SUMMARY OF THE DOCTORAL DISSERTATION

"Modular system for semiconductor material deposition"

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Contemporary electronics and optoelectronics are driven by ongoing miniaturization and increasing demands for device efficiency and energy savings, which pose new challenges in the technology of semiconductor layer deposition. Low-dimensional structures, such as graphene, are distinguished by their high charge carrier mobility and potential for use in flexible and transparent electronic devices, opening new possibilities in fields such as electronics and spintronics. In turn, materials from the TMD (transition metal dichalcogenides) group, due to their layered structure and ability to precisely adjust their energy gap, find wide application in field-effect transistors, photodetectors, and energy storage technologies.

The main objective of the dissertation was to develop a modular vacuum system for the deposition of advanced semiconductor materials, allowing precise control over the deposition process conditions, including substrate temperature, deposition dynamics, and substrate manipulation. The research and development of this system were conducted in collaboration with PREVAC, a company specializing in the production of advanced vacuum equipment. The system was designed with precise control of process parameters in mind, enabling the creation of layers with high uniformity and excellent structural and optoelectronic properties.

Innovative solutions applied in the system, such as an advanced substrate manipulator with precise movement capabilities and heating using a broad laser beam or a resistive heater, allow for exceptional accuracy in controlling process parameters. Thanks to the modular design of the system, it can be adapted to a wide range of research and industrial applications, significantly increasing its functionality in semiconductor layer deposition processes.

The results of experiments, including the deposition of test layers of indium oxide (In_2O_3), confirmed the high quality and uniformity of the deposited layers, demonstrating the effectiveness of the developed system. Precise control of process parameters such as deposition rate, substrate temperature, and working pressure is key to obtaining semiconductor layers with predictable physicochemical properties. Due to its innovative technological solutions, this system offers broad potential for applications in both scientific research on new materials and industry, where high precision and repeatability are required.

The dissertation introduces a novel approach to semiconductor material manufacturing technology by providing a system that addresses the growing demand for advanced solutions in electronics, optoelectronics, and energy storage technologies.