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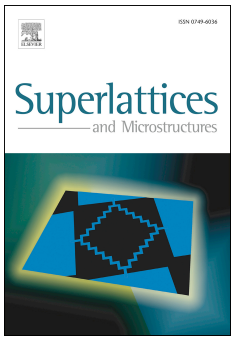

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PII: S0749-6036(17)32121-3

DOI: 10.1016/j.spmi.2017.10.022

Reference: YSPMI 5316

To appear in: *Superlattices and Microstructures*

Received Date: 10 September 2017

Accepted Date: 19 October 2017

Please cite this article as: E. Esmaili, M. Mardaani, H. Rabani, Investigation of electronic transport through a ladder-like graphene nanoribbon including random distributed impurities, *Superlattices and Microstructures* (2017), doi: 10.1016/j.spmi.2017.10.022.

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Investigation of electronic transport through a ladder-like graphene nanoribbon including random distributed impurities

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Abstract

The electronic transport of a ladder-like graphene nanoribbon which the on-site or hopping energies of a small part of it can be random is modeled by using the Green's function technique within the nearest neighbor tight-binding approach. We employ a unitary transformation in order to convert the Hamiltonian of the nanoribbon to the Hamiltonian, a tight-binding ladder-like network. In this case, the disturbed part of the system includes the second neighbor hopping interactions. While, the converted Hamiltonian of each ideal part is equivalent to the Hamiltonian of two periodic on-site chains. Therefore, we can insert the self-energies of the alternative on-site tight-binding chains to the inverse of the Green's function matrix of the ladder-like part. In this viewpoint, the conductance is constructed from two trans and cis contributions. The results show that increasing the disorder strength causes the increase and decrease of the conductance of the trans and cis contributions, respectively.

Keywords: tight-binding, Green's function, ladder-like, nanoribbon, random disorder

1. Introduction

In recent decades, one of the most fascinating areas of research in many sciences, particularly in physics, engineering, and medicine has been focused on the investigation of carbon-based nanostructures, such as graphite. Graphene nanoribbon (GNR) has many novel and interesting properties due to its particular structure and has attracted numerous experimental and theoretical studies [1, 2]. In the researches that have been done on electrical conductivity, many strange transport phenomena have been exhibited. Examples include the anomalous quantum Hall effect [3, 4], finite minimal conductivity [5], Klein paradox [6], electron Veselago-lens [7] and spin qubits [8]. Although pure graphene nanoribbons have wonderful properties such as high intrinsic carrier mobility [9] and consequently the low electrical resistivity. Although, the electronic properties of a graphene nanoribbon is influenced by structural defects and the disorder factors. The disorder factors such as the incoherent lights, magnetic field ripples [1, 10], topological defects [1] and injected impurities [11] can lead to the considerable difference between theoretical predictions and experimental measured values. In general, the disorder is known as one of the major electron scattering sources in GNRs and it can change the local distribution of charge. This fact has a main contribution to the disagreement between theoretical and experimental findings [9, 12]. Therefore, the disorder is a key factor in realizing the electronic transport properties in graphene and has been widely investigated [10, 13–16]. In the presence of strong random disorders, the electronic conductance decreases leading to the famous Anderson localization phenomenon [17]. However, under certain conditions, when the disorder becomes weak and at the charge neutrality point, conductance increases due to charge puddles [18].

The aim of this paper is a semi-analytic study on the effect of on-site and hopping random disorder on the electronic conductance of a lengthy ladder-like graphene nanoribbon at very low temperatures. We suppose that the

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