Nanoscale Memristive Devices for Memory and Computing Applications

Wei Lu
Electrical Engineering and Computer Science
University of Michigan, Ann Arbor, MI 48109, USA

Two-terminal, nanoscale resistive switches (memristors) have been extensively studied for potential applications in memory and computing systems. Two types of devices – one with abrupt resistance change (digital) and one with incremental resistance change (analog) have been developed by choosing the proper combinations of electrode and switching materials, film stack and programming conditions. The digital devices show desirable performance metrics as "the next switch" in terms of scalability, speed, ON/OFF ratio, endurance and retention. Detailed TEM studies have been carried out to verify the switching mechanism. Functional high-density crossbar arrays have been integrated directly on top of CMOS circuits using a back-end-of-line (BEOL) process, enabling hybrid non-volatile memory and reconfigurable circuit applications. The analog devices exhibit incremental conductance changes that are analogous to the behaviors of biological synapses. Besides the ability to emulate synaptic behaviors phenomenologically, the internal ionic dynamics of these devices allow them to implement a number of important synaptic functions realistically. These analog memristive devices are well suited for hardware-based, bio-inspired neuromorphic circuits. Device and SPICE models based on properly chosen internal state variables have also been developed for the understanding and applications of these devices at the system level.