Pulse-controlled access to volatile and non-volatile multibit states in ferroelectric oxide thin films for neuromorphic hardware

A.G. Boni(1) , C.F. Chirila(1), I. Spinu(1), P. Tsipas(1,2), D. Popescu(1), L. Pintilie(1) and A. Dimoulas(1,2)

(1) National Institute of Materials Physics, Atomistilor 405A, Magurele 077125, Romania, (2) Institute of Nanoscience and Nanotechnology, National Center for Scientific Research DEMOKRITOS, Neapoleos 27 and Patriarchou Gigoriou Str, Athens, Attiki 15341, Greece

Neuromorphic hardware requires device platforms with electrically tunable internal states, low-power operation, and the ability to support both transient and persistent response modes. Ferroelectric oxide thin films are of interest in this context because partial polarization switching can provide access to intermediate electrical states relevant to non-conventional computing schemes. In this work, we investigate pulse-controlled state tuning in selected ferroelectric oxide thin-film structures and discuss its relevance for neuromorphic hardware.

By applying electrical pulse sequences with controlled amplitude, width, and repetition, we access multiple electrically distinguishable states, including both volatile and non-volatile regimes. The observed response depends on the device configuration and operating conditions. In some structures, the pulse-induced state evolution is mainly reflected in capacitive behavior, consistent with memcapacitive features, while in others it is associated with resistive changes resembling memristive behavior. These results indicate that ferroelectric oxide thin films can provide more than one electrically readable route for state encoding.

Particular attention is given to multibit state controllability, as gradual pulse-driven modulation is relevant for hardware approaches inspired by synaptic weight update. In addition, preliminary pulse-train experiments reveal response trends that are compatible with synaptic-like functionality. Rather than introducing a new neuromorphic concept, these results show that appropriately designed ferroelectric oxide structures can access different operating regimes of interest for adaptive and energy-efficient hardware. The present study therefore supports the use of ferroelectric thin films as a versatile materials platform for neuromorphic device exploration.

[1] A.G. Boni et al., Phys. Rev. Applied **12**, 024053, 2019.

[2] A.G. Boni et al., Nanoscale, 9, 19271-19278, 2017.