Quantum Current Modelling in Trilayer Graphene Nanoribbons (TGNRs)

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Abstract
Graphene is determined by a wonderful carrier transport property and high sensitivity at the surface of a single molecule, making them great as resources used in Nano electronic use. TGN is modeled in form of three honeycomb lattices with pairs of in-equivalent sites as {A1, B1}, {A2, B2}, and {A3, B3} which are located in the top, center and bottom layers, respectively. trilayer graphene has two types of stable configurations, ABA and ABC stacking orders. In both types, the first two layers are Bernal-stacked, where one sub lattice of the middle layer is located above the center of the hexagons of the bottom layer. The TGN is shown to have different electronic properties which are strongly dependent on the interlayer stacking sequence. ABA-stacked TGN with width and thickness less than De-Broglie wave length can be assumed as a one dimensional material. The present research models transmission coefficient of the Schotcky structure in the graphene-based transistor based on semiconducting channel width and then analysis its quantum properties given dependence on structural parameter. At the same time, the quantum current is presented based on the transmission coefficient for the trilayer graphene.

Keywords: Trilayer graphene, transistor, transmission coefficient, quantum current, barrier.

1. Introduction

For long time graphene was an “elusive” 2D form of carbon. Ironically it was one of the best theoretically studied carbon allotrope. Graphene model is a starting point for study of all carbon-based systems: graphite, fullerenes, carbon nanotubes. We will be talking about the tight-binding model in a sense where three electrons of carbon atom, which take part in σ-bonds, are tightly bonded to the atom, while the forth electron creates rather weak π-bonds with its neighbors, giving rise to two π-energy bands called bonding and anti-bonding π-bands in the Brillouin zone [1]. Research on the use of graphene has increased sharply. Physics of graphene is now one of the most active research fields. The construction of a new high-speed graphene transistor [2] recognizes the hypothesis that graphene can be the best another to replacing silicon nanotechnology-based devices. After the discovery of graphene in 2004 [3], various aspects of the electronic properties of single and three-layer graphene research to find the differences between them brought. Multilayers of graphene can be piled up independently relying on the horizontal shift between consecutive graphene planes, which results in a variety of electronic properties and band structures [5]. Experiments conducted lately about the multilayer could be relevant in the creation of new electronic devices [4,6,7]. There are two forms of bulk graphite called ABA- (AB, hexagonal, or Bernal) and ABC-(rhombohedral) stacked TGN with different stacking manners. In TGN with ABA Stacking, the electric field produces band overlap following a proper linear screening which is explained by Thomas-Fermi approximation, whereas in ABC-stacked TGN, it opens an energy gap in the surface-state band at low energy, which results in a strong non-linear to the field amplitude based screening effect. There is spatial inversion symmetry in the lattice of multilayer with even numbered layers similar to that of monolayer graphene. This situation results in a valley degeneracy, in which time-reversal symmetry is not involved [8,9]. The TGN exhibits a variety of electronic properties that are strongly reliant on the interlayer stacking sequence [10,11]. TGN as a one dimensional device is in our focus therefore quantum confinement effect will be assumed in two directions; in the other words one Cartesian direction is greater than De-Broglie wavelength. It is also notable that the electrical property of TGN is a strong function of interlayer stacking [10]. As shown in figure (1), ABA-stacked TGN with width and thickness less than De-Broglie wave length can be assumed as a one dimensional material. TGN with ABA stacking is modeled in form of