

Effect of Oxygen Adsorption on the Local Properties of Epitaxial Graphene on SiC

C. Mathieu¹, B. Lalmi², T. O. Mentès³, E. Pallecchi¹, A. Locatelli³, S. Latil⁴, R. Belkhou² and A. Ouerghi¹

1. CNRS- Laboratoire de Photonique et de Nanostructures, Route de Nozay, 91460 Marcoussis, France

2. Synchrotron SOLEIL, Saint-Aubin, BP48, F91192 Gif sur Yvette Cedex, France

3. Sincrotrone Trieste ELETTRA, Area Science Park, 34149 Basovizza, Trieste, Italy

4. CEA Saclay, DSM IRAMIS SPCSI, F-91191 Gif Sur Yvette, France

claire.mathieu@lpn.cnrs.fr

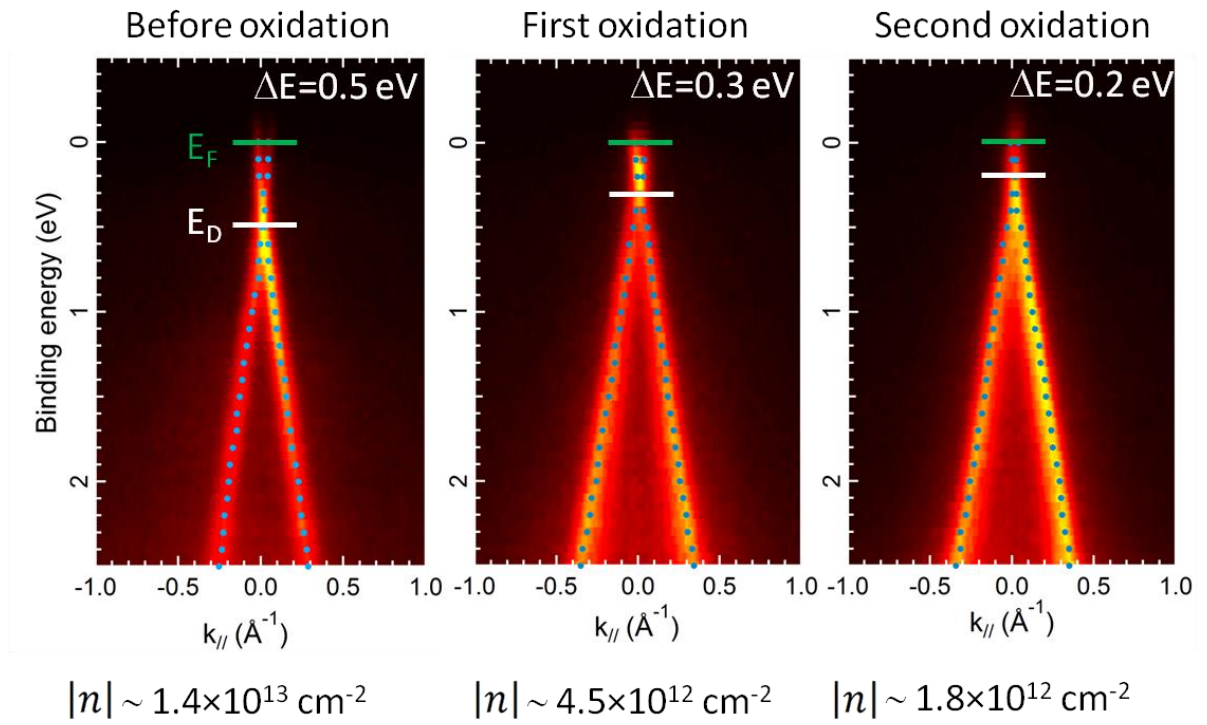
Since its discovery, graphene has attracted tremendous interest and its unusual properties make it a promising candidate for future electronic and optic applications [1, 2]. Along the view of designing graphene-based devices, many efforts are devoted to the achievement of large scale graphene patterning in a reproducible way with controlled structural quality. Among the various ways to produce graphene [3], the growth of graphene layer on silicon carbide (SiC) is a very promising method for homogeneous large scale production with a high crystalline quality, as it has recently been demonstrated [4]. On the Si face, the first carbon layer present a honeycomb structure, which has no graphitic electronic properties, due to one-third of the carbon atoms that are bonded to the Si atoms of the substrate [5]. This layer therefore acts as a buffer layer and allows the next carbon layer, i.e. first graphene layer, to behave, from an electronic point of view, as an isolated graphene sheet. However, the Si dangling bonds that remain below this buffer layer deteriorate the carrier mobility, due to the high intrinsic electron doping. Some recent experiments – LEEM, XPS, and EELS principally – have demonstrated that the graphene π band of the interface layer can be restored by the insertion a thin oxide layer between this interface and the SiC substrate [6].

We have followed, from local point of view, the structural and electronic modifications of epitaxial graphene, for different steps of the oxidation process. This has allowed us to finely study the transition of the buffer layer toward a partially decoupled graphene-like sheet, by a controlled in-situ exposition to oxygen. We demonstrate in the present contribution that the oxygen can partially decouple the buffer layer from the substrate and hence reduce the intrinsic electron doping, which leads in turn to the partial transformation of the buffer layer into a graphene-like one. As a result, the oxygen reacts with the Si dangling bonds, reducing the charge transfer from the substrate to the graphene layer, and also intercalates between the carbon layers.

References

- [1] K. S. Novoselov, Z. Jiang, Y. Zhang, S. V. Morozov, H. L. Stormer, U. Zeitler, J. C. Maan, G. S. Boebinger, P. Kim, A. K. Geim, *Science*, **315** (2007) 1379.
- [2] K. S. Novoselov, A. K. Geim, S. V. Morozov, D. Jiang, Y. Zhang, S. V. Dubonos, I. V. Grigorieva, A. A. Firsov, *Science*, **306** (2004) 666.
- [3] V. Singh, D. Joung, L. Zhai, S. Das, S. I. Khondaker, S. Seal, *Prog. Mater. Sci.*, **56** (2011) 1178.
- [4] C. Berger, X. Wu, P. N. First, E. H. Conrad, X. Li, M. Sprinkle; J. Hass, F. Varchon, L. Magaud, M. L. Sadowski, *Adv. Solid State Phys.*, **47** (2008) 145.
- [5] K. V. Emtsev, F. Speck, Th. Seyller, L. Ley, and J. D. Riley, *Phys. Rev. B*, **77** (2008) 155303.
- [6] S. Oida, F. R. McFeely, J. B. Hannon, R. M. Tromp, M. Copel, Z. Chen, Y. Sun, D. B. Farmer, J. Yurkas, *Phys. Rev. B*, **82** (2010) 041411.

μ-ARPES @ $h\nu=40$ eV



Band dispersion as a function of $k_{||}$ around the K point of the first Brillouin zone, obtained by μ ARPES at $h\nu=40$ eV, performed before oxidation and after each oxidation step. The Fermi level and the Dirac point are superimposed on the images. The charge density is also indicated for every step of the oxidation process.