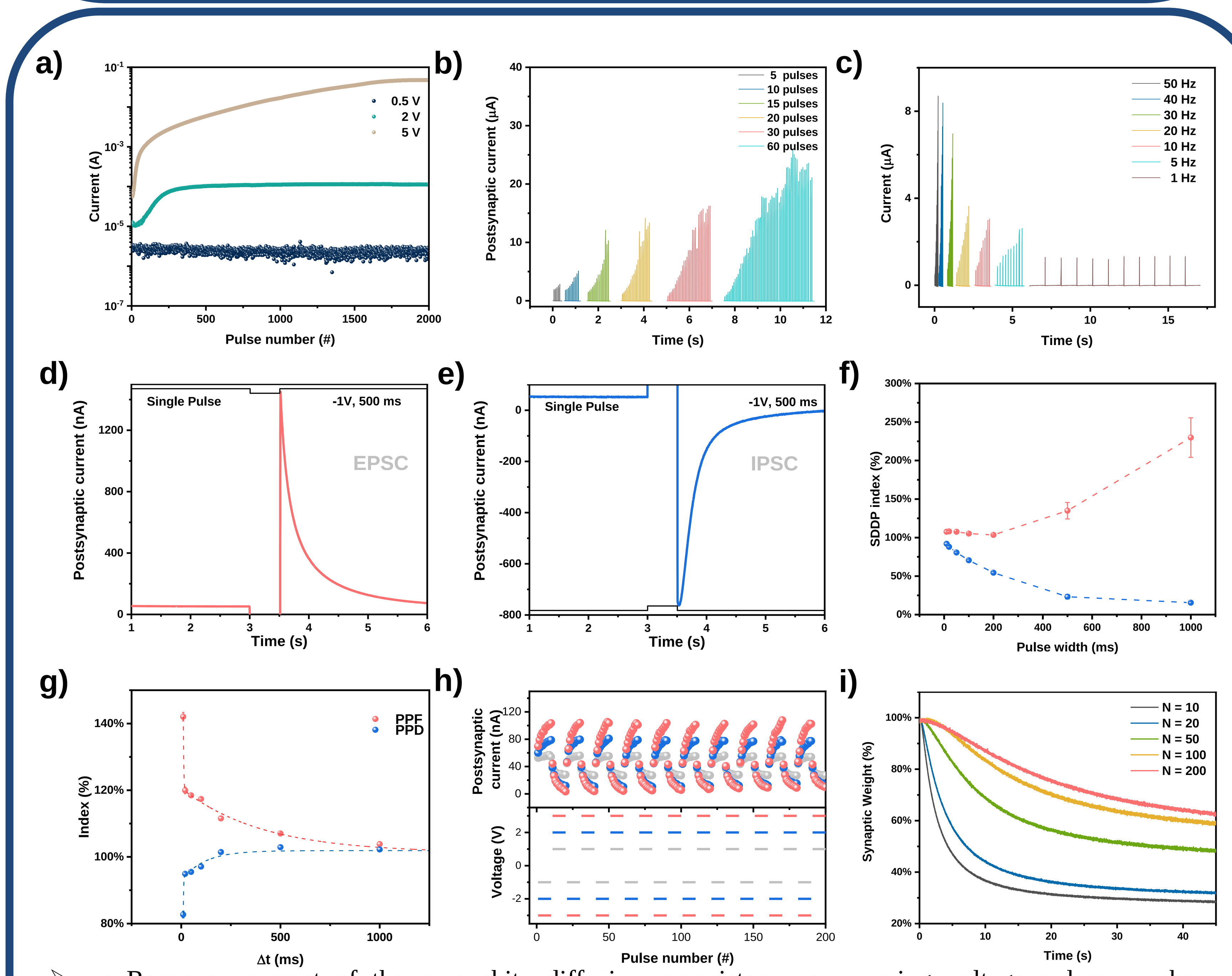
Abstract: The resistance change behavior observed in diffusive memristors shares similarities with the potential change in biological neurons. Here, the diffusive threshold switching phenomenon is utilized to demonstrate the synaptic functions of biological synapse. This FAMA-based perovskite diffusive memristor showed threshold switching properties with excellent uniformity, a high I_{ON}/I_{OFF} ratio (10^4). The perovskite diffusive memristor successfully emulate the biological nociceptor functionalities, typical characteristics of the artificial nociceptor, such as threshold, no adaptation, relaxation, and sensitization. Further, the feasibility of perovskite-based artificial nociceptors in artificial intelligence is being investigated by implementing a thermoreceptor system.

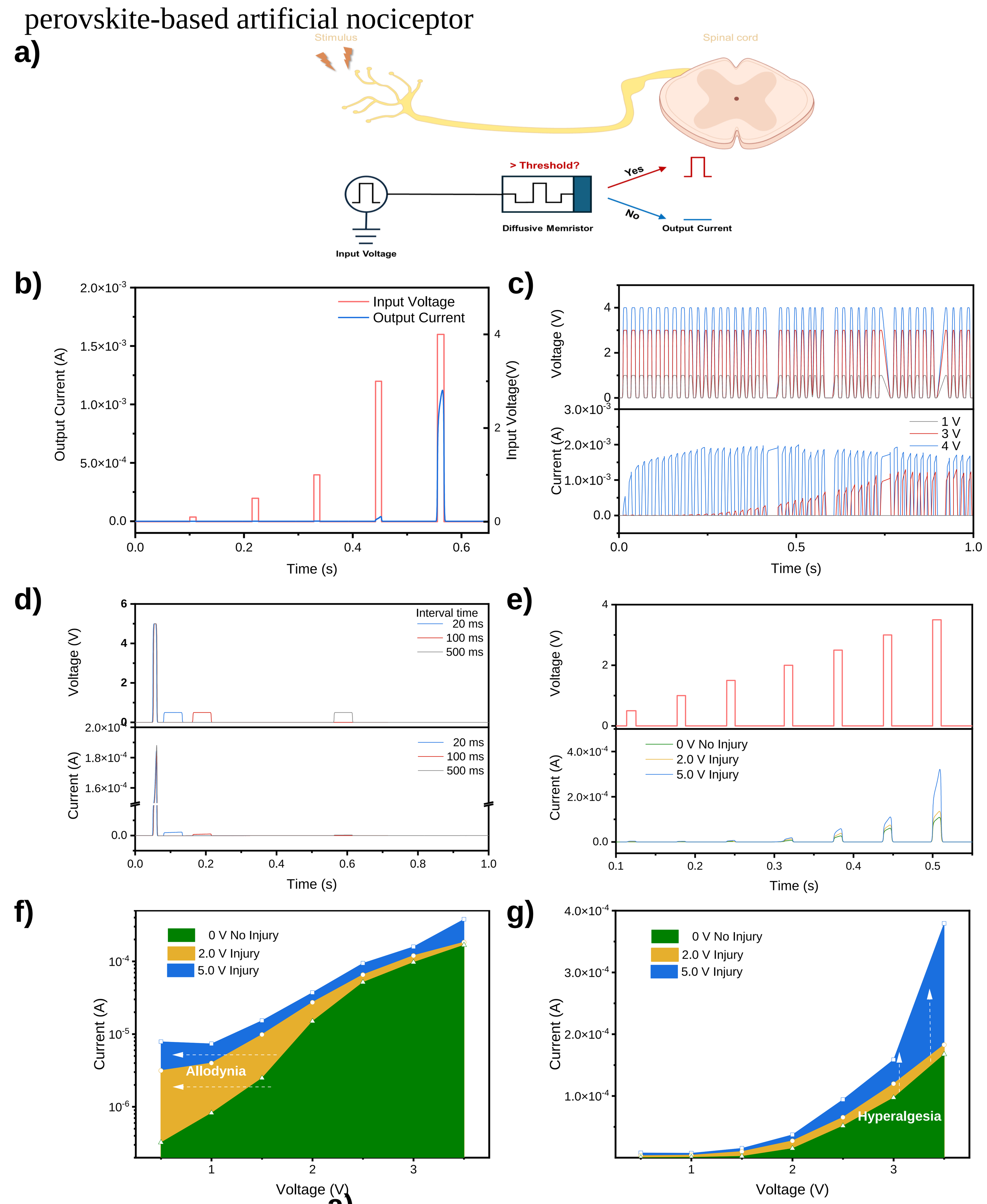
- Electrical performance the perovskite-based diffusive memristor

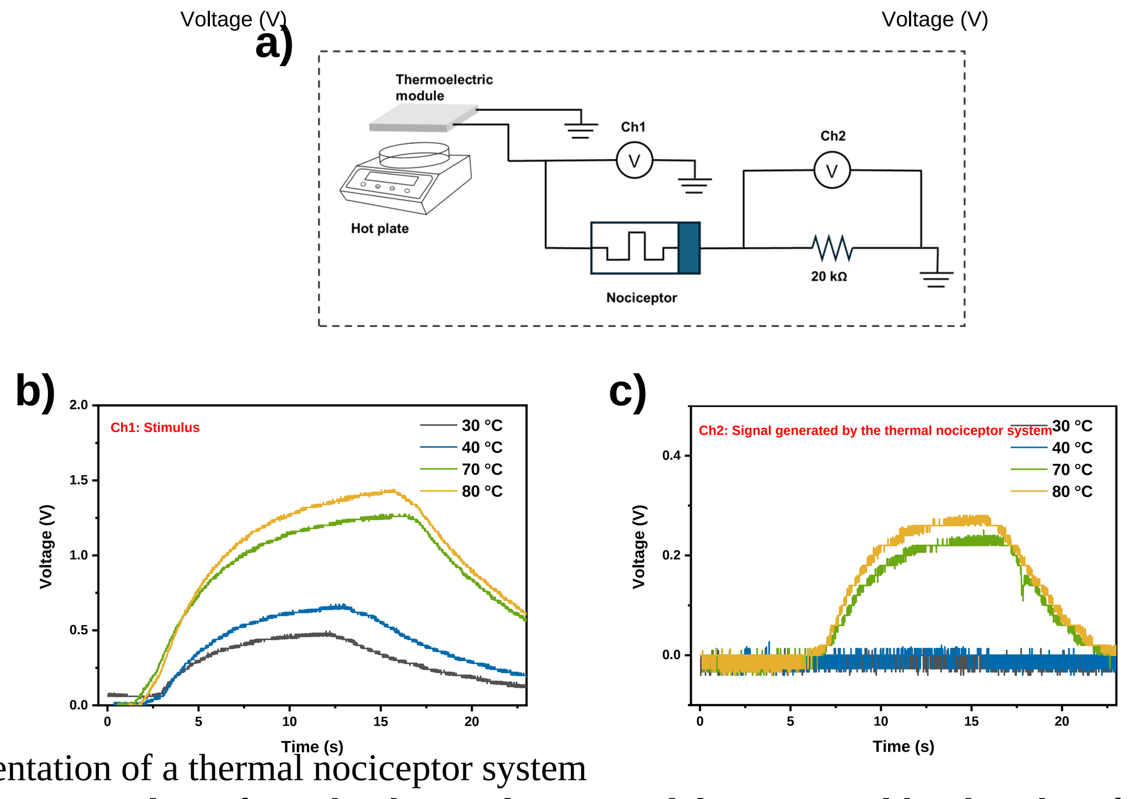




- a-c Response current of the perovskite diffusive memristor upon varying voltage pulses number, amplitude, and frequency.
- d-i Synaptic plasticity (i.e. EPSC/IPSC, PPF/PPD, LTP/LTD) of the perovskite diffusive memristor.

- (a) Schematics of biological nociceptor and an artificial nociceptor electrical circuit. (b-d) Threshold, no adaptation, relaxation and (e-g)sensitization characteristics of the perovskite-based artificial nociceptor





- Top: Implementation of a thermal nociceptor system
- Bottom: The output voltage from the thermoelectric module monitored by the Ch1 of the oscilloscope and (c) The output voltage from the perovskite-based nociceptive device monitored by the Ch2 of the oscilloscope.

Summary and outlook:

- ❑The perovskite-based memristor exhibits a threshold switching behavior (volatile) with stable endurance (10^4 cycles).
- ❑The perovskite-based diffusive memristor emulates well for the synaptic functions and successfully mimic the threshold, no adaptation, relaxation and sensitization characteristics of the biological nociceptors.
- ❑A thermal nociceptor system based on the perovskite artificial nociceptor is successfully implemented.

Reference:

1. ACS Appl. Mater. Interfaces 2023, 15, 10, 13238–13248
2. Adv. Mater.2024,36, 2307334
3. Adv.Mater.2018, 30, 1805454
4. ACS Energy Lett. 2024, 9, 3, 948–958

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