Quantum spin Hall states in monolayer 1T' transition metal dichalcogenides

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A quantum spin Hall (QSH) insulator, or a two-dimensional topological insulator, is a novel quantum state of matter highlighted by quantized Hall conductance in the absence of magnetic field. Such transport properties are tightly integrated with the electronic structure, with key signatures such as topologically protected helical edge states that bridges the energy gap opened by band inversion and strong spin-orbit coupling [1].

By combining angle-resolved photoemission spectroscopy (ARPES), first-principles calculations, and scanning tunnelling microscopy/spectroscopy (STM/STS), we have investigated the electronic structures of epitaxially-grown monolayer 1T' transition metal dichalcogenides, WTe_2, WSe_2, and $MoTe_2$, candidate QSH insulators [2]. For 1T'-WTe_2, we indeed observed all the characteristics of QSH insulator, the band inversion, band gap opening, and geometry-independent edge states, consistent with the theoretical expectations [3]. While 1T'-WSe_2 shares the same essential features of electronic structure with 1T'-WTe_2, it is naturally *n*-doped to give a band gap at higher binding energy [4]. 1T'-$MoTe_2$ is found to have a significant overlap between conduction and valence bands due to the moderate strength of spin-orbit coupling [5].

References

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[4] M. M. Ugeda *et al.*, Nature Communications **9**, 3401 (2018).

[5] S. Tang *et al.*, APL Materials **6**, 026601 (2018).

Figures

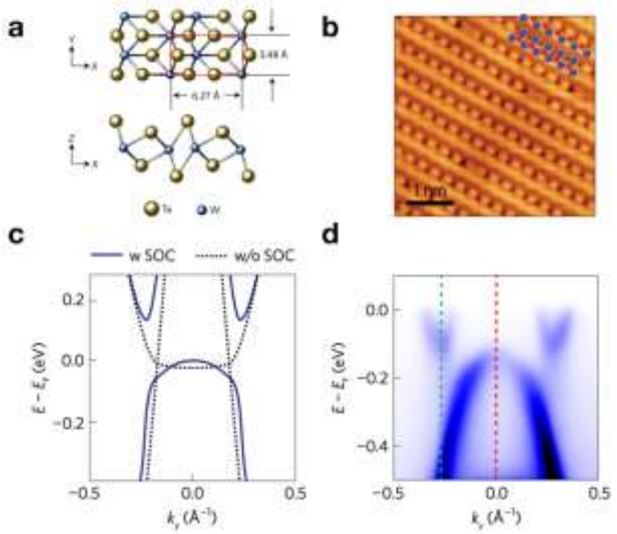

Figure 1: (a) Crystal structure and (b) real-space STM topography of monolayer 1T'-WTe_2. (c) Theoretical and (d) ARPES band structures of monolayer 1T'-WTe_2. Clear signatures of band inversion and band gap opening are observed.

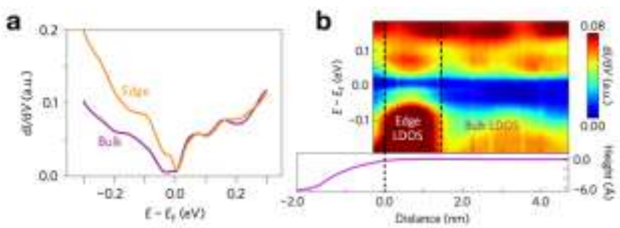

Figure 2: (a) STS spectra for bulk and edge of the monolayer 1T'-WTe_2. (b) Spatial map of STS spectra shows that the edge state is well-localized within a few nanometers.