FLAIR Colloquium

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Electronic Structure Engineering through Atomic-Scale Strain Control in Complex Oxide Heterostructures

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In complex oxide quantum systems, atomic configurations and electronic states are pivotal for understanding exotic phenomena. By modifying strain through epitaxial thin films on diverse substrates, we precisely control local physical properties, revealing novel insights. First, we investigate $La_{0.5}Sr_{0.5}MnO_3$-La_2CuO_4 heterostructures on different substrates, unveiling how epitaxial strain-induced charge redistribution leads to diverse magnetic phases. Epitaxial strain's impact on charge redistribution, counter to single-phase films, influences macroscopic physical properties. This highlights epitaxial strain's role in shaping microscopic charge and spin interactions, offering fresh perspectives on interface engineering.

Next, we explore electron redistribution in LiV_2O_4 films on $SrTiO_3$ and MgO substrates, uncovering competing behaviors: a metallic charge-disordered phase on $SrTiO_3$ and an insulating charge-ordered (CO) phase on MgO. Notably, strained LiV_2O_4 on MgO stabilizes the [001] Verwey-CO phase due to epitaxial strain, deviating from the previously observed [111] CO. In the third part, we delve into $SrRuO_3$ (SRO) quantum dots (QDs) and their distinctive magnetic properties. Magnetic behavior is observed in SRO QDs of various sizes, with relief of epitaxial strain as a key factor. These findings introduce a new approach to tailoring magnetic properties in oxide heterostructures, advancing our understanding of magnetic behavior mechanisms. Patterned QD arrays with novel magnetic configurations hold promise for next-generation spintronic devices.

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