# The promises of graphene structures nano-patterned using high resolution Focused Ion Beams

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Graphene is generating a considerable interest in materials science and condensed-matter physics [1]. Nevertheless a crucial technological problem, that will govern future applicability of this material, is related to the patterning of graphene structures while keeping intact the exceptionally high crystallinity and electronic properties of this material. This presentation is aiming at presenting our preliminary investigations in ultra-thin (2-3 nm) graphene sheets manipulation and nnao-patterning using a high resolution FIB technique.

The interest of using a finely focused pencil of gallium ions for patterning high quality graphene structures is the direct consequence of the energy deposition mechanisms occurring within suspended membranes having thicknesses considerably lower than the projected range of the incoming ions. Such a target structure limits considerably lateral scattering and collision cascades, thus leading to a "stamping-type" FIB patterning process. We will describe the method we have developed for exfoliating and deposing in a clean and controlled way graphene sheets having only few nanometres thicknesses. This methodology allowed us to place onto existing devices (Fig. 1) suspended graphene sheets with good mechanical and electrical contacts. After graphene sheets exfoliation and position monitoring in optical microscopy or SEM, using the ultra high resolution FIB nanowriter (sub-5 nm) developed in our laboratory [2], we have patterned structures directly onto these suspended sheets (Fig. 2). As expected the ion dose necessary for cutting highly resilient graphene sheets is very high. For instance a graphene sheet having a thickness about 3 nm to be drilled requires a point dose of $3.10^6$ ions. As a comparison a 10 nm SiC membrane, for the same conditions, only requires a point dose of $1.10^6$ ions. Also very important we will present the FIB cutting methods we have developed to avoid drifts and reorganization of the graphene foil due to the internal stress.

Finally preliminary characterization results will be presented confirming the interesting potential of high resolution FIB direct patterning of low dimensional graphene structures that are found to preserve the characteristics of this material.

[1] A.K. Geim and K.S. Novoselov, Nature Materials, Vol. 6 March 2007
[2] J. Gierak, A. Madouri, et al., Mic. Eng., Vol. 84 (5-8), May-August 2007, Pages 779-783

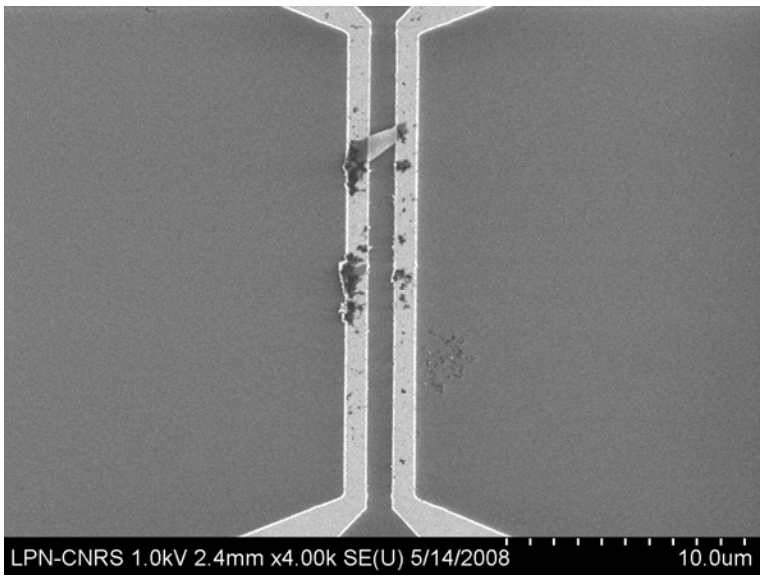


*Fig.1 SEM image of a unique graphene sheet deposited across parallel gold contacts.*

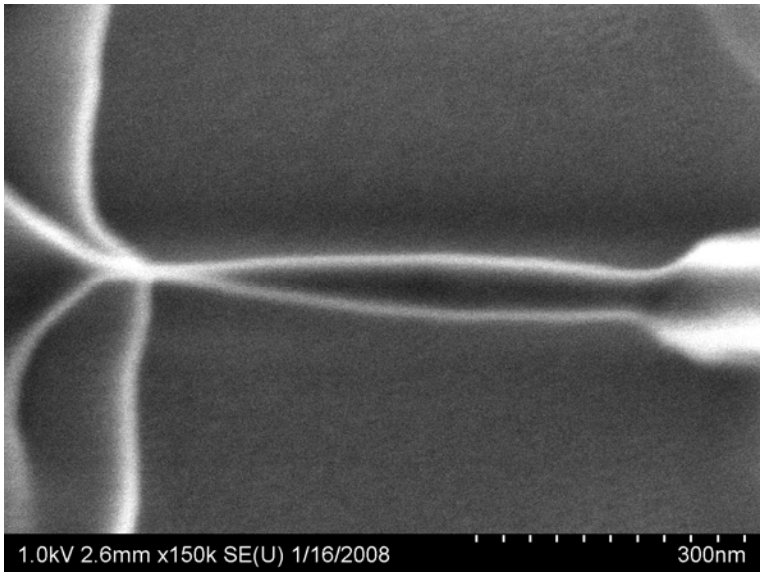


*Fig. 2 SEM image of a FIB sculpted nano-wire with a recess below 10 nm showing evidence of a stress within the fabricated 2D structures that seems to roll-on.*