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DRY CLEANING OF GRAPHENE BY DOWNSTREAM H_2 PLASMA

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CONTEXT

Adsorbents such as PMMA on the surface of graphene have critical impact on the original properties of graphene. During transfer of graphene from the growth substrate to desired substrate for device fabrication, PMMA is used as a protection layer which, can organize itself in 2-D pattern with thermal assistance. This 2-D organized layer of PMMA is strongly bonded with graphene surface and deteriorates the electron mobility in graphene which hinders the device performance [1]. Removal of PMMA residue is still a critical and unresolved issue during the transfer process.

In this study, we present an efficient way of removing PMMA without damaging the graphene layer, downstream H_2 plasma cleaning. Here, we report some preliminary results on the effect of downstream H_2 plasma on graphene surface using TEM observation.

EXPERIMENTAL

Transfer

Electro-chemistry, a clean transfer method, no dissolution of metal substrate.

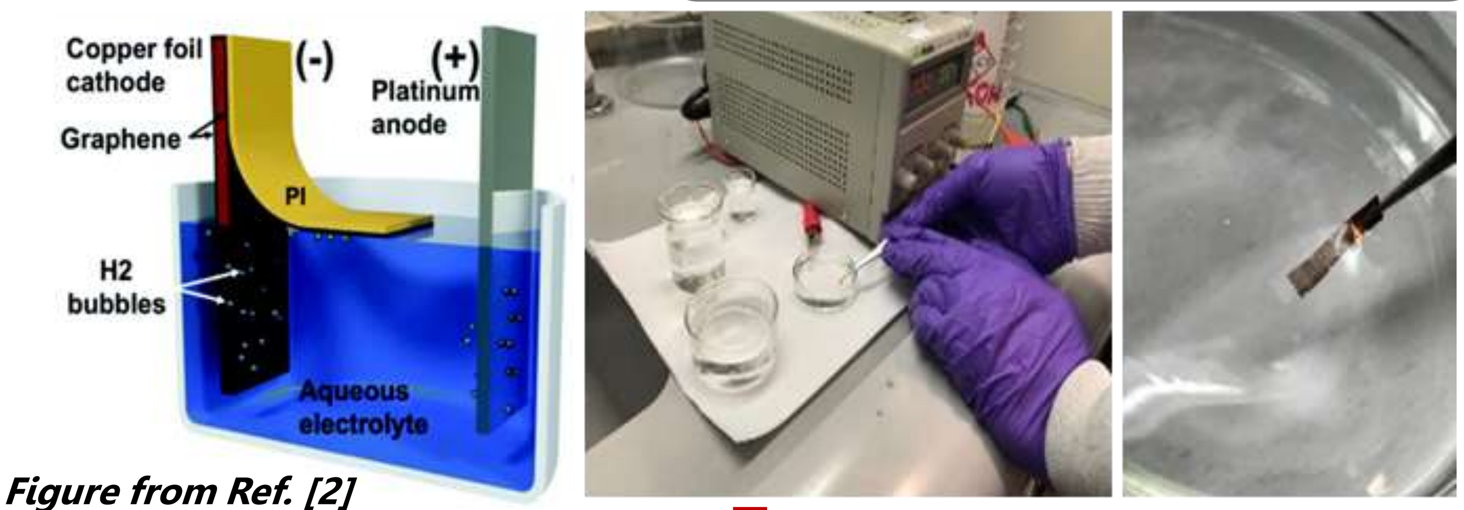
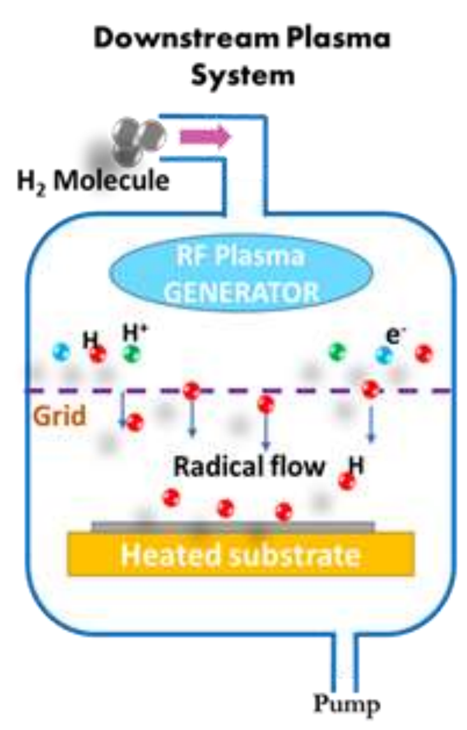
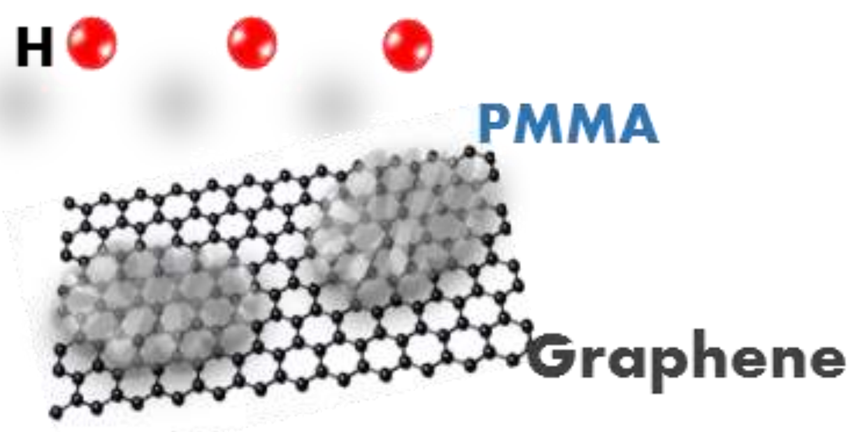


Figure from Ref. [2]

Downstream Plasma

- Etched by low energy radicals.
- Cleaning of 2-D materials without damaging them.





TEM

- Analyzing surface and atomic structure.
- Quantitative investigation of defects.

Double aberration corrector
Monochromator
Titan³ Ultimate (FEI)

CONTAMINATION DURING TRANSFER

Reorganization of PMMA network takes place by employing thermal treatment in transfer process. The previous study from our group [3] has shown three types of PMMA structures as indicated in figure 1 (a). Usually, $PMMA^B$ can be etched using Acetone. Removing $PMMA^{A+G}$ by solvent etching is not possible yet due to their structures such as round-shaped amorphous structure of $PMMA^A$ with average thickness of few nanometers and, 2-D like network, lying on graphene surface referred as $PMMA^G$ [1]. XPS spectra also evidence the presence of $PMMA^{A+G}$ after transferring the graphene layer.

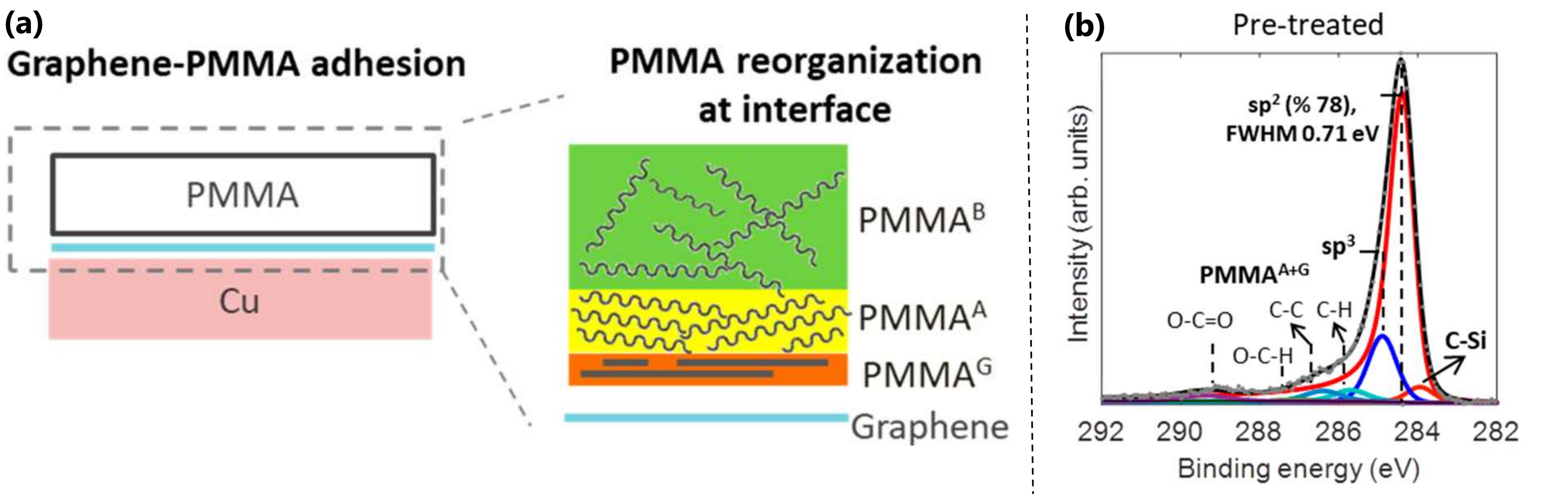


Figure1. Structure of PMMA after reorganization. (a) Three types of structure of PMMA and, (b) presence of $PMMA^{A+G}$ on graphene surface after transfer.

TEM OBSERVATION

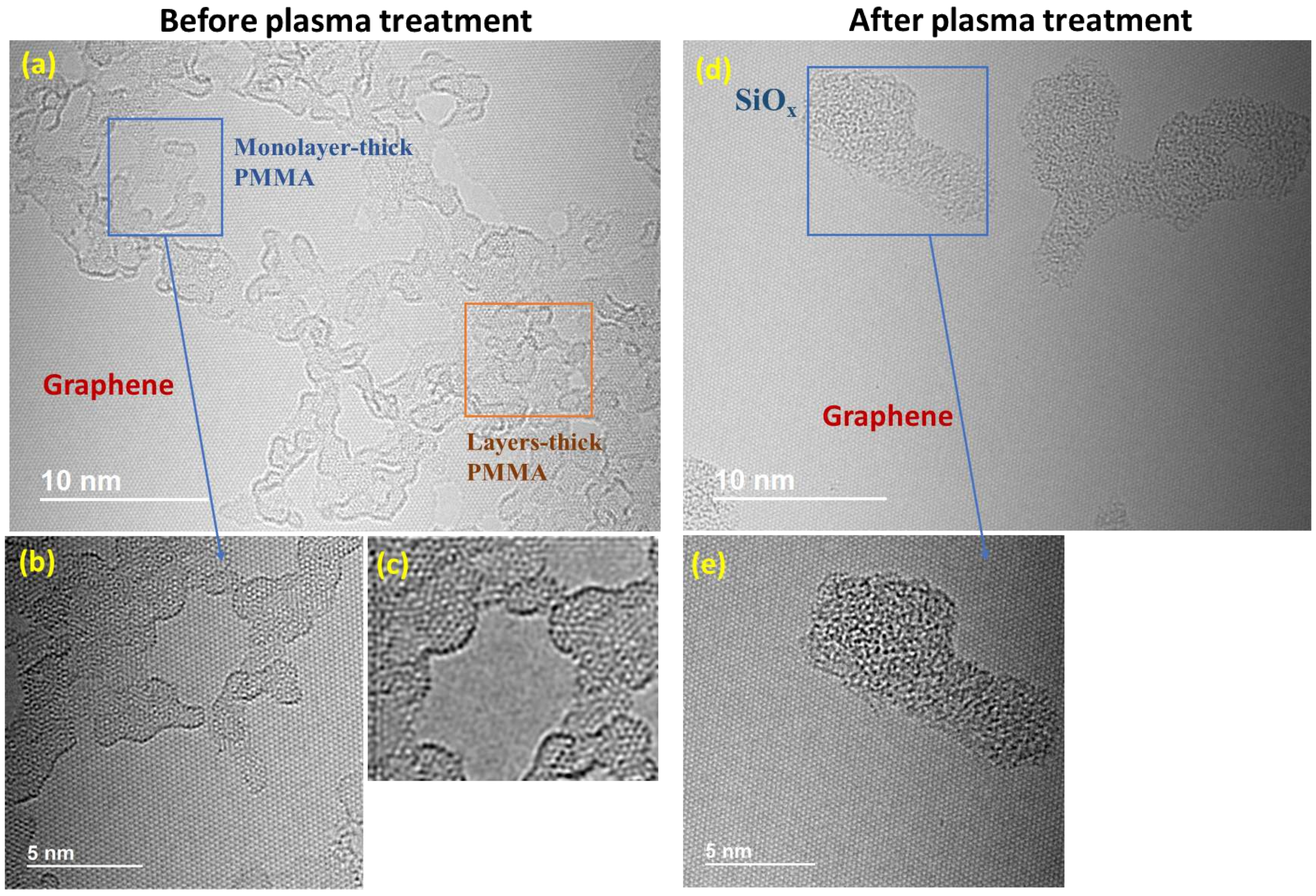


Figure 2. Before and after plasma treated HRTEM images. (a) and (b) Showing $PMMA^G$ consists of 2-D network. (c) After removing graphene signals by Fourier filtering and applying low-pass filter to highlight crystalline structure of $PMMA^G$ with random arrangement of atoms such as pentagons, hexagons and heptagons. (d) Indicating that $PMMA^G$ has been eliminated after plasma treatment without damaging graphene layer. SiOx contamination remains on the surface.

CONCLUSION & PROSPECTIVE

Downstream H_2 plasma cleaning can be used to remove strongly bonded polymeric adsorbents from graphene samples without damaging the graphene lattice.

After eliminating the contamination, we aim to perform electrical measurement in order to have an insight into the impact of contamination on electron mobility. Furthermore, furure work will involve engineering of defects such as vacancies and doping in 2D materials in size and density control manner using plasma technique. Additionaly, TEM and STEM will be used to perform quantitative study of engineered defects in 2D materials.

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