Engineering edge structure and electronic properties of graphene nanoislands by Au intercalation

Michele Gastaldo[1], Gustavo Ceballos[1], Aitor Mugarza[1,2]

[1] Catalan Institute of Nanoscience and Nanotechnology (ICN2), CSIC and The Barcelona Institute of Science and Technology, Campus UAB, Bellaterra, 08193 Barcelona, Spain
[2] ICREA – Institució Catalana de Recerca i Estudis Avançats, Lluis Companys 23, 08010 Barcelona, Spain
michele.gastaldo@icn.cat

Abstract

The interaction with the underlying substrate is an effective way to tailor the electronic and magnetic properties of graphene. The interfacial interaction can dope Dirac cones and induce band gaps [1], spin-polarization [2-3] or spin-orbit coupling [4]. The same interaction also controls the growth morphology and edge atomic structure. Intercalation of metals at the graphene-substrate interface is an interesting method to decouple growth from final physical properties, enabling the choice of the most suitable material for each case. Although metal intercalation in monolayer graphene has been widely studied, the effect of finite size in graphene nanostructures has been basically unexplored. With graphene nanostructures we can explore possible new intercalation mechanisms, the stabilization of different edge structures, and the arousal of one dimensional edge states of different nature.
In this work, we use scanning tunnelling microscopy to show how Au intercalation can modify the characteristics of graphene nanoislands grown on Ni. We have previously shown that on a Ni(111) surface, the interaction with the substrate determines the edge termination and shape of graphene nanoislands: by selecting post-annealing temperature, triangular islands with zig-zag edges or hexagonal islands with alternated zig-zag and reconstructed pentagon-heptagon (zz(57)) edges are obtained [Fig.1a] [5-6]. Gapped spin polarized bands are induced in graphene, leading to spin and edge-dependent electron scattering [3].
Following graphene growth, intercalation of Au is achieved by deposition and subsequent annealing. Graphene nanoislands are found floating on the Au overlayer or embedded in it, with some islands laying on different Au atomic layers. Embedded hexagonal islands now present only zig-zag edges due to the different coordination environment, implying that the intercalated metal can also modify the morphological properties of nanoislands [Fig.1b]. The capability of laterally displacing graphene nanoislands by using the STM tip evidences chemical decoupling from the substrate [Fig.1c], while electronic decoupling is evidenced by the characteristic intervalley scattering patterns observed inside the islands [Fig.1d] [7].

References

[1] P.A. Khomyakov et al., Phys. Rev. B, **79** (2009) 195425
[2] V. Karpan et al., Phys. Rev. Lett., **99** (2007) 176602
[3] A. Garcia-Lekue et al., Phys. Rev. Lett., **112** (2014) 66802
[4] D. Marchenko et al.,Nat. Commun., **3** (2012) 1232
[5] M. Olle et al., Nano Lett., **12** (2012) 4431
[6] A. Garcia-Lekue et al., J. Phys. Chem. C, **119** (2015) 4072
[7] H. Yang et al., Nano Lett., **10** (2010) 943

Figures