Oxide-based memristors for brain-inspired and unconventional information processing

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Oxide-based memristors are emerging as key enabling technologies for neuromorphic hardware and unconventional computing paradigms. These devices have been proposed to emulate biological synaptic and neuronal behaviors directly in hardware, as well as to serve as computational units for in-memory processing and reservoir computing approaches [1]. In this talk, I will present an overview of our recent research on two-terminal oxide memristors exhibiting both volatile and non-volatile resistive switching driven by filamentary mechanisms [2–4], and I will discuss how these devices can be harnessed to implement brain-inspired computing primitives and unconventional information-processing schemes.

In the first part, I will introduce HfO_2-based analog memristors and their application in a memristor-driven circuit inspired by the Murali–Lakshmanan–Chua (MLC) architecture. This circuit exploits the programmable and nonlinear characteristics of $Pt/HfO_2/TiN$ devices, enabling single-node reservoir computing for a broad range of nonlinear classification tasks and real-time signal-processing applications [5]. The second part will focus on our recent results on volatile electrochemical memristors based on an $Ag/SiO_x/Pt$ structure, and on how their functional properties can be tailored by introducing an ultrathin (1–2 nm) Al_2O_3 layer via atomic layer deposition at the SiO_x/Ag interface [6]. I will discuss how the interplay between switching times and relaxation dynamics governs device behavior, and how the insertion of the Al_2O_3 layer enables engineering of distinct retention-time scales—an essential requirement for brain-inspired temporal information processing.

Finally, I will highlight our ongoing work on three-terminal ionic transistors, specifically electrochemical random-access memories (ECRAMs) based on $WO_3/HfO_2/WO_3$ stacks. These devices operate through gate-controlled ion migration that modulates the channel conductivity and represent a promising next generation of memristive technologies for neuromorphic architectures.

References

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