

Supplementary materials

Synaptic Plasticity and Non-Volatile Memory Characteristics in TiN-Nanocrystals-Embedded 3D Vertical Memristor-Based Synapse for Neuromorphic System

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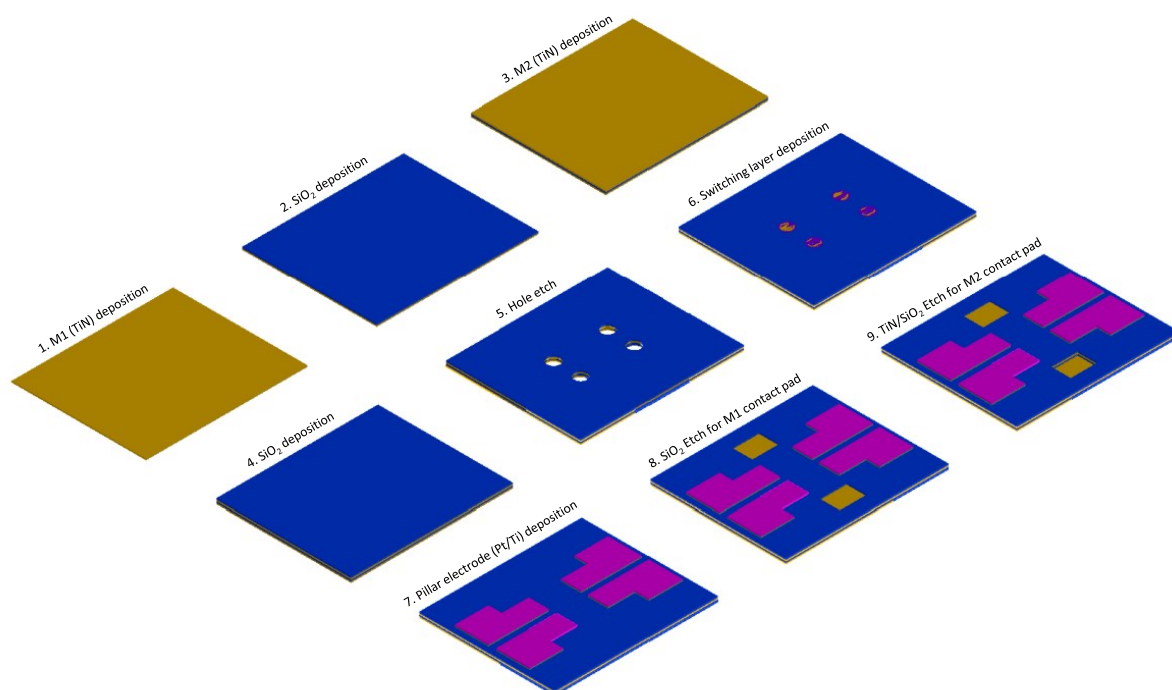
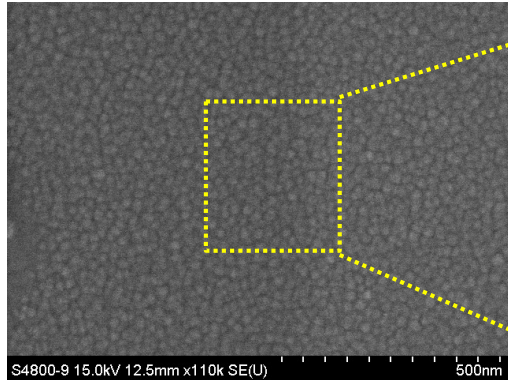
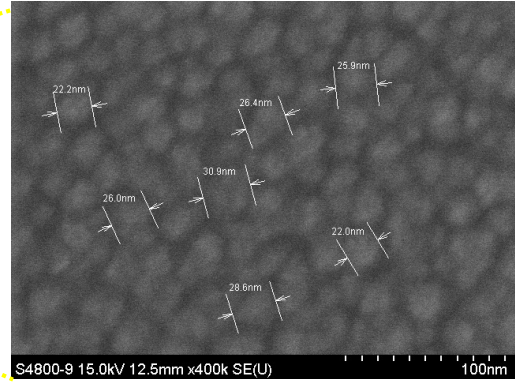


Fig. S1 Fabrication process of vertical RRAM.

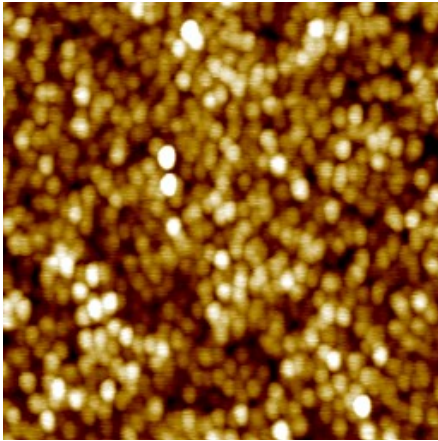
(a)



(b)



(c)



(d)

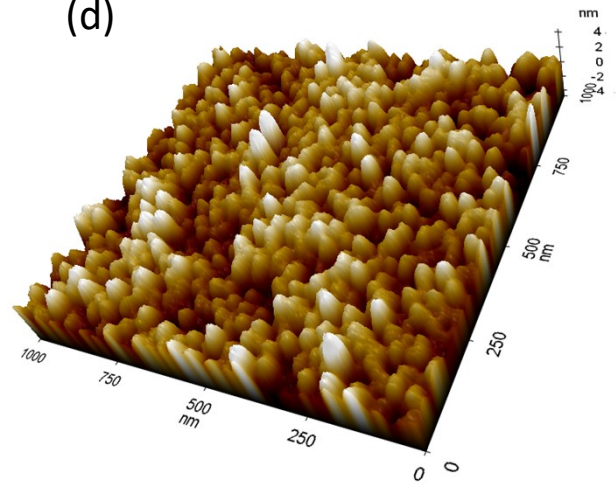


Fig. S2 SEM images of TiN-NCs/HfO_x/TiN sample.

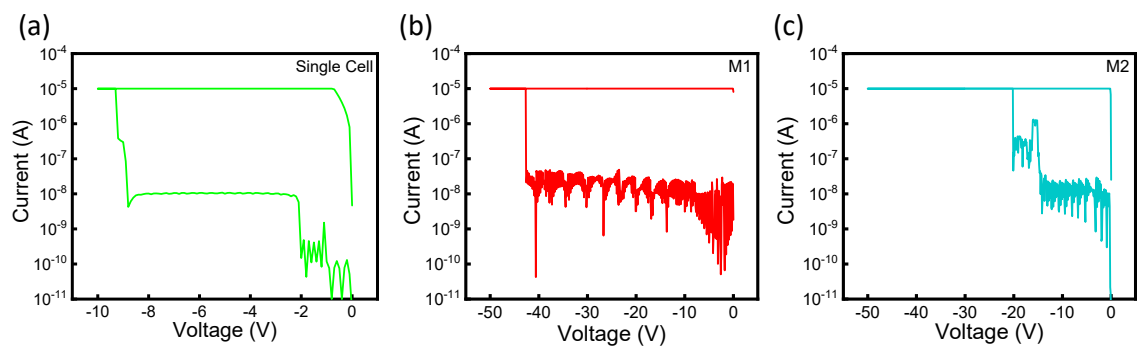


Fig. S3 Forming characteristics: (a) single cell, (b) on the first floor (M1) and (c) on the second floor (M2) of VRRAM.

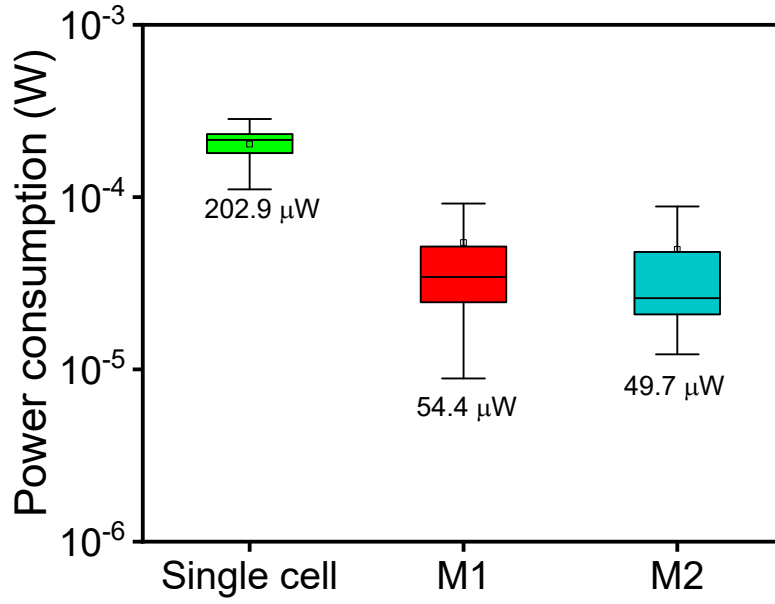


Fig. S4 Comparison of power consumption required to maintain low resistance state.

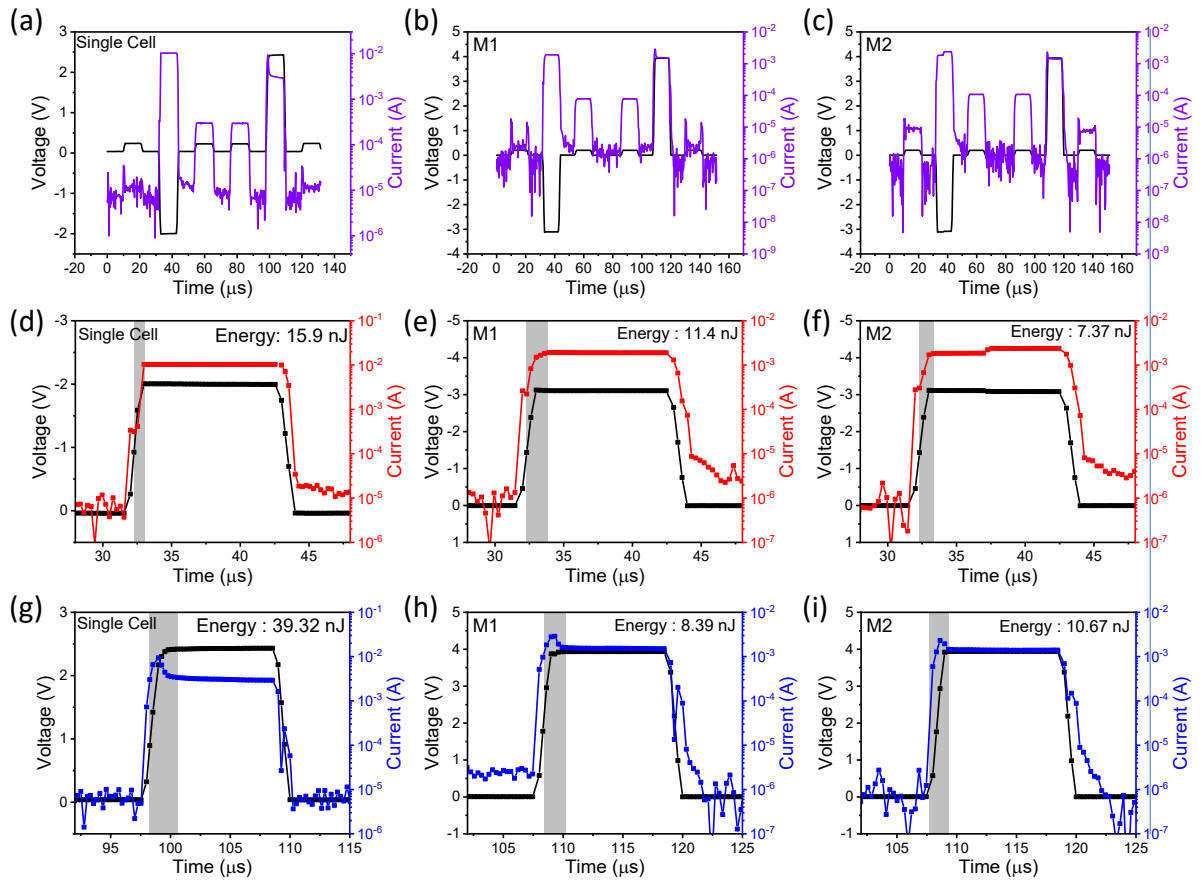


Fig. S5 Transient characteristics: (a) single cell, (b) on the first floor (M1) and (c) on the second floor (M2) of VRRAM. Programming energy consumption: (d) single cell, (e) M1 and (f) M2 of VRRAM. Erasing energy consumption of (g) single cell, (h) M1 and (i) M2.

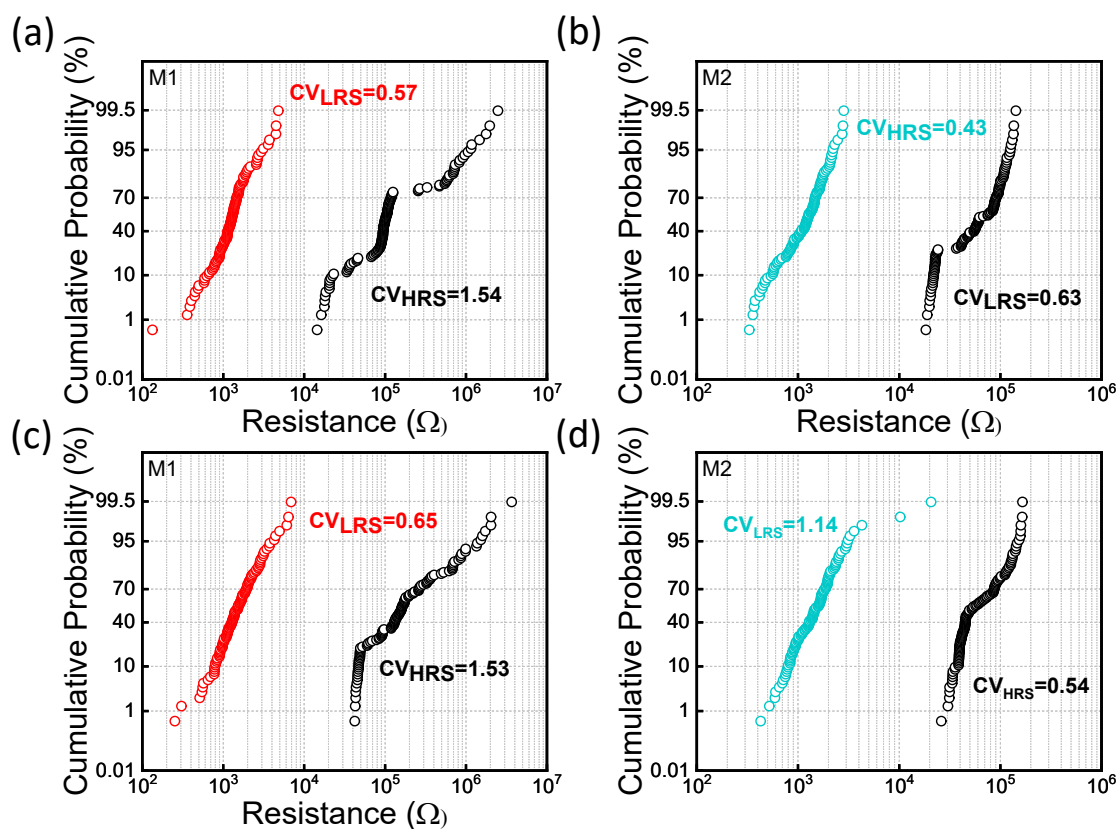


Fig. S6 Resistance value distribution of another batch: (a) on the first floor and (b) on the second floor of D2, (c) on the first floor (M1) and (c) on the second floor (M2) of D3.

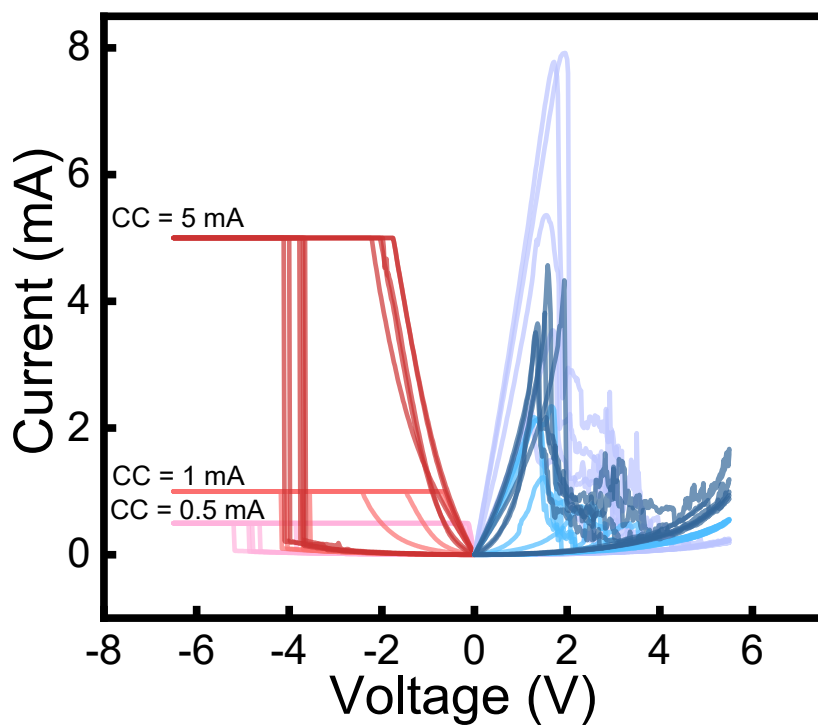


Fig. S7 I-V curves under different compliance current (0.5 mA, 1 mA, and 5 mA).

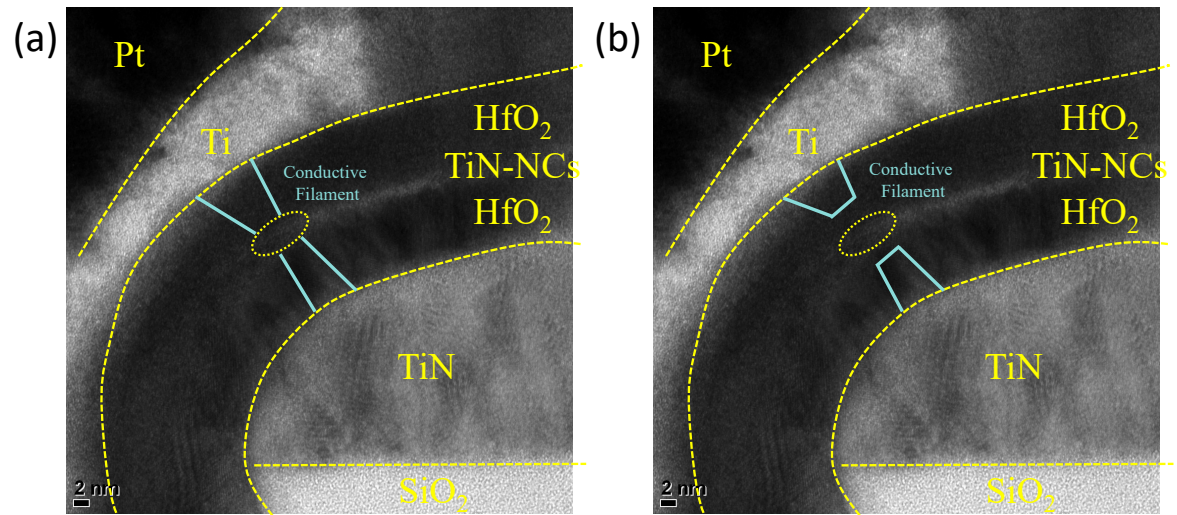


Fig. S8 (a) Conductive filament formation and (b) rupture in 3D VRRAM on TEM image.