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Combining Ferroelectricity, Magnetism, and Superconductivity in Tunnel Junctions – "Neue Abenteuer für Tunnelelektronen"

Complex oxides display a rich variety of physical phenomena including magnetism, superconductivity, and ferroelectricity. From many points of view it is an interesting approach to combine these (partly antagonistic) cooperative phenomena in tunnel junctions. On the one hand, new device functionalities are expected in such complex junctions. On the other hand, tunneling electrons are extremely sensitive to the barrier and interface excitations and, therefore, represent an ideal spectroscopic tool to extract material properties on the nanometer and even atomic scale.
First, we will present our theoretical and experimental results on the so-called ferroelectric tunnel junctions (FTJs). These junctions consist, e.g., of $SrRuO_3/BaTiO_3/SrRuO_3$ trilayers grown on SrTiO3 by high-pressure sputtering. The heterostructures were investigated by means of x-ray diffraction to determine crystallographic structure and lattice strains. Then the electrical properties of FTJs were determined by resistive transport measurements and by recording the polarization-voltage hysteresis loops. Size effects observed in ultra-thin ferroelectric films will be discussed, as well as the theoretical models of the interplay between electron tunneling and polarization state of the barrier.
Second, we will provide an overview for the current status of the international studies of the so-called multiferroic tunnel junctions. By combing ferroelectric or multiferroic tunnel barriers with ferromagnetic and/or superconducting electrodes, a whole “zoo” of novel tunnel junctions can be proposed. The results already obtained for these new types of tunnel junctions and the theoretical and experimental challenges existing in this area will be discussed.

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