Fabrication and characterization of Graphene and Graphene Oxide/hBN heterostructures

V.Clericó[1*], D. López-Díaz[2], J.A. Delgado Notario[1], M.M.Velázquez[2], E. Diez
[1] Fundamental Physics Department, University of Salamanca, Salamanca, Spain,
[2] Physical Chemistry Department, University of Salamanca, Salamanca, Spain,
[*]vito_clerico@usal.es

Graphene (G) is a promising material for devices because of its amazing electrical properties. Mechanical exfoliation continues to give graphene flakes with the best properties and for this reason it is very interesting for studying new physical properties [1]. Epitaxial growth or CVD [2] are postulated as a very good alternative methods to produce graphene in an industrial scale but the main disadvantage is the cost of production. Graphene oxide (GO) is the cheapest and industrial scalable derivative of graphene. GO is synthesized by chemical exfoliation of graphite or carbon nanofibers [3]. GO is often reduced by chemical agents [4] or thermal annealing [5] to restore the carbon lattice and to remove the structural defects and distortions.

It is known that the electron mobility of graphene based devices is extremely influenced by the substrate [6]. Therefore an appropriate substrate should be used for high quality graphene based devices. Hexagonal boron nitride (hBN) is an isomorph of graphite composed of alternating B and N atoms in a honeycomb lattice. Because of its band structure, this compound is an insulating and relatively inert. The above features makes it an excellent candidate to perform such as devices.

In this work, we present the fabrication and characterization of vertically stacked graphene based heterostructure. Two different devices have been fabricated by mechanical cleavage method followed by layer-by-layer transfer techniques. The first one is hBN/G/hBN sandwich type supported on a Si-SiO_2 substrate. For comparative purpose, the second heterostructure have been fabricated by using GO instead of G. As we know, this is the first time that an hBN/GO/hBN heterostructure is reported. The method to produce it is similar to that employed for graphene. However, the main differences between them are that the mechanical exfoliation of graphene oxide is carried out in presence of water and the flakes were deposited on a surface of PDMS instead of Si-SiO_2. The water helps the exfoliation of GO and prevents the cleavage of the flakes while PDMS favors the transference process. In order to remove the oxygen groups and to restore the carbon lattice of the GO, the heterostructure has been annealed at 1200 ºC. The devices thus obtained have been characterized by using Raman Spectroscopy and I-V electrical measurements.

References

[1] Terre, B., Chizhova, L.A., Nat. Comm. 7, 11528, **2016.**
[2] Banszerus, L., Schmitz, M., et al. Science Advances. 1, 1500222, **2015**.
[3] Lopez-Diaz D, Velazquez M M, et al. ChemPhysChem. 14, 4002-4009, **2013**.
[4] Martín-García B, Velázquez M M, et al. ChemPhysChem. 13, 3682-3690, **2012**.
[5] Claramunt S, Varea A, López-Díaz, D. et al. J. Phys.Chem. C. 119, 10123-10129, **2015**.
[6] Hwang, E. H., Adam, S., et al. Phys. Rev. Lett. 98(18), 186806, **2007**.

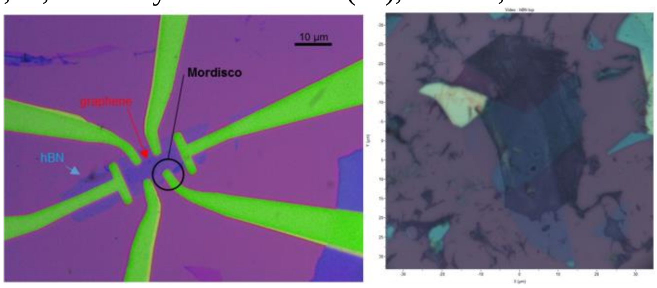

Figure 1: LEFT: Optical image of hBN/graphene heterostructure with a constriction of 300 nm. RIGHT: Optical image of hBN/GO/hBN heterostructure.

Acknowledgement
Authors thanks Junta de Castilla y Leon for funding this research with the project SA045U16.