(*Invited*) Intrinsic Nonlinearity on Emerging Non-volatile Memory for High Density Storage and Computing Applications

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Among the emerging memory technologies, Resistive Random Access Memory (RRAM) has been a good candidate to address the current Von Neumann bottleneck, and the efficiency bottleneck as called "memory wall." To reduce power consumption caused by data transfer between central processing units (CPU) and memory, the in-memory computing is proposed recently. Sneak path currents (SPC) existing in the crossbar configuration hinders the memory storage and computing technology development, due to the programming errors by the unwanted currents from the neighboring memory cells. To solve this issue, the transistor or selector device is integrated to suppress the SPC in the memory array. However, this hinders the scalability of RRAM and increases the cost and complexity of manufacture. To enable the high-density memory array for further high computing demand, intrinsic self-rectified switching behaviors on one individual RRAM device, while with synaptic behaviors, can play a role in cost reduction and fabrication process simplification.

In this work, the intrinsic self-rectified switching behaviors were observed in bilayer oxide stacks, helical materials, and two-dimensional (2D) Van der Waals dielectric materials, which avoids the crosstalk error caused by the sneak path currents[1,2]. The current transport mechanisms on the stacked RRAM are investigated through the numerical current fitting methods. The structural stacking structure of high dielectric layer and low dielectric layer provided a solution towards high density memory application with the optimized working window in a good nonlinearity (>10), larger on-off ratio (>100), low switching energy, and good endurance. Intrinsic nonlinearity in 1R-only RRAMs not only exhibits promising immunity towards sneak path current but also paves the way for advancements in energy efficient high performance in-memory computing applications.

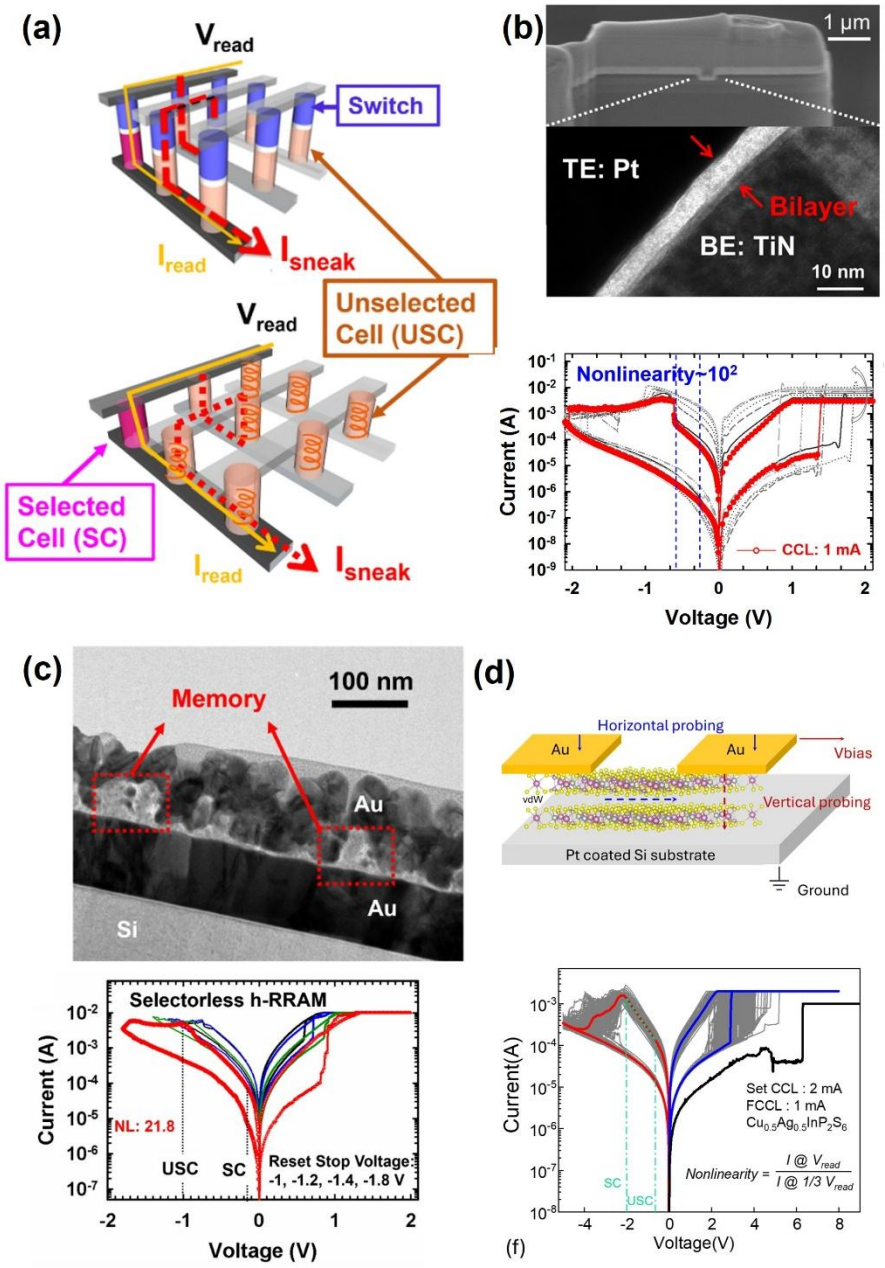

Figure 1: (a) sneak path current on crossbar memory array configuration, (b) SEM images of planar bilayer stacked selectorless RRAM, (c) SEM images of helical materials-based selectorless RRAM, (d) device schematic of van dal Waal materials-based selectorless RRAMs (top), and the I-V transfer curves with intrinsic nonlinearity (bottom).

References

[1] Y.-C. Chen, S. Sarkar, J. Gibbs, Y. Huang, J. C. Lee, C.-C. Lin, C.-H. Lin, *ACS Applied Engineering Materials 1*, 252.

[2] Y. C. Chen, J. Lee, C. Y. Lin, *IEEE Trans Electron Devices* 2021, *68*, 4363.