Impact of the wafer-scale fabrication on the performance of graphene-based flexible devices and new strategies for improvement

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Graphene possesses unique mechanical and electronic properties that make it a crucial material in the biomedical field. Specifically, graphene-based electronic devices have been developed and are in continuous improvement for biomedical recording, stimulating and sensing purposes. Despite the demonstrated capabilities of graphene-based solution-gated field-effect transistors (SGFETs) in this field [1],[2], their wafer-scale fabrication process introduces uncontrolled residual charges on the graphene surface, which has an impact on the final functionality of the devices in the form of undesired doping and thus a deterioration of the general electrical performance.

In this work, we present a detailed study of the effect of residues presence at each step of photolithography in the wafer-scale fabrication process of graphene microtechnology. By means of Raman spectroscopy and spectro-electrochemistry we monitor the doping state of graphene during fabrication processes. As a function of pH and the ionic strength of the electrolyte in contact with graphene, we register the frequency of the graphene´s G phonon that can be directly related with the Fermi energy and doping state of graphene.

Our study reveals that certain steps in the fabrication process leave a higher content of residues on the graphene surface that leads to inhomogeneities at cm scale in terms of device performance. With this information in hand, we propose new fabrication strategies, including encapsulation with 2D materials or deposition of sacrificial layers on graphene to protect it against induced contamination during the whole photolithography process. We analyze the impact of this additional layer on the quality of graphene material, after deposition and final etching procedures. Finalized graphene devices and electrically characterized and compared with standard technology.

References

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