Artificial Intelligence Applications of a Metal Oxide-Based Semiconductor Device

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Abstract:

Artificial synapses serve as fundamental building blocks in neuromorphic computing chips and offer a promising pathway to overcome the energy and data transfer limitations inherent to traditional von Neumann architectures. In this study, we report a cost-effective solutionprocessed zinc tin oxide (ZTO)-based resistive random-access memory (RRAM) device that exhibits analog resistive switching behavior, suited for neuromorphic applications. The Al/ZTO/n+-Si device demonstrates excellent cycle-to-cycle uniformity over 1000 DC sweep cycles and achieves a reliable memory window of approximately 102. Furthermore, the device enables long-term potentiation (LTP) and depression (LTD) under voltage pulse stimulation, which are key characteristics for emulating synaptic learning. In addition, a range of biologically inspired synaptic functions are successfully replicated, including excitatory postsynaptic current (EPSC), spike-number-dependent plasticity (SNDP), and paired-pulse facilitation (PPF). Neuromorphic network simulations based on the conductance modulation characteristics of the Al/ZTO/n^+-Si device are carried out using the MNIST handwritten digit dataset. The effect of different voltage pulse sequences on classification accuracy is analyzed. Using an identical voltage pulse sequence, the network achieves a recognition accuracy of 87.26%. These results confirm the viability of the Al/ZTO/n+-Si device for cost-effective and scalable neuromorphic computing applications.

Keywords:

Resistive random-access memory, solution process, synaptic devices, neuromorphic computing.