Decoupling Graphene from Ni(111) through the Intercalation of a Chromium Carbide Ultra-Thin Film

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During the last decade, graphene has been stabilized on many single crystal metallic substrates [1]. Among them, the Ni(111) surface represents an ideal template for the epitaxial growth of graphene, because the excellent lattice matching between the two materials promotes the stabilization of large-area and defect-free honeycomb monolayers. However, the hybridization between the Ni *d* bands and the graphene *π* states strongly modifies the electronic structure of the latter around the Fermi level. In order to obtain a quasi-freestanding graphene layer, metallic films have been intercalated between graphene and the substrate [2]. In this framework, it is reasonable to assume that an even better decoupled carbon monolayer could be obtained by intercalating insulating compounds such as carbides, oxides or nitrates [3]. Traditional techniques, such as surface exposure to a reactive gaseous environment, are not suitable to stabilize insulating compounds underneath the honeycomb monolayer, because the highly impermeable graphene membrane hinders the chemical reaction between the gas and the metal. Here, we demonstrate that it is possible to grow an ultra-thin Cr carbide between graphene and Ni(111). Auger electron spectroscopy reveals that the deposition of Cr on the graphene/Ni(111) system triggers the segregation of C atoms from the bulk of the Ni substrate, inducing the development of a crystalline Cr carbide at the interface [4]. The atomic structure of the graphene/Cr carbide/Ni(111) system has been investigated by means of low energy electron diffraction and scanning tunneling microscopy. Moreover, scanning tunneling spectroscopy suggests that the intercalation process restores the linear dispersion of the energy bands characterizing the freestanding graphene.

References:

[1] M. Batzill, The surface science of graphene: Metal interfaces, CVD synthesis, nanoribbons, chemical modifications, and defects, Surf. Sci. Rep. **67**, 83-115, **(**2012).

[2] E. N. Voloshina, A. Generalov, M. Weser, S. Bottcher, K. Horn and Y. S. Dedkov, Structural and electronic properties of the graphene/Al/Ni(111) intercalation system New J. Phys. **13**, 113028, (2011).

[3] Y. Dedkov, W. Klesse, A. Becker, F. Spath, C. Papp and E. Voloshina, Decoupling of graphene from Ni(111) via formation of an interfacial NiO layer, Carbon **121**, 10-16, (2017).

[4] A. Picone, D. Giannotti, M. Finazzi, L. Duò, F. Ciccacci, and A. Brambilla, Intercalation from the Depths: Growth of a Metastable Chromium Carbide between Epitaxial Graphene and Ni(111) by Carbon Segregation from the Bulk, J. Phys. Chem. C **121**, 16803−16809, (2017).