Twintronics of van der Waals ferroelectrics

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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, prompted by an out-of-plane electric field [3], manifested by the hysteretic field-effect transistor [4] and tunneling FET [8] operations, 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. Here, 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 ‘magic’ values of 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 a Wigner crystal.

References

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Figures

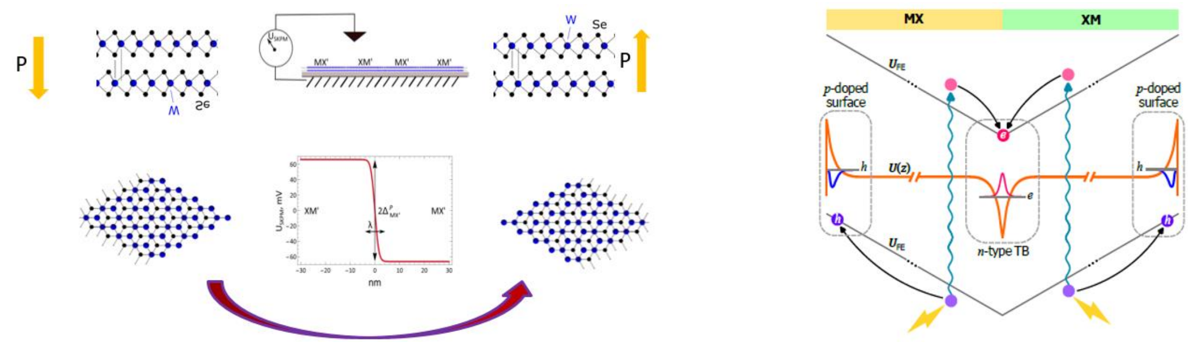

Figure 1: Left: interfacial ferroelectric polarisation, switchable by sliding. Right: electron accumulation at the planes of twin boundaries (internal or twistronic) in thin films of rhombohedral transition metal dichalcogenides.