Solution-Processed YIZO-Based Synaptic Transistors for Neuromorphic Applications

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Neuromorphic electronics, which emulate the operational principles of neural synapses, represent an emerging computing paradigm emphasising cognitive computing capabilities. This paradigm combines rapid parallel processing with high energy efficiency, significantly advancing beyond traditional von Neumann computing systems.

Essential synapse-like device characteristics such as history-dependent analogue states and non-volatile memory have enabled the realisation of two-terminal memristive structures, phase-change memories, and ferroelectric memories as fundamental building blocks of neuromorphic systems. These devices exhibit key synaptic properties by temporally separating signal transmission and the self-learning process, a critical attribute for cognitive computing. However, this temporal separation remains a limitation inherent to two-terminal devices.

In contrast, synaptic transistors (three-terminal devices) perform both signal transmission and self-learning processes concurrently, providing enhanced synapse emulation. Various device architectures and materials have demonstrated synaptic transistor behaviour, notably floating-gate, electrolyte-gate, ferroelectric-gate, and metal oxide dielectric configurations.

This talk specifically focuses on oxide-based synaptic transistors, a class of materials capable of operating at high frequencies without the need for additional switching elements. These materials offer tunable properties and compatibility with CMOS device fabrication techniques. We present and discuss synaptic properties observed in solution-processed thin-film transistors (TFTs) employing Y2O3:Al dielectrics and semiconducting channels based on YIZO. Our findings demonstrate variable synaptic functionality across frequencies ranging from 10 mHz to 90 kHz, supported by detailed performance analysis through the paired pulse facilitation index and frequency response. Additionally, the underlying conduction mechanisms enabling synaptic behaviour are examined and discussed.