Twist-Programmable transport in $BaTiO_3$ Moiré membranes

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Twisted 2D van der Waals stacks have revealed emergent electronic phases driven by moiré superlattice potentials. Recent progress in releasing and transferring single-crystalline transition-metal-oxide membranes has now brought complex oxides into the moiré arena. As correlated 3d-electron systems, oxides host intertwined charge, lattice and spin degrees of freedom, often featuring ferroic order persisting to room temperature, raising the prospect of chiral polar and magnetic textures shaped by twist-controlled interlayer couplings. Yet oxide moiré platforms depart fundamentally from the vdW paradigm because their strong bonding: registry-dependent ionic–covalent bonding, surface terminations and oxygen defect chemistry can drive interfacial reconstruction, disordered layers or even gap-like separations. While substantial effort is directed toward sharpening and reconstructing these interfaces, such defect-enabled interlayers may themselves be functional, providing reconfigurable barriers in which transport is mediated by vacancy-related traps and thermally assisted emission.
In this talk, I will focus on twisted BaTiO3 membrane junctions with symmetric Au electrodes, where the moiré interface acts as a geometrically programmable barrier for oxygen-vacancy motion. Vacancy blocking establishes a non-uniform defect profile and an interfacial dipole that re-partition the electric field and render transport strongly temperature- and sweep-history dependent: at high temperature we observe pronounced irreversibility consistent with a bias-conditioned, trap- and space-charge–modified barrier, whereas cooling suppresses this history dependence and drives a crossover toward field-emission–dominated transport. Increasing twist angle systematically attenuates the irreversibility, consistent with enhanced vacancy confinement and faster relaxation of bias-induced space charge. These results position twist as a single geometric knob to engineer defect electrostatics, enabling reconfigurable memristive elements and suggesting a route to volatile neuromorphic primitives in freestanding oxide membranes.

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