Study the Effect of Mono- and Bi-layer Photoresists in Graphene Biosensor Fabrication

E. D. Ahmadi[1]
J. Mitchell[1], R. Bigham[1], M. Ali[1], G. Looker[1], Z. Tehrani[1], A. Devadoss[1], P. Braeuninger[2], C.M. Fung[1] and O.J. Guy[1]
[1]Institute for Life Science 2, Centre for NanoHealth, Swansea University, Swansea, UK; [2]Department of Engineering, University of Cambridge, 9 JJ Thomson Avenue, Cambridge, UK
e.daghighahmadi@swansea.ac.uk

With graphene technology, it is possible to diagnose diseases like dementia during very early stages compared to the conventional techniques and current biosensors. High performance of graphene biosensor is due to its large surface-to-volume ratio, remarkable optical, electrical, thermal and mechanical properties which provide high detection sensitivity, room temperature operation and open new generation of electrochemical biosensors, based on direct electron transfer between the enzyme and the electrode surface. Graphene biosensors are the new generation of sensing devices proved to be a promising and excellent nanomaterial for broad range of applications from optoelectronic [1] to biomedical applications including sensing [2], and photothermal therapy [3]. There is a direct relationship between the biosensor efficiency performance and minimisation of the fabrication errors. Essential requirement of graphene biosensor fabrication is multiple lithography stages; therefore, resist residue is one of the main parameters affect the sensor efficiency. In this study, the effect of utilising bi-layer photoresist in comparison to mono-layer photoresist in different stages of graphene-based biosensors was investigated. In addition to resist residue, metal residue after lift-off process has a direct influence on biosensor efficiency. Here we optimised the processing of graphene biosensor in terms of minimisation of photoresist and metal residue to improve the biosensor efficiency. Results were fully characterised by X-ray photoelectron spectroscopy, ellipsometry, Raman spectroscopy, scanning electron microscope and I-V characteristic. Furthermore, processing of passivation layer is another challenging step in fabrication of graphene-based biosensor due to the limitation in working on mono-layer graphene as a sensing area in the device. In fact, it is essential to minimise graphene damage during the processing resulted in limitation of fabrication techniques. This work is followed by passivation layer characterisation of silicon nitride (Si_3N_4) and aluminium oxide (Al_2O_3) deposited by plasma enhanced chemical vapour deposition and atomic layer deposition respectively. Comparison between utilising mono- and bi-layer photoresists in end-off device with different passivation techniques including low/high temperature nitride and aluminium oxide deposition was explored. Indeed, low temperature method is in priority as it is resistant to the widest variety of chemical etchants and less damage on graphene mono-layer.

References

[1] Y. Luo, E. D. Ahmadi, K. Shayan, Y. Ma,K. S. Mistry, C. Zhang, J. Hone, J.L. Blackburn, S. Strauf, Nature Communications, 8 (2017) 1-9.

[2] X. Fan, I.M. White, S.I. Shopova, H. Zhu, J.D. Suter, Y. Sun, A review Analytica Chimica Acta, 1-2 (2008) 8–26.

[3] Y. Hashida, H. Tanaka, S. Zhou, S. Kawakami , F. Yamashita, T. Murakami, T. Umeyama, H. Imahori, M. Hashida, Journal of controlled release, 173 (2014) 59-66.