The Fabrication and Characterization of Short and Long Term Memory Proton Induced Thin Film Synaptic Transistors

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The human brain contains 10^11 neurons and 10^15 synapses, which are the crucial connective parts between neurons. Synapses gather sensory inputs and interpret specific patterns of action potential outputs. The objective of this research was to fabricate a synapse-simulating transistor and simulate key aspects of neuroplasticity of the brain such as short-term, long-term memory, and learning through repetitions. The transistors use proton-conductive silicon oxide as the gate dielectric material, with the protons equivalent to the neurotransmitters in a synaptic cleft. Indium-Zinc-Oxide acted as the semiconducting material. DC voltage was applied across source–drain junctions, and to the gate electrode, functioning as the pre-synaptic trigger. At the end of gate voltage pulse, a slow-decaying excitatory postsynaptic current (EPSC) in the transistor channel was observed, analogous to a biological synapse. The transistors showed a slow decay of the channel conductance (50% memory retention after 7 ms following the end of gate pulse), simulating short-term memory behavior. When a paired-pulse facilitation was applied, there was a 20% increase in the peak current for 1 ms of an inter-trial-interval compared to 4.7% for 20 ms of the interval. Changing the Gate Voltage from 1V to 3V increased the peak EPSC current from 4.7% to 12%, results favorable to literature. This research is representative of a new kind of artificial intelligence: one defined by architecture, not algorithms. Applications, not limited to gaining a vastly better understanding of the intricate workings of the human brain, include very energy-efficient technologies and neuromorphic device opportunities.

Awards Won:

First Award of $5,000