Why are Ultrathin Films of Metallic Oxides Nonmetallic?

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It has been discovered that many collective phenomena such as high-temperature superconductivity, "colossal" magnetoresistance, and quantum criticality, which do not appear in simple semiconductors, are emergent in complex correlated electron materials (CMEs). Even more surprisingly, many fascinating properties emerge at surfaces, interfaces, and artificial heterostructures of CEMs, the materials beyond mother nature. "The challenge is to understand how such collective phenomena emerge, discover new ones, and to determine which microscopic details are important and essential."

In contrast with the metallic or even superconducting phenomenon emerging at the interface of two insulating oxides such as $LaAlO_3/SrTiO_3$, several ultrathin films of metallic oxides exhibit nonmetallic behavior, challenging our understanding of these materials at interface and possible technological application. For such "dead layer" phenomena, the central question is: *is this an intrinsic effect caused by dimensional confinement, or caused by strain, interface, segregation, impurity, or stoichiometry*? We have systematically studied the thickness-dependence of structure/ properties for $La_{2/3}Sr_{1/3}MnO_3$ (LSMO) on $SrTiO_3$(001) by using *in-situ* growth of laser MBE and characterization such as LEED, XPS and STM, and *ex-situ* transport measurements. With optimized growth conditions to minimize the oxygen deficiency (oxygen non-stoichiometry), we were able to focus on the other effects associated with the dead layer. In this talk, I will summarize our recent results on the dead layer of LSMO by showing that the dimensionality/structure effects play key role in determining the dead layer. With this optimized quality of ultrathin films, new critical behaviors emerge, such as the non-monotonic structure relaxation with thickness, the enhanced magnetoresistance effect and extreme sensitivity to strain at the critical thickness at ~ 6 unit cells. These behaviors are proposed to correlate with subtle balance of different competing effects.

Supported by US Department of Energy and US National Science Foundation.

Detailed about Zhang's research group can found at http://www.phys.lsu.edu/material-physics/

Colloquium

April 25, 2013
4:00 PM
JH 136
Refreshments in the JH 1st Floor Vending Area at 3:30