Ferroelectric tunnel junctions for information storage and processing

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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 that can be switched with an electric field. Switching the ferroelectric polarization induces large variations of the tunnelling current, enabling a simple non-destructive readout of the polarization state [2]. Furthermore, as polarization switching occurs through the nucleation and propagation of domains, a continuous (analog) change of resistance with non-uniform domain configurations is achievable [3]. This memristive behaviour expands the scope of applications of FTJs from digital storage to brain-inspired computation.

Following our seminal work with $BaTiO_3$-based FTJs [2-3], we will present recent results with tunnel junctions based on ultrathin films of super-tetragonal $BiFeO_3$ [4-7]. The FTJs show fast, stable and repeatable switching with OFF/ON ratios of 10^4 [5-6], although these properties depend on various parameters such as the size or electrodes of the FTJs [7]. Scanning transmission electron microscopy reveals that these ultrathin $BiFeO_3$ films have a large tetragonality with potentially large polarization [4]. Combining piezoresponse force microscopy (PFM) and electrical measurements, we demonstrate a clear correlation between ferroelectric domain configurations and multiple resistance states [5]. Thus, the memristive response of the FTJ provides insights into the switching dynamics of ferroelectric domains. Experiments on cumulative pulse dynamics using both transport and PFM measurements are interpreted by a nucleation-limited model occurring through a disordered ferroelectric.

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