Twintronics:
Ferroelectric domain structures in twistronic 2D crystals

Vladimir Fal'ko
National Graphene Institute, University of Manchester, UK

Over the recent years, several studies have established ferroelectric properties of rhombohedral transition-metal dichalcogenides (TMD), both grown as bulk crystals and assembled into twisted bilayers and multilayers [1-5]. For bilayers assembled from monolayer TMD crystals with parallel orientation of unit cells, lattice reconstruction (characteristic for small-angle twisted bilayers [6,7]) results in the out-of-plane polarised ferroelectric domains and networks of domain walls, switchable by mutual sliding of the monolayers promoted by an out-of-plane electric field [3] and manifested in the hysteretic field-effect transistor [4] and tunneling FET operations [8], and readable optically by the linear Stark shift of the interlayer excitons [9].

In bulk 3R-TMD crystals, groups of layers with the same stacking order appear as three-dimensional twins separated by planes of twin boundaries. Now, we propose [10] the formation of two-dimensional (2D) electron/hole gases at twin boundaries, analyse their stable density in photo-doped structures, which appears to be in the range of $n^{*}\sim 8x10^{12}cm^{-2}$ for electrons at both intrinsic mirror twin boundaries in bulk crystals and twisted twin boundaries in structures assembled from two thin mono-domain films. We also predict the values of 'magic' twist angles between the assembled twins, for which the commensurability between the accumulated carrier density, n^{*}, and moiré pattern would promote the formation of a strongly correlated state of electrons, such as Wigner crystal.

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