Fabrication of high quality graphene nanoribbons on large surfaces by block copolymer lithography

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Large-area graphene is intrinsically a semimetal material. Hence, it is not suitable for logic applications because its zero bandgap nature [1]. Research focuses on bandgap opening and engineering in graphene by doping, functionalization and nanostructuration [2]. Sub-10 nm graphene structures are necessary to open up a significant bandgap and fabricate functional devices [3]. However fabricating such nanostructures represents a challenge from a technological point of view. Block copolymer (BCP) self-assembly presents itself as a breakthrough option for sub-10 nm lithography in the semiconductor industry [4]. The polystyrene-block-polydimethylsiloxane (PS-b-PDMS) is capable to self-assemble and form PDMS cylinders within a PS matrix (Figure 1), which can then be used as a lithographic mask [5]. BCP is spin-coated and annealed directly on graphene. Self-assembly on large surfaces (1 cm^2) is achieved in few minutes and this mask can then be transferred on graphene by oxygen plasma etching, where in a single step will eliminate the PS matrix, oxidized the PDMS cylinders and etch the graphene underneath. Figure 1 shows top-view SEM and TEM cross section of the mask by SEM and TEM images respectively. Oxidized PDMS is removed by wet etching meanwhile carbon residues from PS are removed by hydrogen plasmas. Figure 2 shows the AFM of patterned graphene after this process. XPS and Raman spectroscopies demonstrate the quality of the graphene nanoribbons produced by the fabrication method developed here.

References

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[4] J. A. Liddle and G. M. Gallatin, ACS Nano, 10 (2016) 2995
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Figures

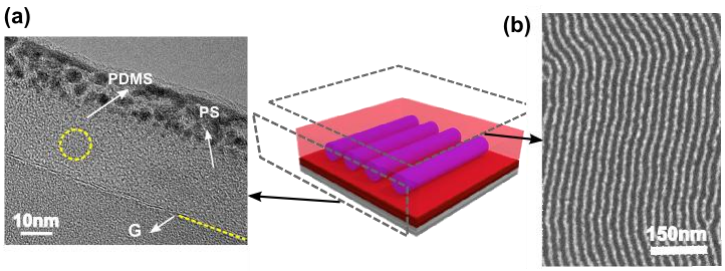

Figure 1: PS-b-PDMS self-assembly on graphene (a) TEM cross-section view (b) SEM top view of oxidized PDMS mask after HBr/O_2 plasma etching.

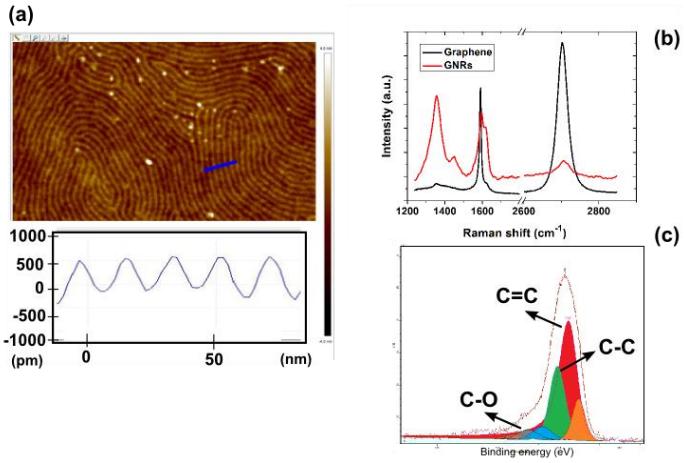

Figure 2: (a) AFM image of patterned graphene after mask removal (b) Raman and (c) XPS spectra of graphene nanoribbons at the end of the fabrication process.