Evidence of the formation of a single layer of graphene and hexagonal boron nitride on Pt(111) from a single molecular precursor

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Hexagonal boron nitride (h-BN) and graphene (G) are honeycomb atomic monolayer materials with similar atomic structure (lattice parameter mismatch less than 1.7%). Graphene has gained a clear prominence among materials thanks to its superb carrier mobility, high transparency, excellent thermal conductivity, chemical inertness. Hexagonal BN shares many of these properties with G, but, differently from it, h-BN is an insulator with a wide bandgap.

One of the most attractive goals is the possibility to merge these two materials in stacked layers or in-plane hybrid heterostructures for the realization of 2D atomic-layer circuits, and novel spintronic devices tailoring the semiconducting properties of graphene[1–3].

Up to now, h-BN-G in-plane hybrid structures have been obtained using chemical vapour deposition (CVD) starting from two or more precursors[4], plasma-assisted deposition[5], by mechanical transfer or hydrogen etching of G layers[2] or by a two step process consisting in the growth of h-BN on existing graphene patches[1,3,6]

We propose a novel bottom-up approach to grow continuous hybrid hexagonal heterostructures combining h-BN and G in 2 dimensional (2D) sheets on single crystals in ultra-high-vacuum (UHV) environment using only one molecular precursor, dimethylamine borane (DMAB).

This novel growth route allows an easy and controlled preparation of perfectly merging domains of G and h-BN of different size and relative concentration or hybridized B-C-N materials on the clean surface of a crystal in UHV just adjusting the substrate temperature.

In particular, G-BN layer grown on Pt(111) at 1000 K was investigated by high resolution X-ray spectroscopy (XPS and NEXAFS), scanning tunneling microscopy (STM), low energy electron microscopy (LEEM) combined with electron energy loss spectroscopy (EELS) and micro-low energy electron diffraction (μ-LEED).

The measurements have shown the formation of a continuous hybrid layer of h-BN and graphene that fully covers the Pt(111) surface. The layer has revealed a complete inertness towards molecular oxygen up to 10^{-6} mbar partial pressure in the temperature range 300 K-600 K.

Our findings have demonstrated that the dehydrogenation of a simple molecular precursor, such as DMAB, is an efficient and easy method for obtaining a continuous h-BN and graphene atomically thin lateral heterostructure on a metal substrate, such as Pt(111).

References

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