Abstract

In the interest of the electronic miniaturization and interconnection applications, each year progress in many areas in both theoretical and applied materials science is made, in order to improve current technology and knowledge. One of the most intensively-growing research field is the field of two dimensional materials in which new physical phenomena appear and the single layer-based devices show exclusive properties owing to their exceptional interactions with light, charge transport mechanisms and mechanical properties. In this context, the transition metal compounds need to be addressed as they provide a promising alternative to the graphene-based systems due to their richness in terms of optical, electrical and magnetic properties. The work presents the results of research on the layered materials, grown by the Molecular Beam Epitaxy (MBE) technique. Unlike the exfoliated materials, those grown by the MBE not only exhibit high crystalline quality but also can be integrated with widely available epitaxial substrates, allowing for the integration of these post-silicon materials into integrated circuits. The research presents the broad characterization of three types of materials: nickel ditelluride ($NiTe_2$), molybdenum ditelluride ($MoTe_2$) and tantalum arsenide ($TaAs$), which are part of the family of transition metal compounds. $NiTe_2$ belongs to the group of the Dirac semimetals and $MoTe_2$ and $TaAs$ belong to the group of the Weyl semimetals. The selected group of materials exist in many crystallographic phases influencing their electrical properties which can substantially differ, from metallic to semiconducting, exhibiting thus a rich array of optoelectronic features. The selected compounds were characterized using numerous experimental techniques, revealing their cross-sections and surface quality and also examining their optical and magnetotransport properties. The experimental data were compared with theoretical models, describing charge transport in two- and three-dimensional systems.

This doctoral dissertation is divided into ten chapters. The first chapter opens the dissertation, presenting the motivation for the research on the layered materials. It also includes a description of the chosen growth method (MBE) and provides a theoretical introduction to the Dirac and the Weyl semimetals, scientific background and aim of the interest. The second chapter describes the experimental methods used to characterize the studied materials and main experimental setups used for measurements. The third chapter presents elements of basic transport models used to describe the obtained experimental results. The forth chapter presents the description and progress in the sample preparation, which is essential for their correct characterization using magnetotransport studies. Chapters five through seven

present the experimental results of selected transition metal compounds, compared with current experimental and theoretical results from other scientific institutions worldwide. The eight chapter summarizes the main advantages and disadvantages of materials grown by the MBE method, based on the results presented in the main part of the dissertation. The ninth chapter presents a summary of all the previous chapters, discusses obtained results and suggests possible paths for further research. The tenth chapter presents the summary of the Author's scientific activity. Appendices A, B, C, D, E and F provide additional information to introduction, experimental methods, $NiTe_2$, $MoTe_2$, $TaAs$ and a short list of the types of characterized materials whose results were not presented in this dissertation, respectively. The bibliography cited in the dissertation is included at the end. All abbreviations used in the dissertation are described just before the Introduction in the Abbreviations section.