Editorial

Graphene V: Recent Advances in Studies of Graphene and Graphene analogues

We are delighted to present a collection of 17 research/review articles on graphene and graphene analogs covering many different aspects. This special issue is the fifth in series on graphene, reflecting the continued excitement in graphene science and more recently, in other 2D materials like MoS₂ and BN. Ever since the discovery of graphene, Raman spectroscopy has played a crucial role in non-destructive characterization of the number and quality of the layers, defects and doping induced phonon-renormalization to understand electron–phonon interactions. In this issue, resonance Raman studies on twisted bilayer graphene, a two-graphene layer system with a mismatch angle between the two hexagonal-structures, have been included [1, 2] which bring out the role of Umklapp double resonance process and the superlattice-induced van Hove singularities in the electronic joint density of states and phonon dispersion relation. Saito et al. [3] have reviewed Raman studies of graphene and carbon nanotubes as a function of gate-induced shift of the Fermi energy. This contribution discusses the electron–phonon interaction not only for the zone-center phonons but also for double resonance processes, involving phonons within the interior of the Brillouin zone. It is also shown that Raman spectroscopy provides information on electron–electron interaction from the electronic Raman spectra observed in metallic carbon nanotubes.

Defects such as chemical dopants, structural modifications, grain boundaries and line defects play an important role in modifying the electronic structures and electron transport in graphene. The review by Botelle-Mendez [4] presents the landscape of defects in the electronic structure and the transport properties using *ab initio* and tight-binding simulations. The correlation between structural distortion and emergence of magnetism in graphene containing a single vacancy has been investigated using first-principle calculations based on density functional theory [5]. Local distortion, reconstruction and the creation of dangling bonds around the vacancy play an important role in the magnetic properties. The electronic structures of graphene nanostructures depend on their edge shape, in which zigzag and armchair edges are two extremes. In the zigzag edge, spin polarized edge-localized π -state is created in spite of the absence of such a state in armchair edges. The geometry dependence can be understood on the basis of chemistry of polycyclic aromatic hydrocarbons. In the review by Konishi et al. [6], electronic structures of graphene nanostructures are discussed from chemistry view point. The effect of shape and edge configuration of graphene nanostructures on the orbital magnetism is reviewed by Ominato et al. [7].

Understanding the effect that strain has on the properties of graphene, in particular the appearance of pseudo magnetic fields,

remains a problem of great interest. A comparison between pseudo magnetic fields obtained using the tight-binding approximation and previous proposed expressions are presented in the contribution by Massoud et al. [8]. An external magnetic field modifies strongly the properties of graphene. Roldan et al. present [9] a hydrodynamic description of the collective excitations of doped graphene in a magnetic field. The Dirac-like nature of the carriers in graphene modifies the interacting properties of the electrons. Chakraborty and Apolkov [10] review the effect of the electron–electron interaction in monolayer and bilayer graphene in the quantum Hall effect regime. Bilayer graphene grown on SiC presents observations that are different from those obtained on exfoliated bilayer graphene. Feng et al. [11] contribute an experimental study of weak localization in p-type epitaxial bilayer graphene on SiC, and compare their conclusions with previous results obtained in exfoliated samples. Incorporating the interaction of epitaxial graphene with the reconstructed surface of SiC substrate, Son et al. [12] derive an effective single-particle Hamiltonian with inputs from first-principles calculations, and explain some of the unusual features in experiments such as the broken-symmetry states near the Dirac point. Their work highlights the crucial role of graphene–substrate interactions in modifying the electronic structure of graphene. Jaziri et al. [13] have addressed the transport properties of single layer graphene quantum well in the presence of the spin–orbit coupling which induces an effective mass -like term in the Hamiltonian. They show that the reflection probability for massive Fermions with wavevector along the transport direction is greatly suppressed.

In recent years, many graphene analogs (2D layered materials) have attracted a lot of attention. This issue has papers on B_xC_yN_z nanoribbons [14, 15] and Graphene MoS₂ heterostructures [16]. Goncalves et al. [14] have reported an extensive *ab-initio* study on the energetic stability of hydrogen passivated B_xC_yN_z nanoribbons and the electronic structure and magnetic properties of BC₂N ribbons with different widths and configurations. It is shown that the zigzag and armchair BC₂N ribbons can be small gap semiconductors or metallic according to the ribbons width.

Roy et al. [16] have presented a simplest device made of graphene and ultrathin MoS₂ where the desirable electrical characteristics of graphene such as high mobility are combined with optical activity of semiconductors. They show that in the presence of an optically active substrate, considerable photoconductivity is induced in graphene which is persistent up to a time scale of at least several hours. This photo-induced memory can be erased by the application of a suitable gate voltage pulse. Amongst the many applications of graphene, energy storage device such as supercapacitor is very important. Gopalakrishnan et al. [15] have

discussed this application based on nitrogen doped reduced graphene oxide and high surface area $B_xC_yN_z$ layers, bringing out the importance of nitrogen content and the high surface area. Porous graphene is of importance for one-atom-thin membrane to separate gases by molecular sieving. The paper by Liu et al. [17] addresses theoretically the permeation of hydrogen gas through the porous graphene using molecular dynamics (MD) simulations.

We do hope that this special issue will be interesting to scientific community in general and graphene community in particular.

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