Ferroelectric Domains Dynamics in Memristive Tunnel Junctions based on Super-Tetragonal $BiFeO_3$

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Ferroelectric tunnel junctions (FTJs) [1] consist of an ultrathin ferroelectric film sandwiched between two electrodes. The information is encoded through the non-volatile ferroelectric polarization than can be switched with an electric field. The tunneling current is influenced by the ferroelectric polarization direction, enabling a simple non-destructive readout of the polarization state [2].

Following our previous work with $BaTiO_3$-based FTJs [3, 4], we recently focused our attention to FTJs based on super-tetragonal $BiFeO_3$ (T-BFO), a material with a very large polarization. We will present results from scanning transmission electron microscopy which reveal that these ultrathin T-BFO films have a large tetragonality and a native ferroelectric polarization pointing toward the bottom electrode of $(Ca,Ce)MnO_3$ [5]. FTJs based on ultrathin T-BFO films show fast, stable and repeatable switching with very high resistance ratios of up to four orders of magnitude [6, 7]. Moreover, quasi-continuous resistance variations can be achieved depending on the amplitude and time of voltage excitations. Thus, FTJs behave as memristors [4] that could be implemented as nano-synapses in neuromorphic architectures. Combined piezoresponse force microscopy (PFM) and electrical measurements give a clear correlation between ferroelectric domain configurations and multiple resistance states. As a consequence, the memristive response of the FTJ provides insights into the switching dynamics of ferroelectric domains in response to trains of nanosecond pulses. We will show recent experiments on cumulative pulses dynamics using both transport measurements and PFM imaging, with possible interpretations considering nucleation of ferroelectric domains with limited propagation as well as Monte Carlo simulations [8].

(We acknowledge financial support from the European Research Council (ERC Advanced Grant FEMMES, No. 267579))

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