in-situ electron microscopy observation during CVD growth of Graphene and controlled stacking of graphene

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Abstract

The properties of two-dimensional (2D) van der Waals (vdW) materials can be tuned through nanostructuring or by controlled stacking and modification of the electronic coupling between layers. Depending on the sacking angle, interlayer hybridization can induce exotic electronic states and transport phenomena. In my talk I will describe a viable mechanism for assisted self-assembly of twisted layer graphene. The process, which can be implemented in standard chemical vapour deposition (CVD) growth, is best described using the analogy to Origami and Kirigami of paper [1]. It involves controlled induction of wrinkle formation in single-layer graphene and subsequent wrinkle folding, tearing, and adlayer-growth. Inherent to the process is the formation of intertwined graphene spirals and conversion of the chiral angle of one-dimensional (1D) wrinkles into a 2D twist angle between layers in a three-dimensional (3D) superlattice. Seeded growth and substrate engineering can be used for tailored formation of layer stacks with pre-defined twist angles. The underlying principle is universal and can be extended to other foldable 2D materials and facilitates the production of miniaturized electronic components, including capacitors, resistors, inductors, and super-conductors. The mechanistic insights were obtained through direct observation of CVD growth inside the chamber of a modified environmental scanning electron microscope [2-4].

References

[1] ZJ Wang *et al.*, Nature Materials, in print
[2] ZJ Wang *et al.*, Nat Commun **7** (2016), p. 13256.
[3] ZJ Wang *et al. ACS Nano* 2015, 9, 2, 1506–1519
[4] ZJ Wang *et al. Adv. Mater. Interfaces 2018, 5, 1800255*

Figures

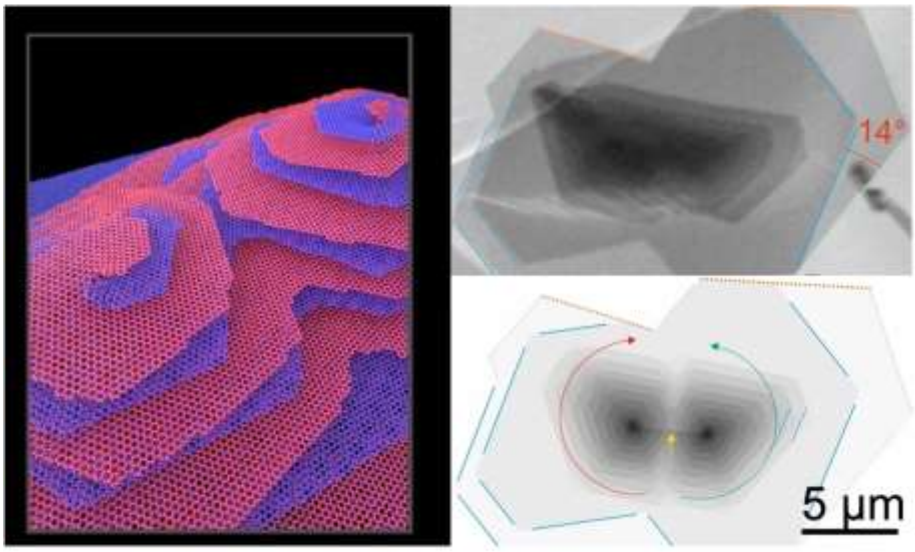

Figure 1: Spirals of twisted layer graphene with pre-defined twist-angle. Comparison between simulation and in-situ observation during CVD growth.