Direct view of gate-tunable miniband dispersion in graphene superlattices near the magic twist angle

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Superlattices from twisted graphene mono- and bi-layer systems give rise to on-demand many-body states such as Mott insulators and unconventional superconductors[1,2]. These phenomena are ascribed to a combination of flat bands and strong Coulomb interactions[3]. However, a comprehensive understanding is lacking because the low-energy band structure strongly changes when the electron filling is varied. Here, we directly access the filling-dependent low energy bands of twisted bilayer graphene (TBG) and twisted double bilayer graphene (TDBG) by applying microfocused angle-resolved photoemission spectroscopy to in situ gated devices. Our findings for the two systems are in stark contrast: The doping dependent dispersion for TBG can be described in a simple model, combining a filling-dependent rigid band shift with a many-body related bandwidth change. In TDBG, on the other hand, we find a complex behaviour of the low-energy bands, combining non-monotonous bandwidth changes and tuneable gap openings. Our work establishes the extent of electric field tunability of the low energy electronic states in twisted graphene superlattices and can serve to underpin the theoretical understanding of the resulting phenomena.

References

[1] Cao et al. Nature 556 (2018) 43-50
[2] Cao et al. Nature 556 (2018) 80-84
[3] Ulstrup et al. Phys. Rev. B 94, 081403 (2016)

Figures

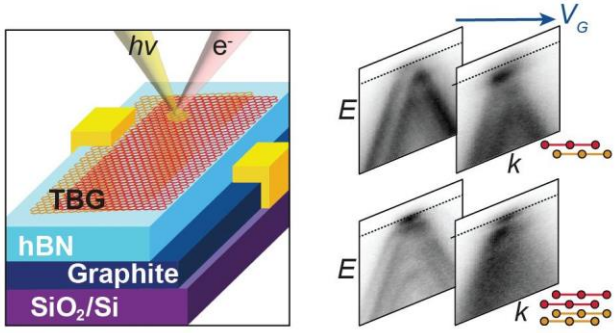

Figure 1: (Left) Schematic illustration of device architecture. (Right) Gate-tunable electronic structure of TBG and TDBG.