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.