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Layered Chalcogenides beyond Graphene: from Electronic Structure Evolution to the Spin Transport

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Recent efforts on graphene-like atomic layer materials, aiming at novel electronic properties and quantum phenomena beyond graphene, have attracted much attention for potential electronics/spintronics applications. Compared to the weak spin-orbit-interaction (SOI) in graphene, metal chalcogenides MX_2 have heavy 4d/5d elements with strong atomic SOI, providing a unique way for generating spin polarization based on valleytronics physics. Indeed, such a spin-polarized band structure has been demonstrated theoretically and supported by optical investigations. However, despite these exciting progresses, following two important issues in MX_2 community remain elusive: 1. the quantitative band structure of MX_2 compounds (where are the valleys -band maxima/minima- locating in the BZ) have not been experimentally confirmed. Especially for those cleaved ultrathin mono- and bi-layer flakes hosting most of recently-reported exotic phenomena at the 2D limit, the direct detection for band dispersion becomes of great importance for valleytronics. 2. Spin transports have seldom been reported even though such a strong SOI system can serve as an ideal platform for the spin polarization and spin transport. In this work, we started from the basic electronic structures of representative MX_2 , obtained by ARPES, and investigated both the band variation between these compounds and their band evolution from bulk to the monolayer limit. After having a systematic understanding on band structures, we reported a giant Zeeman-type spin-polarization generated and modulated by an external electric field in WSe_2 electric-double-layer transistors. The non-magnetic approach for realizing such an intriguing spin splitting not only keeps the system time-reversally invariant but also suggests a new paradigm for manipulating the spin-degrees of freedom of electrons. Acknowledge the support from DoE, BES, Division of MSE under contract DE-AC02-76SF00515.