On demand angle control in van der Waals heterostructures

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Van der Waals (vdW) heterostructures are formed by intercalation of layered, few atoms thick crystalline materials with different electronic, mechanical and optical properties (e.g. semiconductors, insulators). Beyond the individual study of such two-dimensional materials in the ultra-clean limit, this allows us to mix the properties of several materials, yielding new and as of yet inaccessible physics. While these heterostructures have become the gold standard for probing the electronic and optical properties of graphene and other exotic materials, the control over a crucial degree of freedom has been lacking so far: the relative angle between layers, or layers alignment. This angle changes the heterostructures' properties in dramatic ways. A well-known example is graphene on boron nitride, where the relative angle between the two materials generates a periodic (Moiré) potential in graphene, strongly modifying its band structure. The absence of precise control over this angle has left these new properties out of reach so far. Here we developed an approach consisting in realizing heterostructures where the crystallographic alignment between layers can be manipulated in situ using an atomic force microscope to rotate one layer, while its mechanical and electronic properties are measured. We present results of in situ manipulation of a Moiré potential as well as tuning of the transmission between graphene layers by changing the relative orientation of the graphene crystals, Figure 1 a and b. In the later we found a 60° periodicity corresponding to crystal symmetry with additional sharp decreases around 22° and 39° (Fig. 1-c), which are among the commensurate angles of twisted bilayer graphene [1].

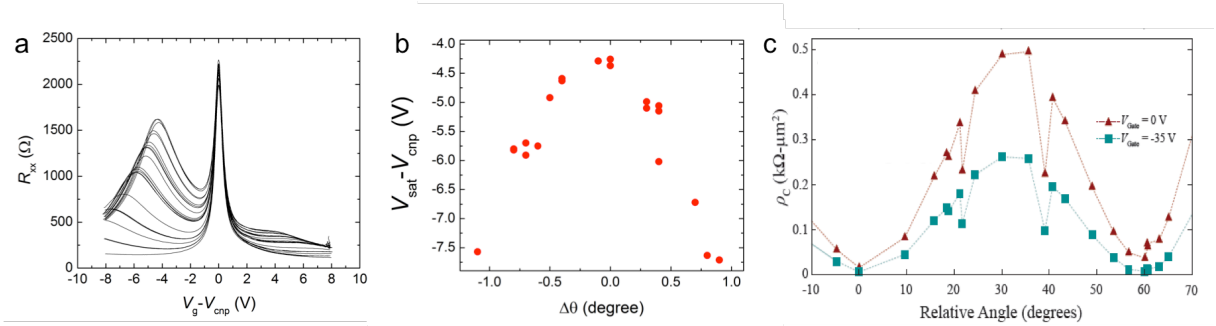

Figure 1. Angle control in van der Waals heterostructures. **a** Resistance as a function of the gate voltage for different angle alignments in a graphene/h-BN structure. **b** Position of the satellite peak as a function of the angle. **c** Resistivity across two graphene layers as a function of the angle.

Reference:

[1] Chari T. et al, Nanoletters 16, 4477 (2016).