Domain Anti-ferroelectric in twisted van der Waals Homojunctions

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Controlling the interlayer twist angle in an artificial two-dimensional (2D) van der Waals (vdW) interface offers an experimental route to create a moire superlattice. One can create exotic electronic states by minimizing electronic bandwidth with a tunable moire length scale. However, in the small twist angle regime, vdW interlayer interaction can cause significant structural reconfiguration at the interface, creating the arrays of domain structures. Particularly, in the crystal symmetry engineered twisted bilayer polar crystals, unconventional ferroelectricity can arise to exhibit the ferroelectric switching mechanism. Here we performed an in-situ transmission electron microscopy (TEM) investigation on dual gated twisted bilayer transition metal dichalcogenides (TMD) devices that enable real-time observation of polar domain dynamics in a 2D system. In combination with the theoretical investigation, we find the polarizability of the twisted bilayer TMD sensitively depends on the moire length and the domain shapes. We also report on the angle-dependent development of ferroelectricity and unconventional domain antiferroelectricity in the twisted bilayer TMD that exhibits intriguing distinction from conventional ferroelectricity and antiferroelectricity.