Fabrication of 2D materials-based nanoarchitectures via innovative CVD processes

Marc G. Cuxart
Catalan Institute of Nanoscience and Nanotechnology (ICN2), Spain.
Instituto Madrileño de Estudios Avanzados en Nanociencia (IMDEA-Nanociencia), Spain.
marc.gcuxart@icn.cat

The abilities to combine complementary two-dimensional (2D) materials and to introduce modifications at the nanoscale open compelling routes to engineer the material's properties and grant novel functionalities [1,2]. In this talk, I will introduce two innovative chemical vapour deposition (CVD) processes enabling flexible growth of atomically thin 2D materials and related heterostructures, such as borophene, hexagonal boron nitride (*h*BN) and graphene.
Specifically, the use of diborane as precursor gas yields large single-crystalline borophene domains (*i.e.*, an atomically thin layer made of elemental boron) on distinct metal supports. Subsequent addition of borazine as precursor in the process allows synthesizing *h*BN conjointly with borophene, which can selectively form lateral or vertical heterostructures. When combined laterally, borophene and *h*BN form uniform covalent lateral interfaces, while the vertically stacked configuration result in van der Waals structures that protect borophene from immediate oxidation [3]. On the other hand, the use of a single molecular precursor (borane tetrahydrofuran) providing boron and carbon enables the fabrication of 2D arrays of boron substitutional species in graphene. These are formed due to segregation of the boron atoms, which is guided by the naturally occurring moiré superstructures in Ir(111)-supported graphene [4].
Our findings are based on a comprehensive surface-science approach that combines atomic-scale and surface-averaged characterization techniques (*i.e.*, scanning tunnelling microscopy and spectroscopy STM/STS, low energy electron diffraction LEED and x-ray photoemission spectroscopies XPS/ARPES), together with first-principles calculations that provide insight into the material's structure, chemical and electronic properties, and interfacial interactions.

References

[1] J. F. Sierra *et al*., Nat. Nanotechnol, 61 (2021) 865-868.
[2] S. Ullah *et al*., Adv. Mater. Interf., 7 (2020) 2000999.
[3] M. G. Cuxart *et al*., Sci. Adv., 7 (2021) 1-8.
[4] M. G. Cuxart *et al.*, Carbon, 201 (2023) 881-890.

Figures

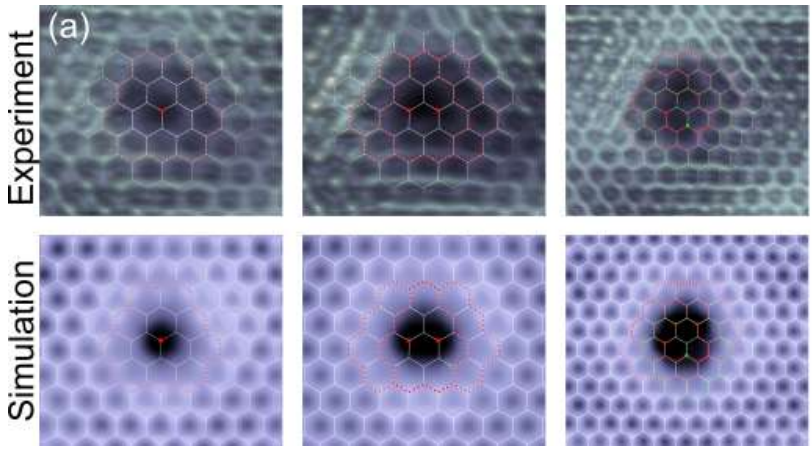

Figure 1: Comparison between experimental and simulated atomically resolved STM images of single and multiple substitutional boron heteroatoms in Ir-supported graphene.