Tunable Complex Oxide Nanostructures

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Interfaces have emerged as key focal points of current condensed matter science. In complex, correlated oxides, heterointerfaces provide a powerful route to create and manipulate the charge, spin, orbital, and lattice degrees of freedom. The most common interface has been shown is artificially constructed heterointerfaces. In ferroic oxides, such as ferroelectrics, domain walls emerge as natural interfaces as a consequence of the minimization of electrostatic and elastic energies. The interaction of degrees of freedom at the interface has resulted in a number of exciting discoveries including the observation of a 2-D electron gas-like behavior at $LaAlO_3$-$SrTiO_3$ interfaces; the emergence of the ferromagnetism in a superconducting material at a $YBa_2Cu_3O_{7-x}$-$La_{0.7}Ca_{0.3}MnO_3$ interface. Recently, several key studies pointed out interesting observations on domain walls in multiferroics, including an observation of insulating interlocked ferroelectric and structural antiphase domain walls in $YMnO_3$ system, the source of the exchange bias interaction between the ferromagnetic metal layer and multiferroic, and local conduction in $BiFeO_3$. These complex oxide interfaces create a huge playground to discover new emergent phenomena. The key question I would like to address in this manuscript: is there any other types of complex oxide interfaces? Will we be able to create intriguing functionalities by designing new types of complex oxide interface? In order to search for new types of complex oxide interfaces, we must go back to examine the existing oxide heterostructures. We found there is one more category has been widely demonstrated, epitaxial self-assembling nano-composites. Such a heterostructure has been shown to enhance or create properties by interface-mediated coupling or local confinement, such as magnetoelectricity, ferroelectrcitiy, low field driven large magneto-resistance. However, there is no systematical study on the interfacial properties in these nano-composites. The key concept is to treat these interfaces as tubular oxide interfaces. Such a concept has been demonstrated in nanowire society in a lot of core-shell structures. Recent demonstration of the photovoltaic device based on this concept is a hint to re-invent the interface between strongly correlated systems. In this presentation, I will show the local coupling located at the interfaces of vertical heterostructure in three examples, $BiFeO_3$-$CoFe_2O_4$, $SrRuO_3$-$CoFe_2O_4$, and $(La,Ca)MnO_3$-$CoFe_2O_4$. Such results open new pathways to create the interfacial properties of an oxide tubular interfaces.