Is my device neuromorphic?

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Typical neuromorphic systems are composed of a big set of processing nodes, or artificial neurons. Each of them has thousands of inputs from other neurons. At each connection of neurons, there is an artificial synapse, which is a memory element in neuromorphic systems. Central to this talk is a development of a device with memory to implement the synapse, as well as a nonlinear device for data processing as is done in the neuron. If we define the synapse and neuron in this way, one might conclude that basically any device with memory can be used for synapses and any nonlinear device for neurons. However, when it comes to the development of truly efficient and intrinsically useful neuromorphic devices, **there are criteria that make the difference.** In this talk we will focus on the criteria to **make diagnosis whether a device may be neuromorphic**.

As an example, we present our $SrTiO_3$-based artificial synapse and neuron. The behavior of the synapse is governed by spike-timing-dependent plasticity (STDP), which is a standard learning protocol. The neuron behavior is leaky integrate-and-fire (LIF). Characteristics of both devices are shown in Fig. 1. They meet the criteria above for neuromorphic devices, but present shortcomings in other aspects, which will be discussed in the talk.

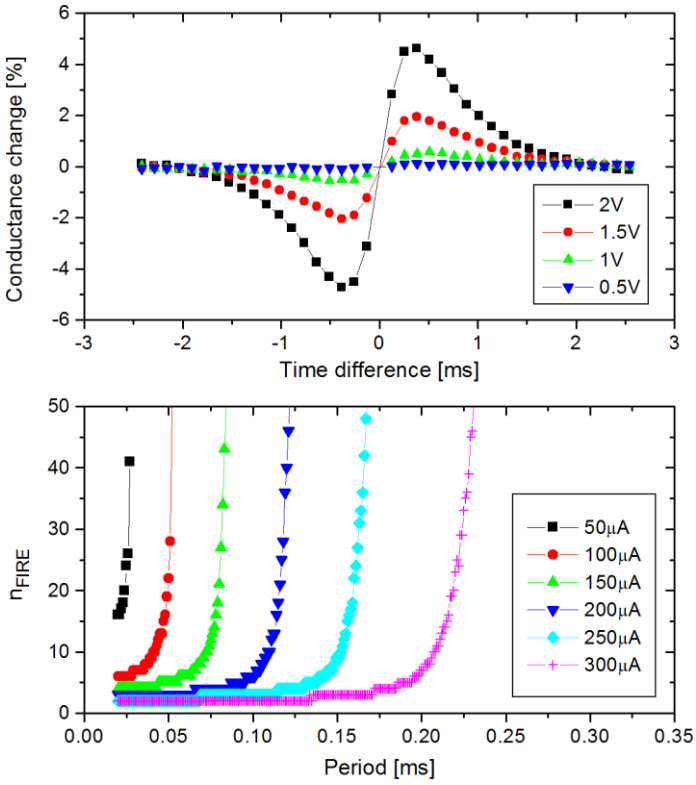

Fig. 1: Characteristics of our artificial synapses (top) and the firing of our artificial neurons (bottom).

The physical principle behind our devices is the insulator-to-metal transition of $SrTiO_3$ caused by the electrostatic carrier density modulation, and inhomogeneous channel formation. To use the metallic channel is an advantage in terms of scaling, but if we consider the die area and the power efficiency, the advantage is not so clear. We will also discuss on this important issue during the talk.

References: Eyvazov *et al.* Sci. Rep. 2013; Kumar *et al.* Sci. Rep. 2016; Schulman *et al.* APL 2017.