Strain superlattices and suspended graphene at the macroscale

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Abstract

The development of graphene growth over macroscopic areas and the improvement of transfer techniques increase the need to control the shape and geometry of graphene once deposited onto the destination substrate. After being transferred on flat surface or suspended (1), graphene membranes always display unwanted ripples that limit electrical, thermal and mechanical properties (2).
Indeed, ripples in graphene-based transistor can alter their electrical conductivity (2). Nevertheless, it offers interesting ways to locally tune strain in graphene in order to influences its electronic, magnetic and vibrational properties (3, 4). Local bending of graphene is a mean to induce an electrical gap or create high pseudo-magnetic fields (3), so that a controlled strain can allow designing "stresstronic" devices. When fully suspended, graphene membranes generally exhibit high electrical mobility and can be used as nano-electromechanical systems (5) or optomechanical devices (6).
Before reaching such control, it appears necessary to understand the formation of graphene ripples during transfer. For this purpose, we investigate here the formation process of strain and ripples in CVD graphene layers by spatially resolved Raman spectroscopy. To do so, we transferred graphene onto a corrugated substrate formed by an array of SiO_2 nano-pillars with varying spacing and apex radius. This ordered corrugated substrate defines strain domains of parallel ripples.By varying the pitch of the array and sharpness of the pillars, different regimes can be found. We explore both limits of low-density arrays where graphene exhibits ripples domains, and of very dense arrays for which no ripples are formed, and so graphene stays fully suspended.
Spatially resolved Raman spectroscopy reveals uniaxial strain domains in the transferred graphene, which are induced and controlled by the array. For the tightest arrays, this technique demonstrates a method to obtain macroscopically suspended graphene membranes with minimal interaction with the supporting substrate. It also offers a platform to tailor stress in graphene layers and offer perspectives for electron transport and nano mechanical applications.

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Figures

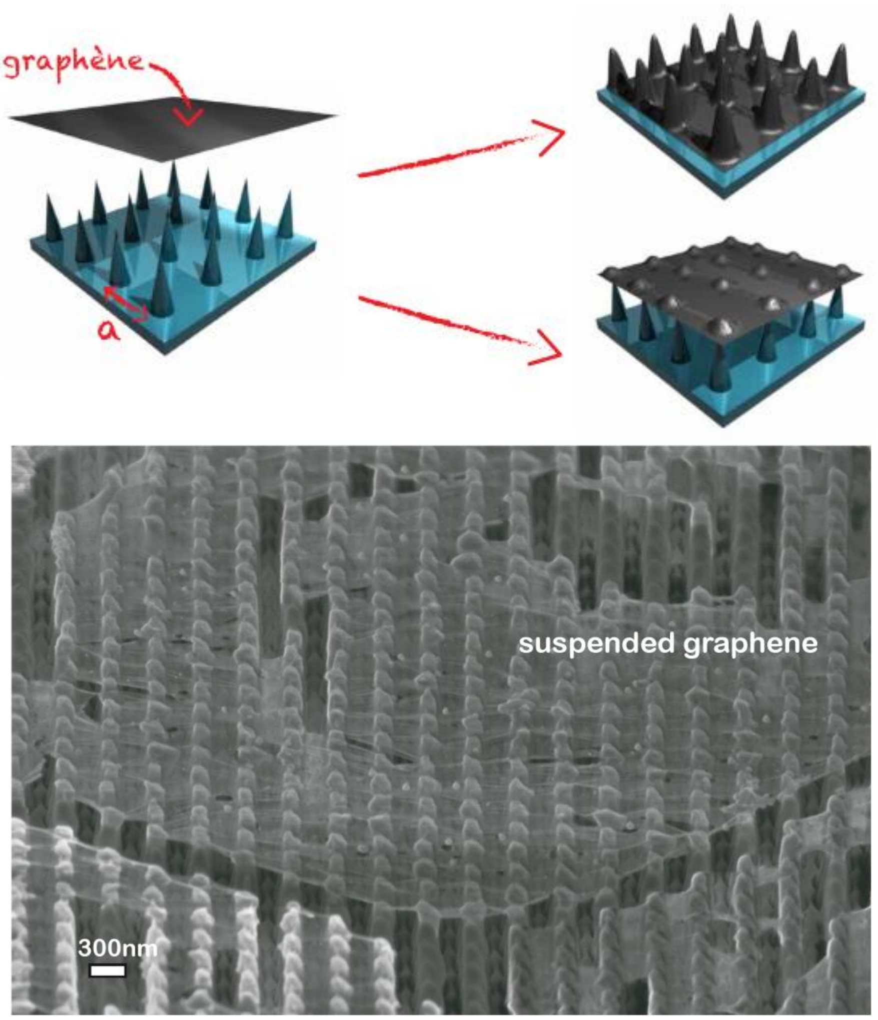

Figure 1: top: principle of the graphene deposition on silicon oxide pillars: depending on the pillars network, the graphene will either collapse or get suspended macroscopically
Bottom: SEM image of a fully suspended graphene monolayer over silicon oxide pillars.