Linearly programmable memristors for neuromorphic computing hardware

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Abstract:
In conventional von Neumann architecture computing, a major bottleneck exists between the processor and memory, leading to high power consumption. To overcome this limitation, neuromorphic computing, which mimics the human brain, has emerged as a promising solution. Just as synapses in the brain perform both memory and computation simultaneously, researchers are developing neuromorphic hardware that uses memristors as artificial synapses and neurons. These devices can store multiple resistance states at low power, which are then used for computation. Our research team is focusing on new materials to overcome the limitations of amorphous metal oxides, which are commonly used in existing memristors. Amorphous metal oxides operate via a conductive filament mechanism, which results in asymmetric and non-linear synaptic weight modulation. This leads to low accuracy in parallel computing and poor energy efficiency. To address this, our team has utilized halide perovskite materials, which have high ion mobility. While conventional organic-inorganic hybrid perovskites suffered from moisture instability and low reliability, the researchers developed a vertically aligned 2D halide perovskite [1]. The devices operate stably in the air for several months. By providing a uniform ion migration pathway, this new material enables highly linear and symmetric synaptic weight modulation. This breakthrough significantly enhances the accuracy and energy efficiency of AI computations.

References

1. S. J. Kim et al, Nature Nanotechnology 20, 83–92 (2025).