Electronic properties of WS_2/Graphene heterostack

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Abstract

Single-layer tungsten disulphide (WS_2) is a 2D direct-gap semiconductor, with high prospects for optoelectronic and opto-spintronic applications owned to the large exciton binding energy [1], room-temperature photoluminescence [2], large band spin-orbit splitting and to the broken inversion symmetry of its crystal lattice. When vertically stacked with graphene, this van der Waals (vdW) heterostack has been proved to display greatly enticing properties, such as proximity-induced spin-orbit effects [3] and remarkable room-temperature polarization conservation [2]. However, to date, a direct observation of the electronic band structure of WS_2 on graphene is still missing. Here, we report the first experimental visualization via photo-electron spectroscopy of the valence band (VB) structure of homogenous monolayer WS_2 obtained via chemical vapour deposition (CVD) [5] on epitaxial graphene on SiC(0001) (WS_2/MLG). Remarkably, the spin-orbit splitting measured at K is 462 meV, the largest reported so far for WS_2. We also observe a significant shift of the VB towards higher binding energies. According to recent band-gap measurements of WS_2 on Ag(111) [6], the minimum of the conduction band should be close enough to the Fermi level to be reached by gating. We have measured the work function, quantitatively determining the band alignment for this system. Moreover, our band structure measurements reveal a perfect azimuthal alignment of the CVD-grown vdW hetero-stack, which could open up the way to valley-selective spin-conserving electron transfer within the heterostack. As the first thorough electronic characterization of WS_2 on graphene our work does not only set as an important reference for this vdW heterostack but unveils appealing properties such as a remarkable spin-orbit splitting, significant charge-transfer and an azimuthal epitaxial alignment, interesting for possible spin-injection prospects in the realm of opto-, spin- and valleytronics.

References

[1] Chernikov et al., PRL 113, (2014) 076802
[2] Rossi et al., 2D Mat 3, (2016) 031013
[3] Avsar et al., Nat. Comm. 5, (2014) 4875
[4] Ulstrup et al., Arxiv (2016) 1608.06023

Figures

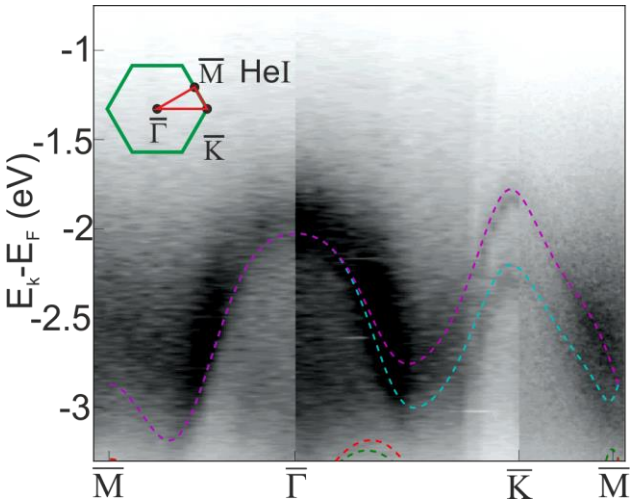

Figure 1: ARPES measured VB structure of WS_2 on MLG with density functional theory calculated bands, including the spin-orbit splitting.