Strain, doping & mobility: tuning the physical properties of graphene on insulator during transfer

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Graphene can be grown up to macroscale by using the chemical vapour deposition on catalytic substrates like copper foil. The development of efficient transfer techniques has allowed transferring CVD graphene onto any kind of substrates which opens new avenues in order to integrate graphene into various type devices including heterostructures [1]. Moreover, as a one-atom-thick layer, graphene properties are strongly modified by the supporting substrate which can be detrimental to graphene's intrinsic performances in terms of electronic mobility or mechanical stiffness.

In this work, we consider the graphene-substrate system as a whole and we present tailored substrates and transfer techniques to control the electronic and mechanical properties of monolayer graphene.

First we will show how wet transfer can be optimized so as to transfer graphene up to tens of centimeter scale while offering versatility in making vertically stacked structure. As a model stack, artificial bilayer graphene is demonstrated, which shows similar features as naturally grown bilayer. Furthermore, this system realizes a vertical version of a classical Hall bar in which we observed an interlayer Hall effect.

Then we will discuss the influence of the underlying substrate on graphene's properties. To remove invasive substrates, we show few tens of microns large suspended graphene and their use for nano-opto-electromechanical systems [2]. To access stress in graphene, we propose a new approach based on corrugated substrates [3] that promote self-organization of strain domains. Using Raman spectroscopy as a probe [4], ripple formation will be discussed along with the limit case where graphene gets fully suspended with a priori no limit in size. The resulting effect on graphene doping and strain will be discussed.

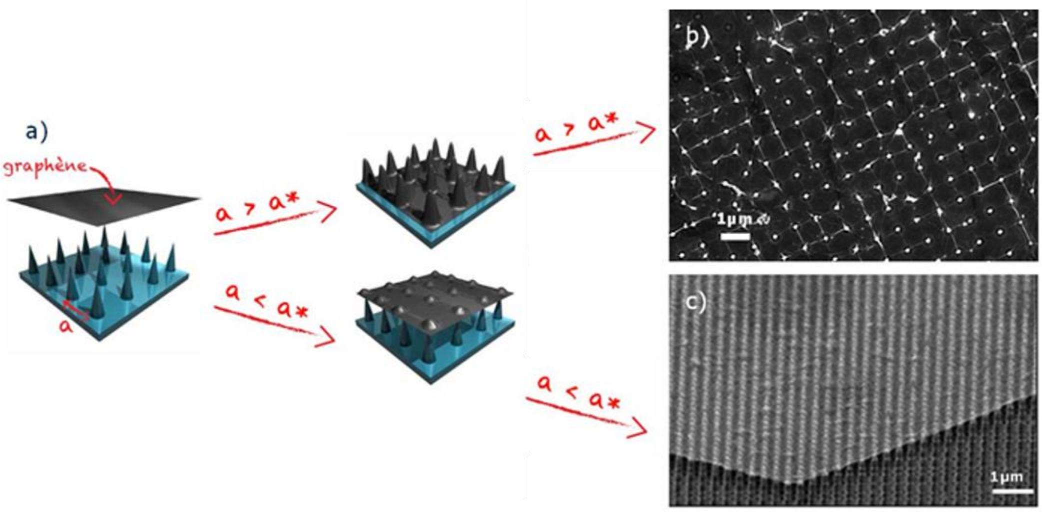

Figure 1: Principle of strain distribution on graphene transferred onto a corrugated substrate: a) sparse silica pillars induce self-organization of ripple formation in domains, b) dense pillar array leads to fully suspended graphene monolayer at the macroscale.

[1] X. Li, W. Cai, J. An, S. Kim, J. Nah, D. Yang, R. Piner, A. Velamakanni, I. Jung, E. Tutuc, S. K. Banerjee, L. Colombo, and R. S. Ruoff, *Large area synthesis of high-quality and uniform graphene films on copper foils*, Science, **324**, 1312 (2009).

[2] C. Schwarz *et al. In preparation*.

[3] A. Reserbat-Plantey, D. Kalita, Z. Han, L. Ferlazzo, S. Autier-Laurent, K. Komatsu, C. Li, R. Weil, A. Ralko, L. Marty, S. Guéron, N. Bendiab, H. Bouchiat and V. Bouchiat, *Strain Superlattices and Macroscale Suspension of Graphene Induced by Corrugated Substrates*. Nano Letters **14**, 5044 (2014).

[4] A. Reserbat-Plantey, L. Marty, O. Arcizet, N. Bendiab, V. Bouchiat, *A Local Optical Probe for Measuring Motion and Stress in a Nanoelectromechanical System*. Nature Nanotechnology **7**, 151 (2012).