Self-assembly of ordered graphene nanodot arrays

Luca Camilli[1], Jakob Jørgensen[2], Jerry Tersoff[3], Adam Stoot[1], Richard Balog[2], Andrew Cassidy[2], Jerzy T. Sadowski[4], Peter Bøggild[1] & Liv Hornekær[2]

[1]*Technical University of Denmark, Ørsteds Plads, Kgs. Lyngby, Denmark*
[2]*Aarhus University, Aarhus C, Denmark*
[3]*IBM T. J. Watson Research Center, Yorktown Heights, New York, USA*
[4]*Center for Functional Nanomaterials, Brookhaven National Lab, Upton, New York, USA*

lcam@nanotech.dtu.dk

The ability to fabricate nanoscale domains of uniform size in two-dimensional (2D) materials would enable new applications in nanoelectronics and the development of innovative metamaterials. However, achieving even minimal control of growth of 2D lateral heterostructures at such extreme dimensions has proven exceptionally challenging. Very intriguing is the evolution and arrangement of nanoscale domains within a 2D layer made of boron, carbon and nitrogen (BCN) [1].

Here, we show the self-assembly and self-organisation of ordered 0D graphene dots epitaxially integrated within a 2D BCN monolayer [2]. A full set of complementary in-situ microscopy, spectroscopy and diffraction techniques is used in this study.

The graphene nanodots exhibit a strikingly uniform size, 1.6 ± 0.2 nm in diameter, a consistent lattice alignment and strong hexagonal ordering over large areas, with periodicity that can be tuned via the growth conditions. The ordering can be understood as resulting from the presence of long-range repulsive interactions among the dots, while the uniform dot size is explained by a model taking into account the dot boundary energy and a moiré-modulated interaction with the Ir substrate. This substrate interaction presumably also drives the lattice alignment among the graphene nanodots.

Because the behavior in our system results from a simple competition of edge energy and moiré-modulated substrate interaction, it might also occur for heterostructures of other 2D materials on appropriate substrates.

References:
[1] J. Lu, et al. Nature Communications **4**, 2681 (2016).
[2] L. Camilli et al., Nature Communications **8**, 47 (2017).

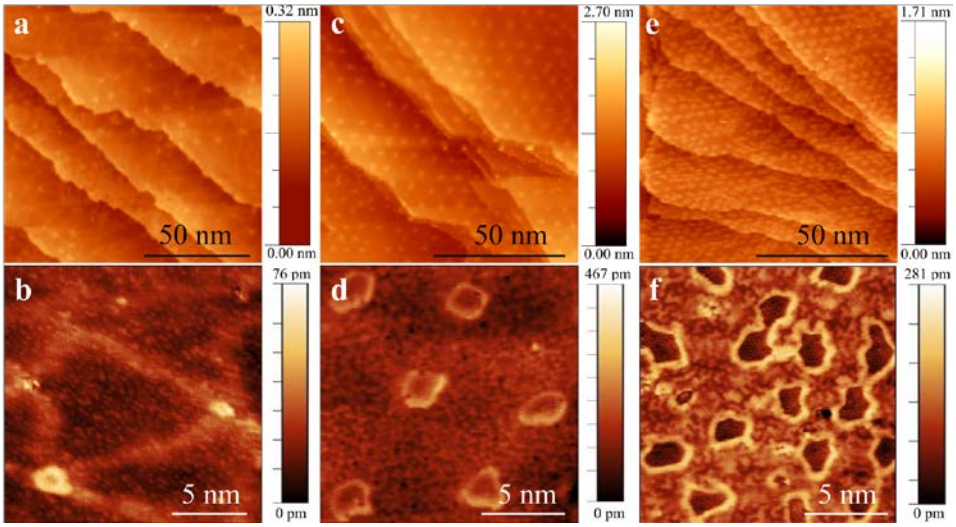

Figure 1: Scanning tunnelling microscope images of an Ir(111) surface after co-deposition of borazine and ethylene at various carbon fractions: (a, b) low, (c, d) medium and (e, f) high carbon fraction.