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Removal of Polymer Residue from Graphene by Ar Gas Cluster Ion Beams: An In-Situ XPS, Raman and ToF-SIMS Study

The transfer of chemical vapour deposition grown 2D materials typically involves deposition of a thin polymer layer, usually PMMA to transport the 2D layer, which is then dissolved in solvent. Any polymer residue is then typically further reduced in a thermal annealing step to remove it from the surface. However, this is rarely fully effective, with trace PMMA residue usually detected. This can affect the electrical and physical properties of the 2D layer. Recently, a number of mechanisms have been explored to further improve the quality of the transferred layer, from introducing further solvent and annealing steps, to the use of plasmas, and argon gas cluster ion beams (GCIB), to remove any remaining residue. In this study, we explore the use of size selected argon GCIBs to clean polymer residue from a CVD-grown graphene surface. The energy per Ar atom in the gas cluster can be tuned to <0.5 eV/atom, which has been shown to be below the threshold to cause damage to the graphene, but sufficiently energetic to remove polymeric material.
To characterise the polymer removal from the graphene surface, a range of in-situ characterisation techniques were employed which allow us to probe changes in the chemical and structural properties of the graphene as the surface is cleaned by the GCIB. Using a combined X-ray photoelectron spectroscopy (XPS) and Raman spectroscopy system, we could examine changes in the chemical composition of the graphene surface while monitoring changes in the Raman spectra to determine whether defects were being generated. The changes in the sample were further probed using 3D time of flight secondary ion mass spectrometry (ToF-SIMS) imaging, to clearly show the removal of polymer materials during GCIB cleaning, while leaving the underlying graphene layer intact. Through the combination of these measurements, we are able to determine that by keeping the energy per argon atom less than 1 eV, we can prevent the introduction of defects to the graphene layer, as well as significantly decrease the level of contamination present on the graphene surface.

References

[1] B.J. Tyler et al., J. Phys. Chem. C, 119 (2015) 17836.

Figures

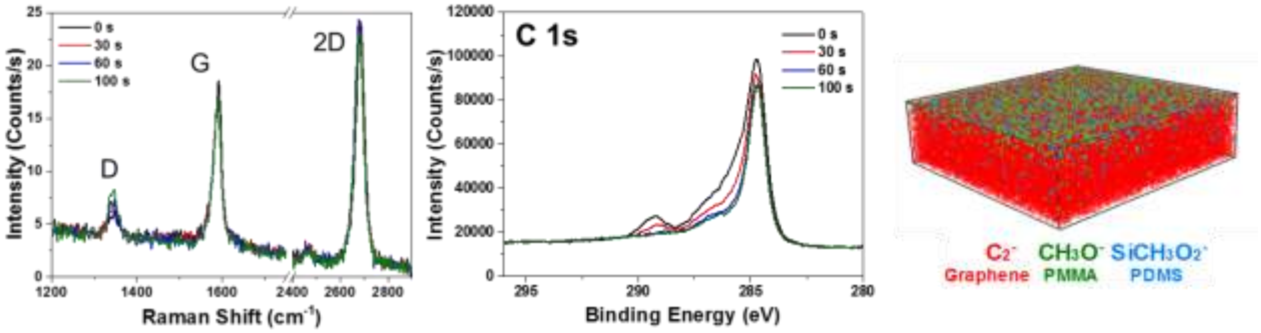

Figure 1: In-situ Raman, XPS and ToF-SIMS of polymer removal from a CVD graphene surface with an Ar gas cluster ion beam.