Band dispersions and interlayer interactions in 2D heterostructures revealed by angle resolved photoemission spectroscopy

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We report band structure measurements of heterostructures of 2D materials, using angle-resolved photoemission spectroscopy with submicrometre spatial-resolution (nanoARPES), with a focus on heterostructures that include graphene and the MoWSeS group of semiconducting transition metal dichalcogenides (MX_2, where M = Mo / W and X = S / Se). We show that nanoARPES can directly reveal layer-dependent valence band dispersions in similar heterostructures to those used for optical and transport studies, measure interlayer hybridisation effects, and directly correlate valence band alignments to the binding energies of interlayer excitons for twisted MX_2 heterobilayers [1]. By fabricating samples in a field-effect transistor geometry, with flakes partially capped by graphene and supported by a hexagonal boron nitride on graphite back gate, we can electrostatically dope during ARPES measurements [2], populating the conduction band minimum in semiconducting samples. In this way, beyond the valence band parameters usually accessible by ARPES, the conduction band edge can be determined and inter- and intra-layer band gaps measured as a function of carrier concentration. Field-dependent band alignments between layers can also be probed [3]. In addition, twist-dependent effects interlayer interaction effects, such as moiré-induced replica bands, can be directly measured.

References

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Figures

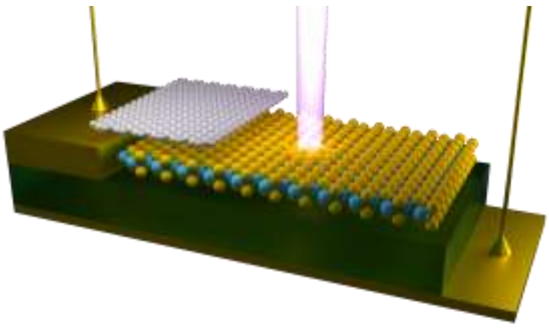

Figure 1: Illustration of 2D heterostructure under inverstigation by nanoARPES