Pt/Ag-Ag_2S Nanoparticles/Pt Diffusive Memristor for In-Materio Reservoir Computing

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Reservoir computing (RC) is a kind of recurrent neural networks that enable temporal information processing with greatly reduced learning complexity. The RC-based dynamic memristor has been successfully realized to gain high-efficiency temporal signal processing[1]. In this work, we report a planar diffusive memristor that process switching dynamic based on the basis of atomic switches. The Ag-Ag_2S nanoparticle random networks (NRN) was located between two electrodes (Pt/Ti = 24/6 nm) that rested on a SiO_2/Si substrate. The device structure of Pt/Ag-Ag_2S NRN/Pt is schematically illustrated in Fig. 1(a). A current-voltage (*I-V*) characteristic of the device was measured by a DC voltage sweep with 30mV/s of scanning rate. The typical *I-V* characteristic is shown in Fig. 1(b). The device exhibits a threshold switching behavior in both positive and negative polarities. This behavior suggests that the device can spontaneously relax back to the low-current state by removing the bias. Fig. 1(c) shows a statistical distribution of the switching voltage (V_s) measured from 45 cycles in the positive sweep. This repeatable switching indicates the reproducibility of the device. It is noted that the broad range of V_s is attributed to the different conductive pathways of random network devices. The dynamic characteristics of the device were also investigated by applying stimulation pulses and recording the response current, as shown in Fig. 2(a). The current increases under the write pulse and then decays to the initial low-current state under the read pulse, suggesting a typical short-term memory feature. The current decay process was analyzed by curve fitting with a stretched-exponential function, as shown in Fig. 2(b). The decays time constant (τ) obtained by fitting is 626 ms. These experimental results imply that the output of the dynamic memristor depends not only on the present input but also on the history of the input signal. In summary, such a fading memory feature of the Pt/Ag-Ag_2S NRN/Pt device gives it the ability to implement the in-materio reservoir computing.

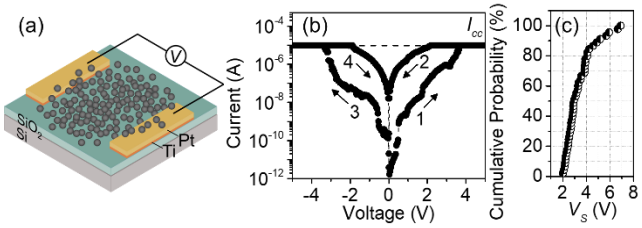

Fig. 1 (a) Schematic structure of the Pt/Ag-Ag_2S NRN/Pt device (b) Typical *I-V* switching curve of the device. The arrows indicate the direction of the voltage sweep. (c) Cumulative probability plot of the switching voltage over 45 *I-V* positive sweeps.

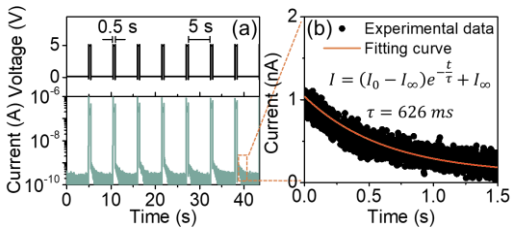

Fig. 2 (a) Current responses of the device. The input stimulus is a sequence of write voltage pulses (5 V, 0.5 s) followed by read voltage pulses (0.1 V, 5 s). (b) Current decay analysis with obtained 626 ms of time constant τ.

[1] Y. Zhong, J. Tang, X. Li, *et al*. *Nat Commun.* **12**, 408 (2021).