Simulation of various nanoelectronic devices based on 2D materials

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Abstract: The development of field-effect transistors (FETs), resonant-tunneling diodes (RTDs), vertical heterostructures and other device structures on the basis of 2D materials is one of the important tasks for producing a new element base for micro and nanoelectronics.

The wave function formalism was applied in the development of numerical model of vertical heterostructures based on 2D materials [1, 2]. Combined self-consistent models [3, 4] were adapted for the case of taking into account vertical transport in the conduction band. The influence of various factors on the electric characteristics of the vertical heterostructures based on graphene, h-BN and MoS2 was investigated with the use of the developed model. The IVcharacteristics of such structures were calculated for different number of layers of 2D materials that forms potential barriers and quantum wells. Comparison of the results of simulation of the investigated structures is carried out.

A numerical combined model based on a self-consistent numerical solution of the Schrödinger and Poisson equations in the active region of the device was used to calculate the IV-characteristics of GaN/AlGaN-based RTDs with vertical transport [5, 6]. The proposed model was used to study the effect of the aluminum concentration in the barriers on the IV-characteristics of the considered RTDs.

Developed quantum drift-diffusion model of FET based on monolayer graphene was described in detail [7, 8]. The model is based on quantum drift-diffusion approximation of carrier transport. Graphene channel is located between topand back-gate dielectrics. With the use of the model simulation of dual-gate FET with channel width 18 μm was considered. A good agreement with experimental data was obtained for number of applied voltages. Adequacy of the model is confirmed by these calculations. The programs realizing the proposed models were included in the nanoelectronic devices simulation system developed at the BSUIR since 1995 [9, 10].

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