Control of Interlayer Separation in van der Waals Heterostructures

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The electronic properties of van der Waals (vdW) heterostructures can be tuned via a number of degrees of freedom – for example, the choice of vdW materials in the heterostructure and their ordering, as well as the relative rotation between layers. The interlayer separation is another critically important degree of freedom in these vdW heterostructures as the electronic interaction between layers typically depends strongly on this spacing.

We will discuss various novel experimental efforts to control the interlayer separation in vdW heterostructures, using the case of aligned graphene on boron nitride (BN) as a testbed. First, we demonstrate the ability to compress and relax the graphene/BN spacing on the atomic scale using the vdW attraction from an STM tip (Fig. 1) [1]. Changing the interlayer separation modifies the stacking potentials of the carbon atoms in graphene with the BN substrate, and under very high compression the graphene becomes commensurately stacked with the BN locally underneath the tip.

Finally, we will discuss efforts to extend the control of interlayer separation to the device-scale using hydrostatic piston cylinder pressure cells. Aligned graphene on BN samples typically exhibit band gaps due to the interaction between layers, and we find that by compressing the layers together with pressure we are able to enhance this gap by over 40% (Fig. 2). These techniques are easily generalizable to other vdW heterostructures where interlayer interactions determine the overall electronic device properties.

References

[1] M. Yankowitz *et al.*, Nature Comm., 7 (2016) 13168

Figures

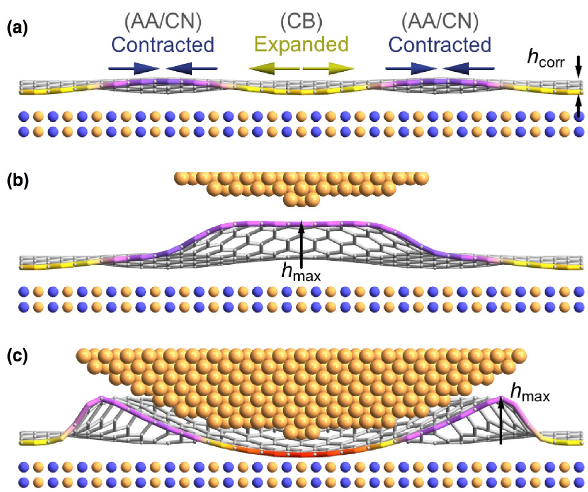

Figure 1: Schematic of the local control of interlayer separation of graphene on BN with an STM tip, showing (a) equilibrium structure, (b) local pulling of graphene off BN, and (c) local compression of graphene towards BN.

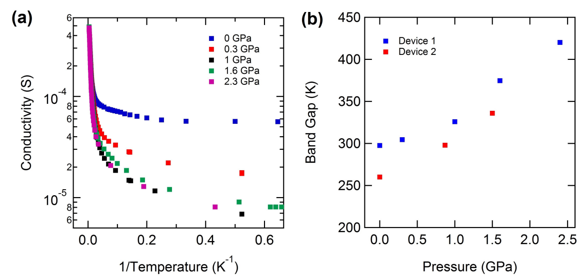

Figure 2: Electronic response of aligned graphene on BN devices under pressure. (a) The Dirac point resistance generally grows under pressure, implying (b) a growing band gap with pressure.