Pulse-Engineered Synaptic Linearity and Digital Memory in MoO_3/TiO_2 Bilayer Memristors for RRAM based Neuromorphic Computing

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Oxide-based memristors are actively explored for non-volatile memory and neuromorphic computing, yet the coexistence of reliable digital switching and linear synaptic weight modulation within a single device remains challenging due to stochastic filament dynamics. Our study explores the optimization of pulse sequences in Au/MoO_3/TiO_2/FTO bilayer oxide memristors for controlled conductance modulation. The switching characteristics can be controlled from interface-driven self-rectifying behaviour, through an electroforming step, to a stable non-volatile bipolar resistive switching governed by oxygen-vacancy-mediated filament formation. Robust memory operation is demonstrated, showing stable endurance (up to 25,000 cycles) and retention (~1,000 sec), switching at fast scan-speeds (up to 500 V/s), low variability and reliable operation over extended time and temperature range, making it useful for resistive random-access memory (RRAM) applications. Additionally, quantized conductance jumps during the RESET process indicate atomic-scale constrictions in the conduction path, implying additional filament control. Interestingly, we also observe field-induced electrochromism in the device, providing a direct visual signature of the valence-change mechanism (VCM). Furthermore, pulsing scheme optimization using non-identical pulses ensures gradual, controlled conductance evolution resulting in linear learning and forgetting characteristics (NLF ~ 0.002) over extended number of cycles, making the device highly suited for artificial synapse-based image-recognition applications. These results highlight control of pulse scheme, combined with oxide bilayer architecture, as an effective strategy for realizing multifunctional memristors, offering a viable route toward integrated neuromorphic in-memory computing hardware.

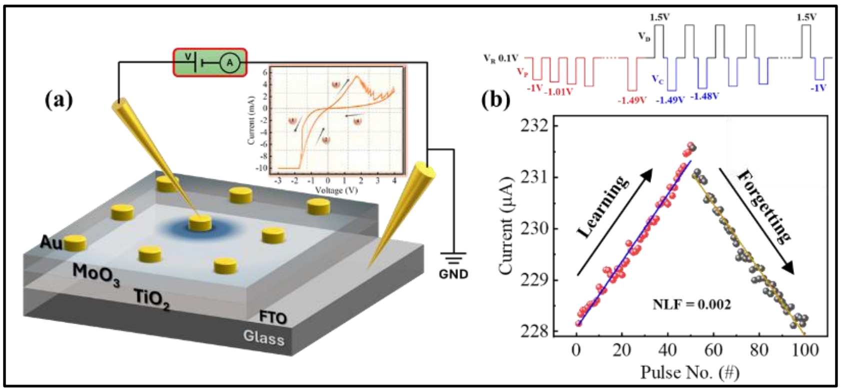

Figure 1: (a) Device schematic and I-V characteristics (inset). (b) Linear potentiation-depression achieved by optimized pulsing scheme (top).

References:

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