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Brain-inspired computing with resistive switching memory (RRAM): Devices, synapses and neural networks

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Abstract – **The human brain can perform advanced computing tasks, such as learning, recognition, and cognition, with extremely low power consumption and low frequency of neuronal spiking. This is attributed to the highly parallel and the event-driven scheme of computation, where energy is used only when and where it is needed for processing the information. To mimic the human brain, the fundamental challenges are to replicate the time-dependent plasticity of synapses and to achieve the high connectivity in biological neuron networks, where the ratio between synapses and neurons is around 10^4. This combination of high computing capability and density scalability can be obtained with nanodevice technology, notably by resistive-switching memory (RRAM) devices. Here, the recent advances in RRAM device technology for memory and synaptic applications are reviewed. First, RRAM devices with improved window and reliability thanks to SiO_x dielectric layer are discussed. Then, the application of RRAM in neuromorphic computing are addressed, presenting hybrid synapses capable of spike-timing dependent plasticity (STDP). Brain-inspired hardware featuring learning and recognition of input patterns are finally presented.**

Keywords: **Neuromorphic engineering, resistive switching memory (RRAM), memristor, multilevel storage, deep learning, spike-timing dependent plasticity (STDP).**