Photoconducting neuromorphic elements with synaptic memory effect based on semiconductor metal oxides

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One of the promising future ways of computing is using principles similar to the human brain work mechanism. Neuromorphic photonics makes it possible to create computational elements with properties similar to the principles of the biological synapse. Neuromorphic computers can overcome the von Neumann bottleneck [1] fundamental limitation of existing computing systems. There is an urgent need to develop hardware suitable for neuromorphic computing. A neuromorphic integrating circuit needs to have plasticity properties, operates spiking signals and combine computation and memory functions. Some papers previously presented structures with similar properties [2, 3].

In a current study, we demonstrate a neuromorphic properties, observing on photoconductive structures based on nanocrystalline ZnO, In2O3 triggered by presynaptic light spikes with the 405 nm wavelength. Photoconductive structures based on ZnO, In2O3 were deposited as a $100 - 200$ nm thick film on the surface of the chip. This chip allows us to measure photoconductivity with two Pt electrodes and heat the metal-oxide layer up to 300°C.

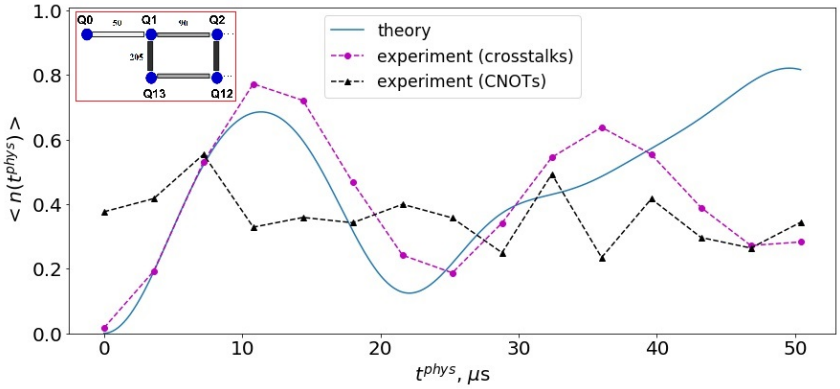

Figure 1: Long-term-memory behavior of the light-stimulated synaptic transistors with a presynaptic light pulse width of 300 s. (405 nm, 8 mW/cm^2).

To study the neuromorphic properties of samples, the excitatory post-synaptic current value was measured for different excitation pulse durations. The excitatory post-synaptic current caused by a pair of presynaptic light spikes was studied for different delay times between pulses. Besides, the ability of these structures to act as biological synapses like high-pass temporal filtering function was demonstrated by measuring post-synaptic current when exposed to a series of 30 consecutive presynaptic light spikes.

The studied photoconductive structures showed the presence of a spike reaction properties, the effect of amplitude and frequency filtering, short-term and long-term memory, and they are looking promising for use as elements of neuromorphic photonics.

References

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