

Mechanically-exfoliated 2D WS₂-based memristors as artificial synaptic devices

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Abstract

Memristors that employ 2D transition metal dichalcogenides as switching mediums are potential contenders for artificial synapses in neuromorphic computing. The most common technique for creating 2D materials for memristors is chemical vapor deposition. Although the technique creates imperfections (grain boundaries and vacancies) that improve the memory window, it creates inconsistencies which affect the yield levels [1]. On the other hand, mechanically exfoliated 2D materials obtained by peeling bulk crystals offer better quality, (i.e. fewer defects compared to the chemical vapour deposition) resulting in reduced device variability. Literature suggests that pristine exfoliated materials often do not exhibit resistive switching behavior unless subjected to post-treatments such as oxidation, plasma treatment, or electron beam irradiation, since their defect level is low [2]. However, in [2], untreated, mechanically exfoliated MoS₂ demonstrated resistive switching capabilities. These findings emphasize the general suitability of defect lean and high quality 2D layers for memristor fabrication. In this study, untreated mechanically-exfoliated WS₂, sandwiched between Au/Ti and Pt electrodes, is introduced as a resistive switching device. It (inset Figure **a**) exhibits a no-forming, gradual switching behavior. Moreover, the memory window increases with increasing the applied voltage (Figure **a**). Compared to the MoS₂ based device [2], this device exhibits a significantly larger memory window. It shows distinct potentiation and depression characteristics, confirming its synaptic functionality. The I_{max}/I_{min} ratio for our device is 6 (Figure **b**), showing another improvement from compared to the MoS₂ based device [2]. With these findings, using exfoliated 2D materials as high-quality resistive switching medium without additional treatments serves as a foundation for artificial synaptic functions in neuromorphic systems.

References

- [1] Li, M. et al. Nat. Electron., 2023, 6, 491–505
[2] Fejzaj D., et al. Adv. Elect. Mat, 2026, 10.1002/aelm.202500691

Figures

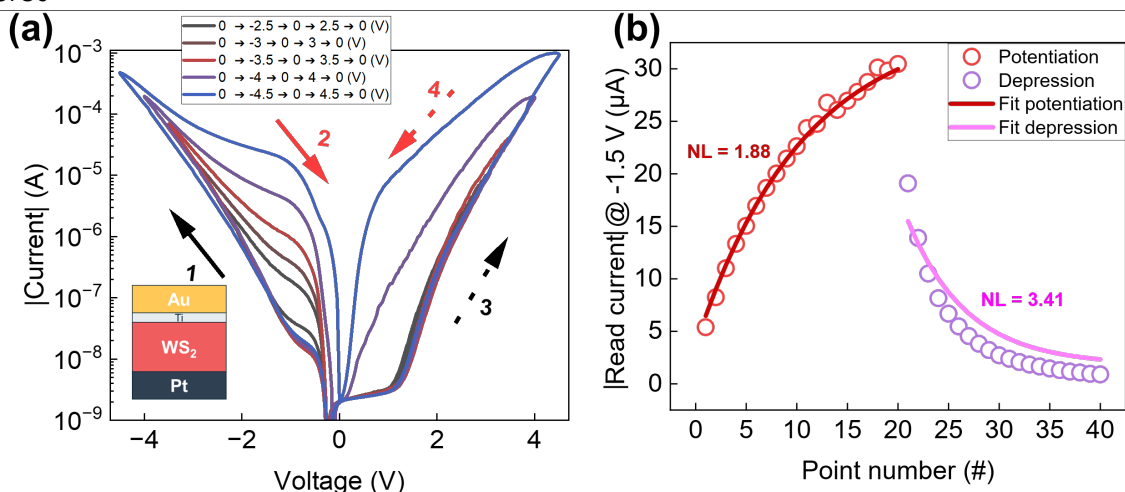


Figure 1: (a) I-V curves of Au/Ti/WS₂/Pt memristor (the inset shows the schematic device stack) with the sweeping order 1→2→3→4. (b) Consecutive potentiation (-4 V as programming voltage) followed by depression (4 V as programming voltage) curves measured at a readout voltage of -1.5 V together with fitting curves and the extracted nonlinearity values (NL).