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THE INFLUENCE OF REGION SIZES ON THE CURRENT-VOLTAGE CHARACTERISTICS OF GRAPHENE-BASED FOUR-BARRIER RESONANT TUNNEL STRUCTURES

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Annotation. This article discusses the concept, essence, and application areas of graphene-based four-barrier resonant tunnel structures. The purpose of this paper is to study the influence of various technological parameters on the electrical characteristics of the structure. The current-voltage characteristics of graphene-based resonant tunnel structures on silicon dioxide (SiO2) and hexagonal boron nitride (h-BN) substrates are modeled for different barrier widths and quantum wells. The calculations that were carried out using a numerical model based on the Schrodinger equation are presented.

Keywords. Resonant tunnel structures, current-voltage characteristics, graphene

When the Fermi level of the injection electrode coincides with the discrete level of a low-dimensional structure bounded by two potential barriers, there is a sharp increase in the tunnel current flowing through it, which is manifested on the volt-ampere characteristic by a section with a negative differential resistance, which is shown in Figure 1. This phenomenon is called " resonant tunneling» [1].

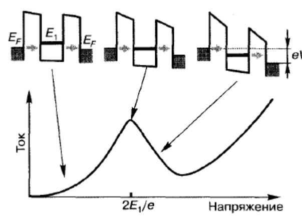

Figure 1 - Energy diagram and current-voltage characteristic of a two-barrier structure with a quantum well

If you continue to lower the energy level of E_1, then the charge carriers will no longer be able to tunnel with the conservation of energy and momentum, so they are delayed in the well. The current through the structure will begin to decrease, which will lead to the appearance of a section with a negative differential resistance on the current-voltage characteristic. The further increase in the voltage leads to the increase in the thermally activated, above-barrier emission of charge carriers and to the corresponding increase in the current through the structure.

The study of resonant tunnel structures is one of the most promising areas in nanoelectronics. Currently, there are many devices based on the tunnel effect, such as resonant tunnel diodes and a transistor.

The numerical model based on the solution of the approximated one-dimensional Schrodinger equation and included in the RTS-NANODEV [2,3] nanoelectronic device modeling software package was chosen as the main model for calculating current densities. The model provides two approximation options: an internal boundary condition method and a dummy point method. As a result of the approximation, the equation (lower) is obtained, which reduces to the SLOUGH solution. The result of solving this SLA is the values of the wave function in the nodes of the spatial sampling grid for a given energy of the incident particle and the applied voltage. The model allows us to consider both an uneven and a uniform grid, depending on how the grid step is set.

Figure 2 shows a four-barrier resonant-tunnel structure and a zone diagram, as well as zone symbols.

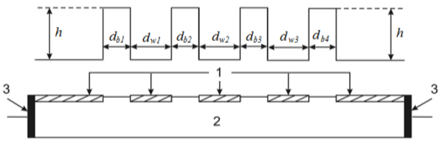

Figure 2 - Graphic designation of the simulated resonant-tunnel structure based on graphene

Table 1 shows all the main simulation parameters for the current-voltage characteristics.

Table 1 - The main parameters of modeling of the studied graphene-based RTS

Substrate material	Width of barriers, nm			Width of quantum wells, nm		
	1	2	3	1	2	3
SiO_2	1,2	1,3	1,5	3,0	3,5	4,0
h-BN	1,2	1,3	1,4	3,0	3,5	4,0

Figure 3 shows the current-voltage characteristics of the RTS when changing the width of the barriers: on a substrate made of SiO_2 (left); on a substrate made of h-BN (right).

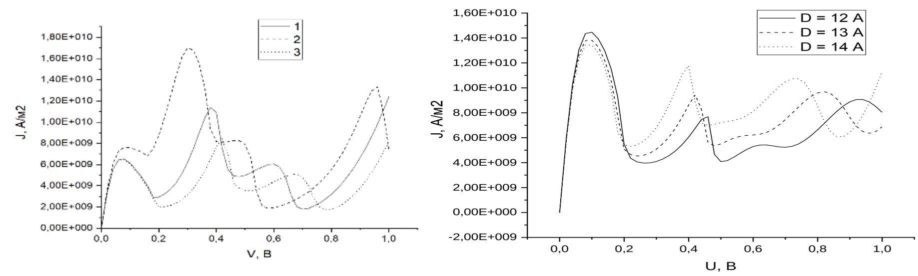

Figure 3 - Current-voltage characteristic at different values of the barrier width

Figure 4 shows the current-voltage characteristics of the RTS when changing the width of the quantum wells: on a substrate made of SiO_2 (left); on a substrate made of h-BN (right).

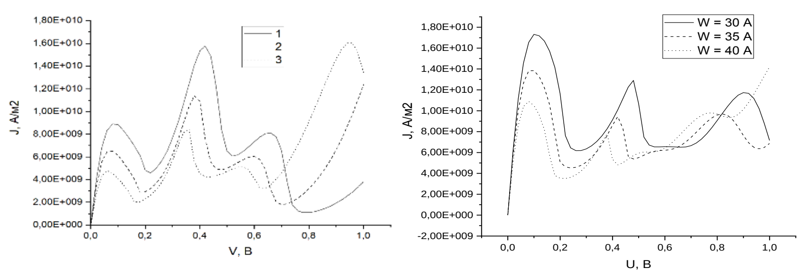

Figure 4 - Current-voltage characteristic at different values of the width of the quantum wells

It is found that the decrease in the width of the barriers leads to the decrease in the current density, as well as the increase in the voltage values of the second and third peaks. As the width of the quantum wells increases, the current density decreases and the peaks shift to lower voltage values.

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