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Interface engineering of metal-oxygen bonds as a new route for exploring functional properties of transition metal oxides

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Metal-oxygen bonds in transition-metal oxides are responsible for a broad spectrum of functional properties, and atomic-level control of the bonds is a key for developing future oxide-based electronics. Artificial heterostructures with chemically abrupt interfaces consisting of dissimilar oxides have provided a good platform for engineering novel bonding geometries that could lead to emergent phenomena not seen in bulk oxides. Here we show that the Ru-O bonds (or oxygen coordination environments) of a perovskite, $SrRuO_3$, can be controlled by heterostructuring $SrRuO_3$ with a thin (0–4 monolayers thick) $Ca_{0.5}Sr_{0.5}TiO_3$ layer grown on $GdScO_3$ substrates [1]. We found that a Ru-O-Ti bond angle characterizing the $SrRuO_3/Ca_{0.5}Sr_{0.5}TiO_3$ interface structure can be engineered by layer-by-layer control of the $Ca_{0.5}Sr_{0.5}TiO_3$ layer thickness, and that the engineered Ru-O-Ti bond angle not only stabilizes a Ru-O-Ru bond angle never seen in bulk $SrRuO_3$ but also tunes the magnetic anisotropy in the entire $SrRuO_3$ layer. The results demonstrate that interface engineering of the metal-oxygen bonds is a good way to control additional degrees of freedom in designing functional oxide heterostructures.
[1] D. Kan et al Nature Materials 15, 432 (2016).