2D crystal based Heterostructures: from Superlattices to Devices

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The isolation of various two-dimensional (2D) materials, and the possibility to combine them in vertical stacks, has created a new paradigm in materials science: heterostructures based on 2D crystals. Such a concept can be used to focus on particular phenomena or for specific applications.

In this talk I will show that layering sheets of graphene and hexagonal boron nitride (hBN),molybdenum disulfide (MoS_2), or tungsten disulfide (WS_2) allow operation of tunnelling transistors [1,2] and efficient flexible photovoltaic devices with external quantum efficiency of above 30% [3]. Furthermore, I will show that graphene placed on hexagonal-Boron Nitride (h-BN) experiences a superlattice potential, which leads to a strong reconstruction of graphene's electronic spectrum [4,5]. Raman spectroscopy is found to allow high-throughput and non-destructive identification of graphene/hBN superlattices [6], making this technique a fundamental tool in the fabrication of superlattice based-devices.
In the last part of this talk I will show that heterostructures can also be assembled from chemically exfoliated 2D crystals [7], allowing for low-cost and scalable methods to be used in heterostructures fabrication [8].

References

1. Georgiou et al, Nat. Nanotechnol. 8, 100 (2013)
2. Britnell et al, Science 335, 947 (2012)
3. Britnell et al, Science 340, 1311-1314 (2013)
4. Wallbankey al, Phys. Rev. B87, 245408 (2013)
5. Ponomarenko et al, Nature 497, 594 (2013)
6. Eckmann et al, Nano Lett. 13 (11), 5242 (2013)
7. Yang et al, 2D Materials, 1, 011012 (2014)
8. Whiters et, al Nano Letters, 14, 3987 (2014)
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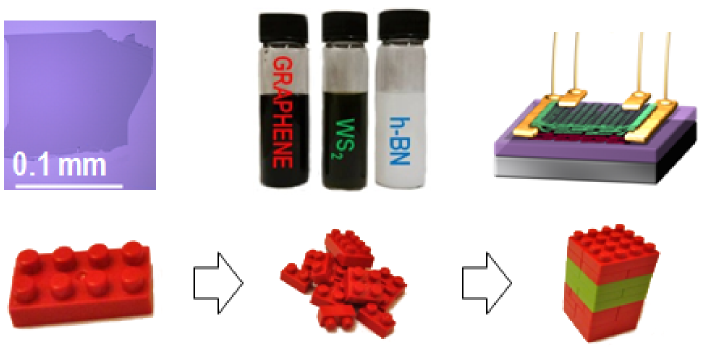

Figure 1: Heterostructure based photo-detectors can be assembled from 2D crystals inks.