Ferroelectric tunnel junctions

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In 1971, Esaki et al. proposed to couple ferroelectricity, with quantum-mechanical tunnelling in ferroelectric tunnel junctions composed of metallic electrodes with a ferroelectric tunnel barrier. In these ferroelectric tunnel junctions, large changes in the resistance are observed and correlated with the direction of the ferroelectric polarisation of the barrier [1]. This give rise to large electroresistance phenomena (TER) that amounts to 75000% for a 3nm $BaTiO_3$ tunnel barrier as revealed by scanning probe microscopy. This resistance switching in solid-state ferroelectric tunnel junctions is large, fast, stable, reproducible and reliable electroresistance offering new opportunities for ferroelectrics in future data storage [2].
By controlling the ferroelectric domain configuration, they also offer the opportunity to obtain reproducible intermediate resistance states. Voltage-controlled of the domain configurations in these ferroelectric tunnel barriers thus yield a memristive behaviour with resistance variations exceeding two orders of magnitude and a 10 ns operation speed. Using models of ferroelectric-domain nucleation and growth, we explain the quasi-continuous resistance variations and derive a simple analytical expression for this memristive effect. Our results suggest new opportunities for ferroelectrics as the hardware basis of future neuromorphic computational architectures [3].
Combined with ferromagnetic electrodes in a ferroelectric-ferromagnetic-tunnel junction, a modulation of the tunnel magnetoresistance, reflecting changes in the spin polarisation of the electrode when the ferroelectric polarisation is switched, has been observed [4]. These junctions thus also provide an interesting opportunity to obtain a robust room temperature magnetoelectric effect and to achieve an electric control of the spin polarisation.

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3] Nature Materials 11,860 (2012); ACS Nano 7, 5385 (2013)
4] Science 327, 1106 (2010) ; Nature Materials 10, 753 (2011)
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