VAN DER WAALS HETEROSTRUCTURES BASED ON GRAPHENE/MOS_2*

P.V. VINOKUROV, E.P. SHARIN, S.A. SMAGULOVA

[1]North-Eastern Federal University, Yakutsk, Russian Federation

Vertical heterostructures based on two-dimensional materials are currently the main direction in the creation of device structures in nanoelectronics. They are created by gradually transferring layers of two-dimensional materials onto each other, when the transition into a single structure is maintained only by the van der Waals force. Such vertical van der Waals heterostructures exhibit new electronic phenomena that expand their capabilities for fundamental research and practical applications [1]. An important achievement of the developed heterostructures is the demonstration of the capabilities of new physical methods for creating device structures that different from traditional approaches in silicon electronics. Currently, graphene/MoS2 heterostructures are of particular interest [2].

To experimentally study the interaction between graphene layers and MoS_2, a Graphene/MoS_2 heterostructure was created on a silicon substrate. Graphene and MoS_2 films were grown by chemical vapor deposition. A transfer method using polymethylmethacrylate (PMMA) was used to create the vertical heterostructure. First, MoS_2 films were transferred to a silicon substrate, then a graphene film was deposited on top by transfer. Raman spectra were collected for the graphene/MoS_2 heterostructure (Fig. 1 a). In Figure 1 a, two peaks belonging to the MoS_2 film are clearly visible: a vibrational mode in the $E2_g$ plane at about 386 cm^{-1} and a vibrational mode outside the $A1_g$ plane at about 405 cm^{-1}. For a graphene film, there are two peaks characteristic of graphene: G and 2D. In addition, peak D is observed, associated with the appearance of defects in the graphene film as a result of transfer.

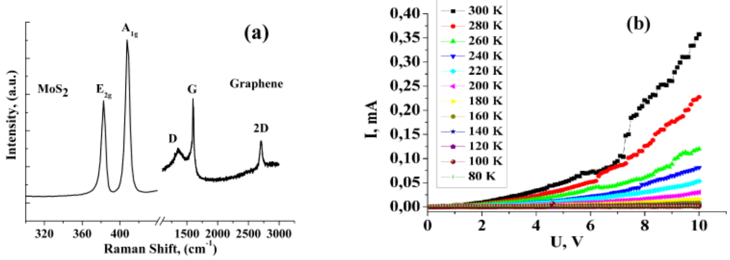

Fig.1. Raman spectrum of graphene/MoS_2 heterostructure (a). Current-voltage characteristic at T=80-300 K (b).

The current-voltage characteristics (I-V characteristics) of the graphene/MoS2 heterostructure were measured and shown in Figure 1 b. As can be seen from Figure 1 b, the current-voltage characteristic of the graphene/MoS_2 heterostructure is similar to the current-voltage characteristic of a semiconductor diode. This type of current-voltage characteristic indicates the presence of a p-n junction at the interface between graphene and MoS_2.

This work discusses the interactions of graphene and MoS2 layers with the properties of graphene/MoS2 heterostructures. Theoretical calculations of the band structure and optical parameters of Gr/MoS2 heterostructures are also presented. Electronic structure calculations were performed within the framework of density functional theory. When graphene and MoS2 monolayer are incorporated, the internal energy of the atoms changes with the inclusion of graphene, which leads to the opening of the band gap in room K. The calculated band gap of large-scale graphene is 4 eV. The above results show that due to the formation of heterojunction optical properties, graphene/MoS2 heterostructures undergo changes compared to single layers, which expands the possibilities of using 2D materials in optical applications.

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