**Annotation**

**« Synthesis and investigation of promising systems based on graphene and BiTeI semiconductors for spintronics and nanoelectronics application»**

**Rybkina Anna Alekseevna**

**Candidate of Physical and Mathematical Sciences, Junior Researcher, Department of Solid State Electronics**

The series of works is devoted to the development of fundamental principles and practical approaches for creating new functional nanomaterials and systems based on graphene and BiTeI semiconductors in order to design spintronics and nanoelectronics devices. The rapid development of spintronics is due to the solution of urgent problems in the field of information storage and processing, as well as the need to create an element base for quantum computing. The necessity of energy-efficient generation and precise control of spin currents at room temperature requires the synthesis of new quantum materials and epitaxial layered nanostructures, in which such effects as the quantum spin and quantum anomalous Hall effects, the Rashba-Edelstein effect, and the spin-torque effect will be realized. In this regard, of particular interest are materials with strong spin-orbit and exchange interactions, which will make it possible to convert charge and spin currents, control the electron spin, and also realize the described effects.

From the point of view of the electronic structure, graphene is characterized by a low concentration and high mobility of charge carriers, a zero band gap, and a mixed type of conductivity. For effective use in electronic devices, it is necessary to be able to control the band gap, set the type of conductivity and increase the concentration of charge carriers, stimulate the spin splitting of electronic states, control the density of states near the Fermi level, and also synthesize graphene on a non-metal substrate.

To achieve this goal Rybkina A.A. carried out systematic studies of the electronic and spin structure of graphene on ferromagnetic (Ni, Co) and non-magnetic (Pt, SiC) substrates, and studied the effect of intercalation of different metals (Au, Al, Gd, Co) on the graphene electronic structure. For the first time, the effect of giant Rashba splitting in graphene on a monolayer of Au was discovered, which was absolutely not achievable earlier in isolated graphene. For the first time, magneto-spin-orbit graphene based on Au/Co(0001) was synthesized and studied, which not only retains its unique characteristics, when interacting with intercalated gold atoms and a magnetized cobalt substrate, but also adopts the properties of these metals - magnetism and spin-orbit interaction.

To implement the magneto-spin-orbit graphene on a non-metal substrate, Rybkina A.A. developed a technique for synthesizing a buffer layer of graphene on a SiC(0001) substrate and a comprehensive study of the Co intercalation under the buffer layer was made. It was found that the Co intercalation leads to the transformation of the buffer layer into a graphene monolayer with the formation of a ferromagnetic ultrathin layer of cobalt silicide under it. Thus Rybkina A.A. synthesized a quasi-freestanding graphene in contact with a magnetic substrate, while retaining the electronic structure in the form of a Dirac cone in the region of the K point, which is the basis for the further implementation of magneto-spin-orbit graphene on a semiconductor substrate.

According to the results of the research carried out by Rybkina A.A. the models of electronic devices based on graphene and its contact with heavy metals (Au and Pt) have been developed - this is an improved graphene spin filter and an information recording device for

SOT-MRAM magnetoresistive memory, operating without the use of an external magnetic field. The developed graphene spin filter device is intended for the formation of groups of polarized electrons with a given spin orientation in solid-state electronic devices, as well as for the selection and extraction of such electrons. Similar devices that allow manipulation of spin-polarized electrons can be used as means of processing and transferring information in quantum computers. Another promising application of graphene was shown by Rybkina A.A. in an information recording device for SOT-MRAM (magnetoresistive random access memory with spin moment transfer), where it is proposed to use graphene and metal monolayers, which increase the spin-orbit interaction in graphene and significantly improve the characteristics of a SOT-MRAM memory memory cell.

A new approach to the synthesis of an epitaxial nanothin Pt5Gd alloy through intercalation under graphene for use in nanoelectronics and catalysis has been developed. Nanothin epitaxial PtxGd alloys are synthesized on the surface of a Pt(111) single crystal coated with well-oriented graphene, and the electronic and atomic structure are studied at different stages of synthesis. Graphene doping control by changing the alloy stoichiometry opens up new possibilities in the development of modern electronics. Due to the well-known catalytic activity of the Pt5Gd alloy, the synthesized thin-film system is promising for the production of catalysts.

Rybkina A.A. carried out the experimental studies of a new type of systems based on magnetically doped BiTeI semiconductors. These materials have a strong spin-orbit interaction, and the magnetic interaction is induced by a magnetic impurity. Due to the influence of magnetic impurities in the electronic structure of magnetically doped BiTeI, the opening of a local energy band gap was discovered and the modulation of its value was studied depending on the concentration of magnetic impurities and temperature. The opening of the magnetic gap in magnetically doped BiTeI at higher temperatures gives the possibility of generation and energy efficient transport of spin currents in spintronic devices.

The research results were published in 8 articles in high-ranking journals, including Nano Letters, Scientific Reports, Physical Review B, etc. The results were presented at 22 international and Russian conferences. On the basis of the scientific research carried out by Rybkina A.A. received 3 patents of the Russian Federation (RU №2585404 C1 – 2016, RU №179295U1 – 2018, RU №2677564 – 2019).