Graphene Biosensors for Point of Care Diagnostics

Owen J Guy, Z. Tehrani, R. Forsyth, R. Bigham, G.Burwell, K-A. D. Walker

Centre for Nanohealth, College of Engineering, Swansea University, Singleton Park, Swansea, UK
o.j.guy@swanse.ac.uk

Abstract

Graphene devices and sensors promise to be a disruptive technology in next generation electronics and healthcare diagnostics - due to graphene's exceptional electronic properties. This presentation outlines the development of novel graphene sensor technology for healthcare diagnostics based on a chemically functionalised graphene microchannel. Graphene biosensors have been fabricated using graphene grown on both the silicon and carbon faces of on-axis 4H-SiC substrates [1-3], screen printed graphene sensors [4] and on CVD graphene.

The presentation will review chemical functionalisation methods and sensing applications of graphene. Following a brief review of different sensing techniques, the presentation will focus on electrochemical and CHEMFET biosensors. The suitability of different types of graphene for sensing applications will be discussed. A range of different chemistries will be presented including methods used for exfoliated and solution based graphene as well as CVD and epitaxial graphene. Direct and indirect (using a modification of an adsorbed layer or polymer film on top of the graphene) functionalisation techniques including diazotisation, aminosilane chemistry and plasma functionalisation methods will be reviewed. An emphasis on production friendly techniques suitable for fabricating devices on a large scale (full wafers or large area) will be presented.

Single layer, bilayer and few-layer graphene have all been functionalised using an aryl diazonium coupling reaction to achieve aniline terminated graphene. This chemistry has been used to modify graphene in order to attach "bioreceptor" molecules, capable of specific and selective detection of target biomarkers will be reviewed. The aniline molecule has been used to graft antibodies - targeted against the cancer risk biomarker 8-hydroxydeoxyguanosine (8-OHdG) - onto the graphene surface. Antibody attachment to graphene has been verified using Fluoresence Microscopy to detect quantum-dot labelled antibodies bound to the graphene surface. Changes in the current-voltage characteristics of the graphene sensors have been used to detect 8-OHdG at nanoMolar concentrations.

The effect of functionalisation on electrical transport properties including carrier type and mobility has been demonstrated using direct current and electrochemical platforms. Issues including characterisation of sensor operation, reproducibility and reliability will all be addressed. There are several advantages of graphene sensors over alternative sensor platforms such as carbon nanotubes (CNTs) or silicon nanowires (SiNWs) [5]. The main benefits of graphene for sensing applications will be highlighted in a comparison with other materials.

Finally, the issues of integrating graphene sensors into packaging and microfluidics will be considered and the range of potential applications from DNA sensors to immunoassays to detection of food toxins will be reviewed. Results from antibody based "immunesensors" and nucleic acid detection devices will be reported.

References

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