Multistate memories to neuromorphic computing with ferroelectric-related materials

B. Dkhil[1] et al.[2]

[1]Université Paris-Saclay, CentraleSupélec, UMR CNRS 8580, Laboratoire SPMS, 91190 Gif-Sur-Yvette, France
[2]many authors involved
Brahim.dkhil@centralesupelec.fr

The processing of cognitive and data intensive tasks, such as real-time image recognition, data classification or natural language processing, to name but a few, requires to go beyond the conventional von Neumann architecture and move toward neuromorphic computing by imitating the structure of the human brain and the way it operates. As a result, ferroelectrics have been considered to emulate artificial synapse behaviors by designing memristors based on the ability to tune the domain configurations using electric field pulses. Here, besides classical ferroelectrics, we also explore other ferroelectric-related materials such as antiferroelectrics and relaxor relaxor-based materials to achieve multiple state memories and synaptic functions. Instead of exploiting the domain arrangements, we rather use the possibility to switch the polarization and dielectric responses using close energy phases, e.g. by exploring the flat energy landscape in relaxors. We show that indeed electric field pulses induce phase transitions enabling to tune the polar and capacitance responses along multiple states and in a non-volatile manner. We also show it is possible to reproduce memcapacitor behavior similar to that of biological synapses. Some fundamental learning rules including short-term and long-term memory or spike-timing-dependent-plasticity are successfully emulated.