Novel Functionalities at Oxide Interfaces

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Perovskites display within the same family of compounds a variety of exciting electronic properties ranging from ferroelectricity to ferromagnetism and superconductivity. These systems are often characterized by strong electronic correlations, complex phase diagrams and competing ground states. This competition makes these materials very sensitive to external parameters such as pressure or magnetic field. An interface, which naturally breaks inversion symmetry, is a major perturbation and one may thus expect that electronic systems with unusual properties can be generated at oxide interfaces [see for instance 1-3]. I will in this lecture give three examples of exciting interface phenomena found in oxide heterostructures.

The first striking example is the interface between $LaAlO_3$ and $SrTiO_3$, two good *insulating* perovskite oxides, which was found in 2004 to be conducting with a high mobility [4], and superconducting with a critical temperature of about 200 mK [5]. Field effect experiments revealed the sensitivity of the normal and superconducting states to the carrier density. In particular, the electric field allows the on-off switching of superconductivity and reveals a strong spin orbit coupling that depends on the doping level of the system [6,7].

$PbTiO_3$ / $SrTiO_3$ epitaxial ferroelectric / paraelectric superlattices have also proven to be an exciting system. Over most of the compositional range, the structural and electrical properties can be well described by a simple Landau-theory-based electrostatic model with bulk $PbTiO_3$ and $SrTiO_3$ parameters [8,9]. However, as the individual layers get thinner and the number of interfaces increases, an unusual coupling between oxygen octahedral rotations and the polar mode is found leading to improper ferroelectricity [10]. Such a coupling was shown to be a path to the development of novel multiferroic materials [11].

I will finally talk about nickelate based structures where charge transfer and charge ordering phenomena may also be a way to induce novel properties. In (111) $LaNiO_3$/$LaMnO_3$ (LNO/LMO) superlattices, we observed ferromagnetic behavior below 200K, with a temperature-dependence of the magnetization very similar to that of single LMO thin films. However, at lower temperatures, the magnetization loops become asymmetric indicating that exchange bias develops in this regime. Such biasing is the signature of a magnetic order that is induced within the paramagnetic LNO material when embedded between ferromagnetic LMO layers [12].

Through these different examples, I will discuss how these materials are prepared and characterized.

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