Hydrogenated Graphene

Stefan Heun

NEST, Istituto Nanoscienze-CNR and Scuola Normale Superiore, Piazza San Silvestro 12, 56127 Pisa

On SiC(0001), epitaxial graphene is obtained by sublimation of Si from the substrate. The graphene film is separated from the bulk by a carbon-rich buffer layer which in part covalently binds to the substrate. We report scanning tunneling microscopy (STM) studies of the buffer layer and of quasi-free-standing monolayer graphene (QFMLG) that is obtained by decoupling the buffer layer from the SiC(0001) substrate by means of hydrogen intercalation. Atomic resolution STM images of the buffer layer reveal that, within the periodic structural corrugation of this interfacial layer, the arrangement of atoms is topologically identical to that of graphene. After hydrogen intercalation, we show that the resulting QFMLG is relieved from the periodic corrugation and presents no detectable defect sites [1].

Reversible hydrogenation of graphene has been recently reported, and it was shown that hydrogenation opens a bandgap in graphene. We report on site-selective adsorption of atomic hydrogen on monolayer graphene grown on SiC(0001), and measure a band gap which increases with increasing hydrogen coverage. Therefore, hydrogenation allows for band-gap engineering in graphene. We also show that at low coverage hydrogen is found on convex areas of the graphene lattice. No hydrogen is detected on concave regions. These findings are in agreement with theoretical models which suggest that both binding energy and adsorption barrier can be tuned by controlling the local curvature of the graphene lattice. This curvature dependence combined with the known graphene flexibility may be exploited for storage and controlled release of hydrogen at room temperature, making it a valuable candidate for the implementation of hydrogen-storage devices [2].

Futhermore, we investigate the morphology of QFMLG formed at several temperatures by hydrogen intercalation and discuss its relationship with transport properties. Features corresponding to incomplete hydrogen intercalation at the graphene-substrate interface are observed by STM on QFMLG formed at 600 and 800ºC. They contribute to carrier scattering as charged impurities. Voids in the SiC substrate and wrinkling of graphene appear at 1000ºC, and they decrease the carrier mobility significantly [3].

[1] S. Goler, C. Coletti, V. Piazza, P. Pingue, F. Colangelo, V. Pellegrini, K. V. Emtsev, S. Forti, U. Starke, F. Beltram, and S. Heun, Carbon 51, 249 (2013).

[2] S. Goler, C. Coletti, V. Tozzini, V. Piazza, T. Mashoff, F. Beltram, V. Pellegrini, and S. Heun, J. Phys. Chem. C 117, 11506 (2013).

[3] Y. Murata, T. Mashoff, M. Takamura, S. Tanabe, H. Hibino, F. Beltram, and S. Heun, Appl. Phys. Lett. 105, 221604 (2014).