SUPPORTING INFORMATION

Flexible artificial nociceptor using a biopolymer-based forming-free memristor

Jun Ge, Shan Zhang, Zhiyu Liu, Zhikun Xie, Shusheng Pan**

Solid State Physics & Material Research Laboratory, School of Physics and Electronic Engineering, Guangzhou University, Guangzhou, 510006, China

*E-mail: speegejun510@gzhu.edu.cn, sspan@gzhu.edu.cn

1. I-V sweeps endurance measurement

In the I-V measurements, the voltage was applied using a step-by-step voltage rising mode. Specifically, the durance for each step of our measurement is 50 ms and the rising voltage by each step is 0.01 V. The cycling procedure is 0V-1V-0V, meaning each cycling sweep lasts 10 s. Normally, the device degrades because of the high voltage stress resulting in robust conductive filaments that could not be disconnected. During the cycling process, the device is at LRS for at least 50 % of measuring time, meaning the device endured at least 5 s of relatively high current flow facilitating the filament growth. In the measurement under AC mode however, each cycle only corresponded to a 1V pulse of 0.2 ms. The entire pulse number (1.5×10^5) would give a total time of about 30 s. The test strength equals to about only 6 of our I-V cycles in regard of total pulse duration. Furthermore, in the AC mode every two 1V pulses have an interval of about 2 ms to fully relax the device back to the insulating state, while during the I-V test, there is no time for the device to relax due to the stair-type of the applying voltage, resulting in more and stronger conducting filaments inside the CιC layer thus degrade the performance.

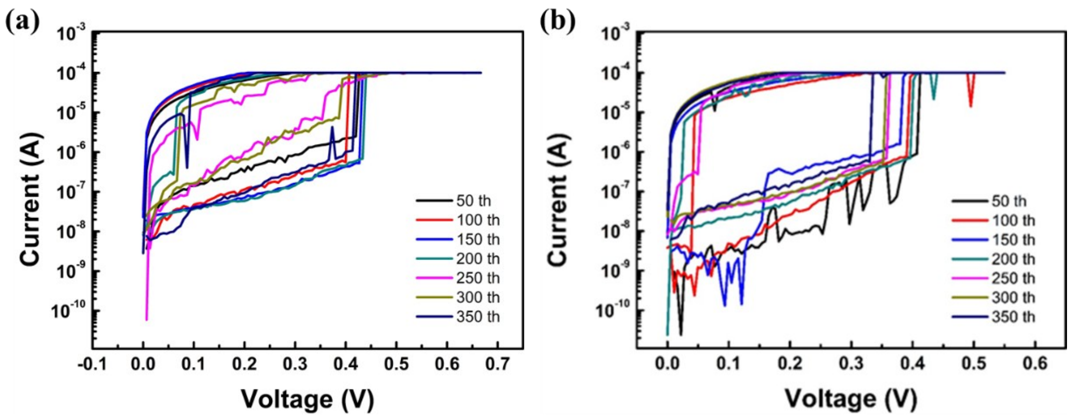

Figure S1. Endurance characteristics of the nociceptor device on semi-log scales with the d.c. sweep rate at (a) 200 mV S^{-1} and (b) 500 mV S^{-1}.

2. Variation measurement

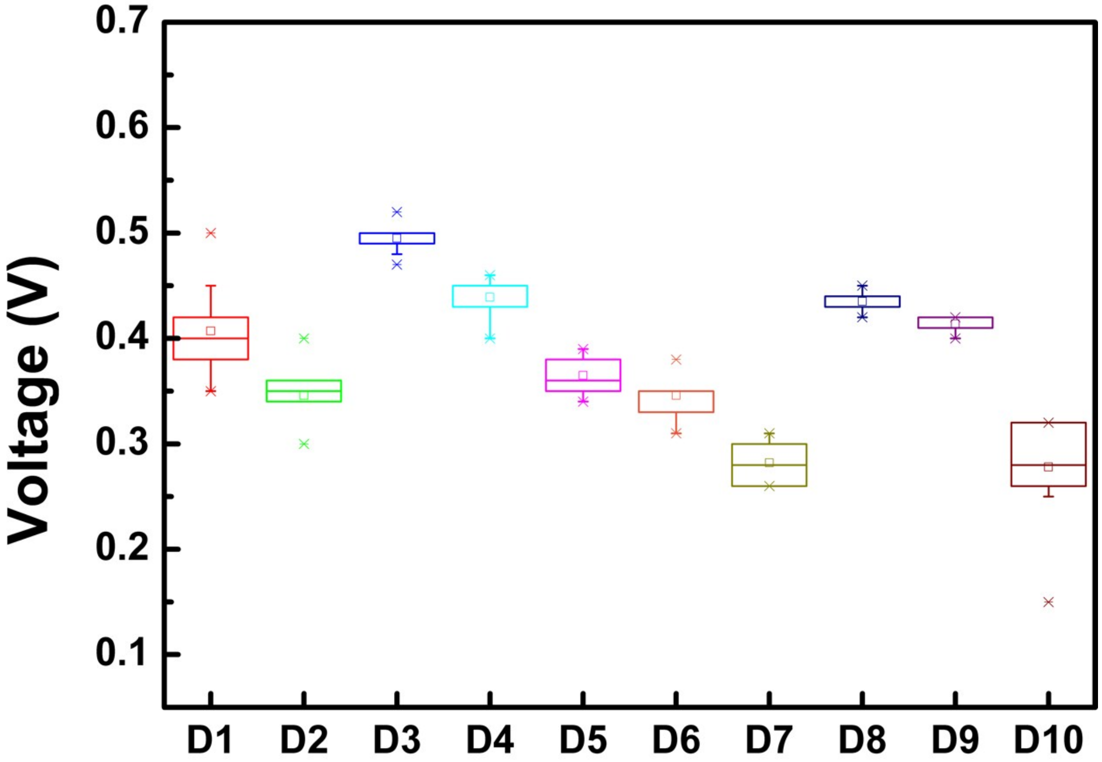

Figure S2. Device to device uniformity of DC operating voltages (error bar: max and min data, box: standard error).

3. Thickness dependence of the device

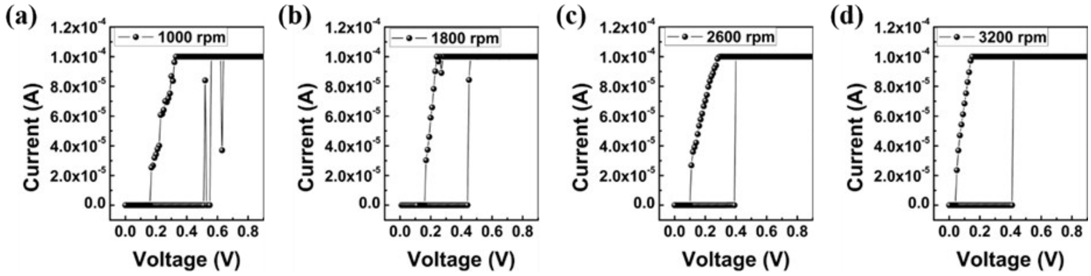

Figure S3. Typical I-V characteristics of Ag/CιC/ITO devices with various switching layer thickness using different spin-coating speed at 1000, 1800, 2600 and 3200 rpm, respectively.

4. Temperature dependence of the device

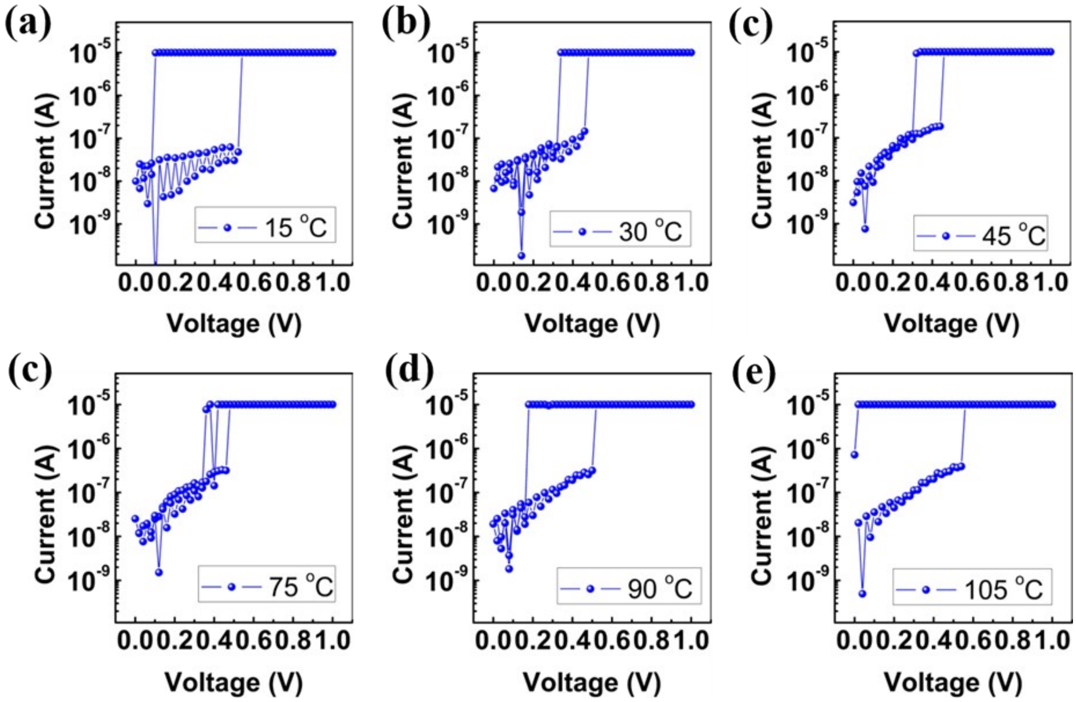

Figure S4. Typical I-V characteristics of Ag/CιC/ITO devices measured at different temperatures.

5. Bending method

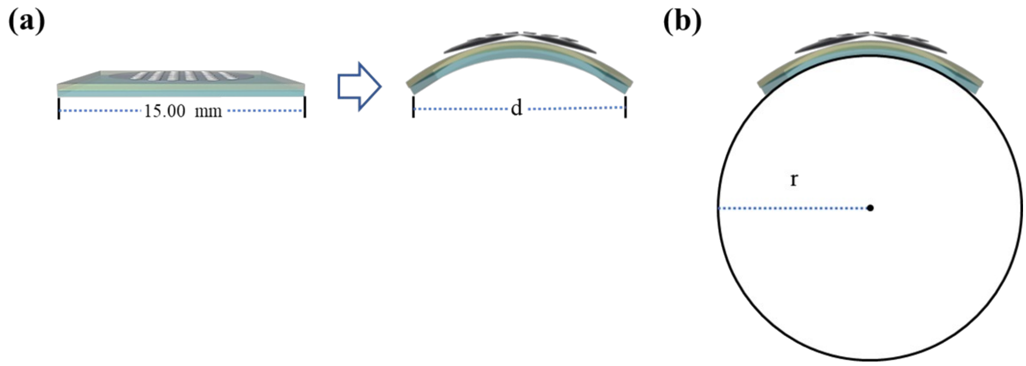

Figure S5. (a) Bending method. (b) Estimation of radius of curvature of the flexile Ag/CιC/ITO nociceptor device. The strain (%) was calculated from the equation below.

$$\text{Strain (\%)} = \frac{Total\ thickness\ of\ device}{2\ \times radius\ of\ curvature} \times 100$$

6. I-V characteristics of Au/CιC/ITO devices

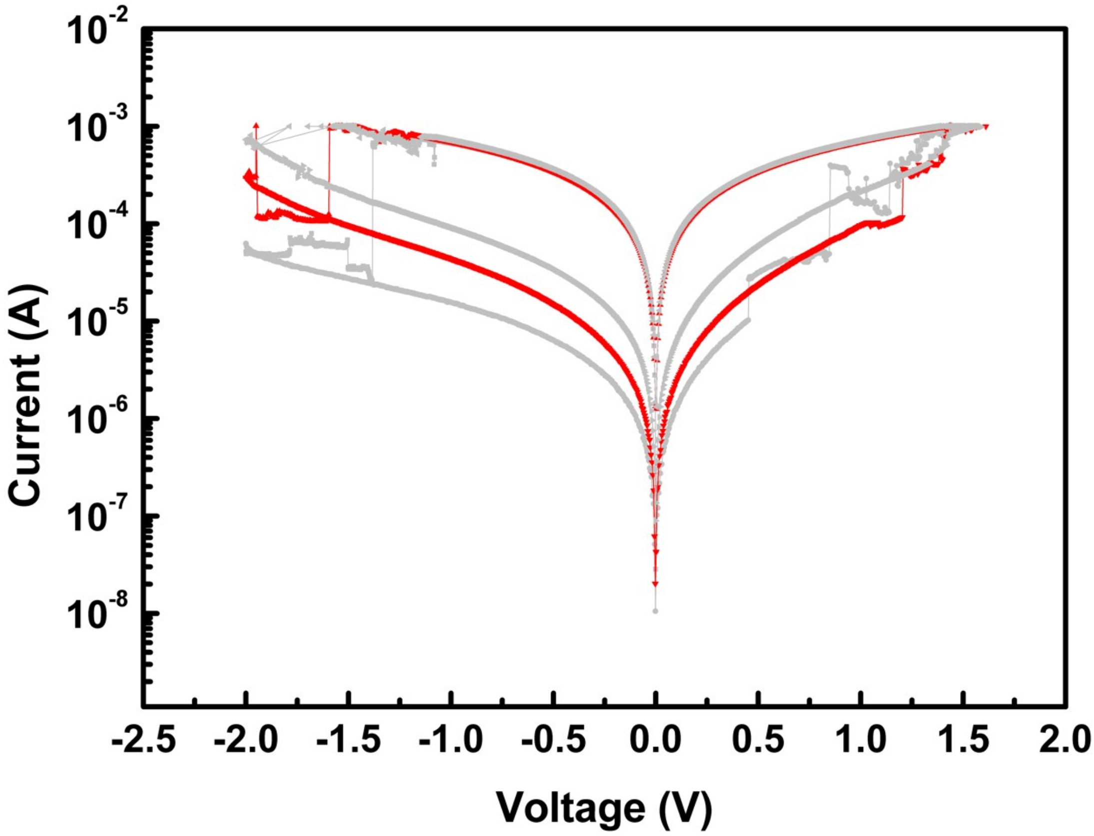

Figure S6. Resistive switching I-V characteristics of Au/CιC/ITO devices under CC = 1×10^{-3} A. The red loop is depicted from the first sweep and the grey loops present the subsequent cycles.