

Abstract

Properties of graphene-based nanoelectronic devices are found to be limited by disorder, e.g., vacancies, impurities and ripples on the surface. We investigate the specific effect of defects concentration as well as the structural modulation (ripples) on the electronic properties of layers of graphene-based electronic devices. We show the promise of a possible route for improvement of the current-voltage characteristics by incorporating nitrogen atoms in the defective graphene (which has limited device applications). In this work, we develop the tight-binding model of two-dimensional (2D) carbon and use the recursive Green's function method to study the effect of defects concentration as well as periodic structural disorder (ripples) where it has already been studied using the Dirac Hamiltonian.

The combined effect of vacancies and ripples on the electronic transport of graphene devices was studied. The presence of vacancies results in quasi-localized states at the Fermi energy. This is also found to be common in the presence of ripples, but in that case they are Landau levels originating from the gauge field induced by the ripples. In contrast, resonant states emerge when charged impurities are substituted. The density of these resonances was found to be tunable by controlling the ratio between the impurity-carbon coupling to impurity on-site potential as well as the concentration.

With regard to the mesoscopic phenomena, the system gains zero conductance due to the opening of an energy gap when the ripples as well as vacancies are present. In particular, the transport becomes diffusive rather than ballistic in the case of ripples, which has already been found previously within the Dirac Hamiltonian approach. On the other hand, the impurity enhances the transport properties due to augmentation of the resonant states in the vicinity of the Fermi level. Moreover, the increase of the sample-lead coupling was found to broaden the levels and increase the current by over one order of magnitude. The study shows the possibility of tuning the electronic transport of 2D carbon systems by controlling the structural and topological defects, which can be extended toward the understanding of experimental observations such as enhanced transport properties in 2D graphitic carbon films incorporated with nitrogen.