Twisted oxide membrane interface by local atomic registry design

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Moiré interference between twisted complex oxides offers new prospects for fundamental research and the discovery of novel physical phenomena, such as 2D dipole crystals with moiré periodicity, non-collinear magnetism, coexisting moiré periodic antiferromagnetic and ferromagnetic order, and topological magnetic quasiparticles. We designed moiré crystals at the coincidence site lattice condition, providing commensurate structure within the moiré supercell arising from the multi-atom complex oxide unit cell. We fabricated such twisted bilayers from freestanding $SrTiO_3$ membranes and used depth sectioning-based TEM methods to discover ordered charge states at the moiré interface. By selectively imaging $SrTiO_3$ atomic planes at different depths through the bilayer, we clearly resolved the moiré periodic structure at the twisted interface and found that it exhibits lattice-dependent charge disproportionation in the local atomic registry within the moiré supercell. Our density-functional modelling of the twisted oxide interface predicts that these moiré phenomena are accompanied by the emergence of a two-dimensional flat band that can drive new electronic phases. Our work provides a novel guideline for controlling moiré periodicity in twisted oxides and opens pathways to exploit the new functionalities via moiré lattice-driven charge-orbital correlation.

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