Nanomechanics in Van der Waals Heterostructures

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Van der Waals heterostructures are a unique arena which is constantly revealing new physics.[1] Crystallographic alignment between neighbouring crystals is a parameter that has been shown to exhibit superlattice dirac peaks,[2] the renowned Hofstadter butterfly[3] and topological currents.[4] Since then, closer attention has been paid to the mechanics of constituent crystal interactions. In particular, graphene exhibits a mechanical stretching of its lattice to conform to the potential of an hexagonal boron nitride (hBN) substrate when crystallographically aligned,[5] and it macroscopically rotates to align with hBN when they have a $\theta \approx 1\text{-}2^{\circ}$ mis-alignment.[6] We are developing devices (Fig. 1) that electrostatically move graphene across hBN allowing us to study the mechanical interactions between flakes and provide dynamic control of flake morphology. Using a combination of AFM, raman and electrical transport measurements, we present our findings and identify routes of future study. There are a number of applications for these devices, primarily in nanomechanical actuators.

References

[1] Geim. A.K., Grigorieva I.V. Van der Waals heterostructures, Nature 2013 499, 419.
[2] Yankowitz, M. et al. Emergence of superlattice Dirac points in graphene on hexagonal boron nitride, Nature Physics 2012 8, 382.
[3] Ponomarenko, L.A., et al. Cloning of Dirac fermions in graphene superlattices, Nature 2013 497, 597.
[4] Gorbachev, R.V., et al. Detecting topological currents in graphene superlattices, Science 2014 346, 448.
[5] Woods. C.R., et al. Commensurate-incommensurate transition in graphene on hexagonal boron nitride, Nature Physics 2014 10, 451.
[6] Woods, C.R., et al. Macroscopic self-reorientation of interacting two dimensional crystals, Nature Communications 2016 7.

Figures

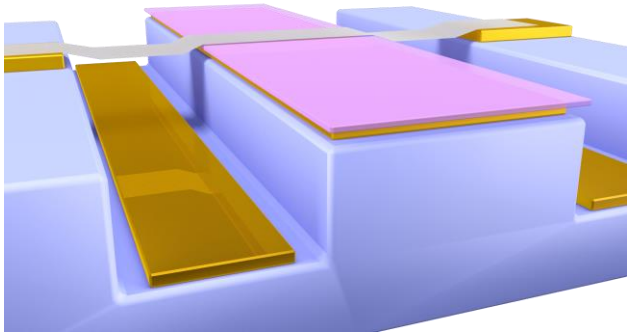

Figure 1: Cartoon of one of the types of device we have fabricated and studied.