Engineering Interface Magnetism and Transport *via* Defect Ordering in Complex Oxide Heterostructures

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The remarkable functionality of complex oxides provides many opportunities for new science and applications in oxide heterostructures. The manganites and cobaltites crystallizing in the perovskite structure provide excellent examples, being of interest in solid oxide fuel cells, catalysis, gas separation, ferroelectric RAM, resistive switching memory, and oxide electronics/spintronics. However, the same delicate balance between phases that provides such diverse functionality also leads to a serious problem: The difficulty of maintaining desired properties (*e.g*. high spin polarization) close to the interface with other oxides, *i.e.* the "dead layer" problem. Although this appears universal, and presents a significant roadblock to heterostructured devices for oxide electronics/spintronics, there is no consensus on its origin. In this work, using $SrTiO_3/La_{1-x}Sr_xCoO_3$ as a model system (a non-magnetic semiconductor / ferromagnetic metal interface), we have determined the fundamental origin of the deterioration in interfacial transport and magnetism. The effect is due to nanoscopic magnetic inhomogeneity near the interface, driven by depletion in hole doping due to accumulation of oxygen vacancies. This occurs due to a novel mechanism for accommodation of lattice mismatch based on formation and long-range ordering of oxygen vacancies. With this understood we demonstrate how interfacial magnetic and electronic properties can be fine-tuned by manipulating oxygen vacancy ordering using strain and crystallographic orientation. The result is a large suppression in dead layer thickness, an important advance for heterostructured oxide devices. Other surprising results, such as oxygen-vacancy-order-enhanced anisotropic magnetoresistance and perpendicular magnetic anisotropy will be touched upon.

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