# Graphene Contamination Removal Using Argon Cluster Etching

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## Abstract

As graphene starts to progress from the research laboratory towards industrial applications, the requirement to overcome the practical problems related to 2-D materials, such as quality, reproducibility and contamination, increasingly needs to be met. An emerging global graphene industry requires large-scale production of graphene material that still achieves the exceptional properties demonstrated in smaller scale experiments.

Chemical vapour deposition (CVD) growth methods can produce large-scale graphene sheets utilising roll-to-roll processing, however, the transfer steps required to remove CVD graphene from sacrificial metal substrates and subsequent electronic device manufacturing steps lead to inhomogeneous polymer contamination. This polymer residue from photoresists and transfer polymers cause undesired reductions in conductivity and irreproducibility in the production of graphene devices. Although heating graphene surfaces can improve the consistency of these devices, we show with high-sensitivity secondary ion mass spectrometry (SIMS) and X-ray photoelectron spectroscopy (XPS) that this does not fully remove the contamination present.

However, we reveal that argon cluster ion beam etching, which is commonly used in the semiconductor industry, can be used to remove contamination from graphene layers whilst minimising any damage to the graphene lattice itself. Confocal Raman spectroscopy investigations reveal an impact energy of less than 1 eV per atom in the cluster is required. Optimised conditions for sputter profiling the organic overlayers whilst minimising graphene lattice damage will be presented and the effect on conductivity, as measured using a large-scale and contactless microwave dielectric resonator perturbation technique, is discussed.