Editorial

Graphene Electronics, volume 2

Over last few years, graphene, a two-dimensional arrangement of carbon atoms, has been the subject of sustained research effort worldwide both in academia and industry. In this, UK has played a significant role, underpinned by the award of the 2010 Physics Nobel Prize to UK scientists which brought graphene into mainstream research. Since then, a great effort and resources have been devoted to both fundamental and applied graphene research, leading to the creation of spinouts trading in graphene materials. The *Institution of Engineering and Technology* celebrated this significantly British achievement by devoting a special issue of *IET Circuits, Devices & Systems,* to graphene electronics. The current issue contains nine contributions from leading players were especially invited to present the state of the art in graphene electronics. A particular emphasis is given to growth methods functionalisation of graphene and allied composites, nanomechanical resonators, electronics transport properties and fabrication of graphene sensors for application in a wide range of disciplines and the challenges associated. It is anticipated that current special issue will not only generate interest in the fundamental and devices applications introduced but also raise awareness of outstanding challenges and enthuse researchers and industry to develop a practical exploitation platform for this novel material while pursuing cutting-edge research in graphene electronics.

Using density function theory, Zhong et al., from the Michigan Technological University (Houghton, Michigan, US) and the US Army Research Laboratory, Weapons and Materials Research Directorate, investigated the stability of several bilayer of 6- and 12- zigzag graphene nanoribbons to demonstrate that AB-α bilayer is energetically preferred, while the AB-β bilayer converges to the AB-α bilayer in the geometry optimization process. They also showed that AB-stacking exhibit a magnetic nature which makes them promising candidates GNRs applications.

R. Kumar and A. Kaur of the Department of physics and Astrophysics, University of Delhi, Delhi, India, investigate Charge transport mechanism of hydrazine hydrate reduced graphene oxide. The work shows that 3D variable range hopping is applicable to hydrazine hydrate–reduced graphene oxide in the temperature range of 77K to 400K, with a consistency between theory and experiment.

In a bid to contribute to the transition of graphene from laboratory to industry, a non-contact technique based on microwave resonance was proposed, by Hao and co-workers (from National Physical Laboratory, Teddington and Department of Mechanical, Aerospace and Civil Engineering, Brunel University Uxbridge, UK), as a quick method to control the quality of the electrical properties of graphene during growth.

Following an excellent review of graphene sheet resistance and other desirable properties for application of graphene and allied composites as transparent electrodes for photovoltaics and display technology, a group led by M Craciun from the Centre for Graphene Science, University of Exeter, UK, elegantly demonstrates that functionalizing a few layers of graphene with FeCl3 leads to three folds increase in the conductivity while retaining its flexible nature. Sheet resistance as low as 8.8 Ω/□ and 84% optical transmission were achieved.

A review of graphene mechanical resonators for future RF communications, ultrasensitive mass and temperature detection using changes in resonance frequency of the nano-resonators was conducted by Sharma co-workers from the Australian National University, Canberra, in collaboration with Husain from the College of Engineering and Technology, Aligarh Muslim University, India. Of a particular interest are the experimentally established non-linear characteristics of graphene mechanical resonators at high driving amplitudes, which could pave the way unforeseen electronics and sensing applications.

Collaboration between Imperial College (London, UK), National Physical Laboratory (Teddington, UK), Wroclaw University of Technology (Poland), Institute of Electron Technology (Piaseczno, Poland), Brunel University (Uxbridge, UK) and Fudan University (Shanghai, China) led to the development of chemical vapour deposition methods to grow monolayer graphene on copper foil substrates. The film produced was subsequently transferred onto SiO2/Si substrates to form free suspended graphene drums which the team is now exploring for application to highly sensitive nanomechanical resonators.

In another electrical characterisation of graphene oxide, voltage controlled negative differential resistance was observed by Banerjee et al., Brunel University London, UK. The GO was shown to contain 7.24 nm crystallites with a (001) orientation in multilayer stacks, 1.04 nm apart and to exhibit a wide bandgap and memristor characteristics.

To further demonstrate the application of graphene to a wide range of application, Celik et al. (Brunel University, London, UK) provided an excellent review of graphene based biosensors, depicting the most recent advances in glucose and DNA sensing, drug and gene delivery, cancer therapy and other related biomedical applications. Existing challenges and future perspectives were equally discussed.

The most recent developments and challenges in graphene electronic sensors was reviewed by Moldovan and collaborators from Universitat Rovira i Virgili, Tarragona, Spain and McMaster University, Hamilton, Canada. The state of the art in graphene functionalization, devices structures together with their performance key sensor applications such as biological, mechanical and chemical are presented.

In summary, this special issue of IET Circuits, Devices & Systems highlights notable research contribution in graphene electronics spanning functionalisation, electronic and mechanical properties of graphene and derivations for solar cells, display and sensing applications. Research in this special issue covers applications across traditional disciplines boundaries and provides excellent insight into the challenges ahead to transfer laboratory prototypes in industry.

Guest Editors for this Special Issue
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