

Analog Weight Update Rule in Ferroelectric Hafnia using pico-Joule Programming Pulses

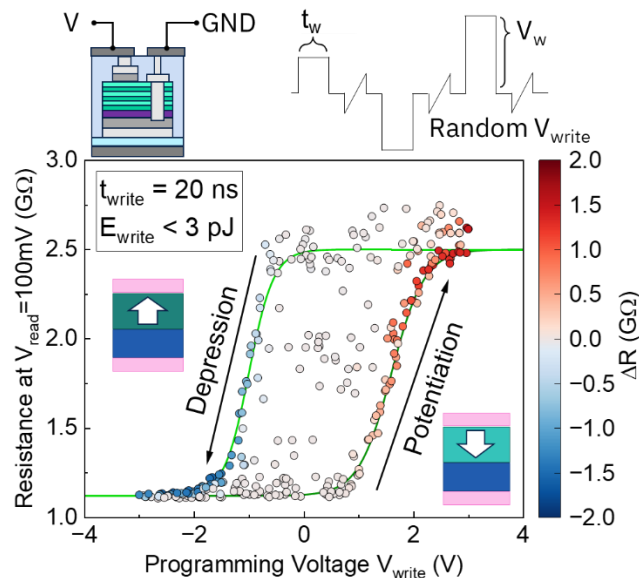
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Abstract:

In an effort to compete with the brain's efficiency at processing information, neuromorphic hardware combines artificial synapses and neurons using mixed-signal circuits and emerging memories. In ferroelectric resistive weights, the strength of the synaptic connection between two neurons is stored in the device conductance. During learning, programming pulses are applied to the synaptic weight, which reconfigures the ferroelectric domains and adjusts the conductance. One strategy to lower the energy cost during the training phase is to lower the duration of the programming pulses. However, the latter cannot be shorter than the self-loading time of the resistive weights, limited by intrinsic parasitics in the circuits. We fabricate ferroelectric resistive weights using a process compatible with CMOS Back-End-Of-Line integration, based on hafnia/zirconia nanolaminates [1]. By laterally scaling the device area under $100 \mu\text{m}^2$, the self-loading time becomes sufficiently short to enable 20 ns programming, which corresponds to a maximum of 3 picoJoules per pulse [2]. Further, the weight update rule with 20 ns pulses is experimentally measured not only for different amplitudes but also for different initial conductance states. We find that the final weight is determined by the pulse amplitude, independent of the initial weight value.



References:

- [1] L. Bégon-Lours *et al.*, *Adv. Electron. Matter.*, 10 (5), 2300649, 2024.
- [2] A. Baigol *et al.*, Accepted in *Adv. Electron. Matter.* <https://arxiv.org/abs/2601.01186>