Memristive Nanodevices and Arrays for Brain-Inspired Computing

Qiangfei Xia
Department of Electrical and Computer Engineering, University of Massachusetts, Amherst, MA 01003
Email: qxia@umass.edu

It becomes increasingly difficult to improve the speed-energy efficiency of traditional digital processors because of limitations in transistor scaling and the von Neumann architecture. Computing systems augmented with emerging nanodevices such as memristors offer an attractive solution. A memristor (resistive switch) is an emerging nanoelectronic device that uses conductance states to represent digital or analog information. Built into large-scale crossbar arrays, they perform in-memory computing by utilizing physical laws, such as Ohm's law for multiplication and Kirchhoff's current law for accumulation. The current readout at all columns is finished simultaneously regardless of the array size, offering massive parallelism in vector-matrix multiplication and hence high computing throughput. The ability to directly interface with analog signals from sensors without analog/digital conversion could further reduce the processing time and energy overhead.

In this talk, I will first introduce a high-performance analog memristor that meets most requirements for in-memory computing in artificial neural networks, highlighting its 2 nm scalability and 8-layer stackability. I will then showcase the integration of large memristor crossbar arrays for analog signal and image processing and the implementation of multilayer memristive neural networks for machine intelligence applications. Finally, I will introduce a diffusive memristor as a bio-realistic synapse and neuron emulator, and review further applications of memristors in reconfigurable radiofrequency systems and hardware security.