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Optical properties of molybdenum disulfide layers (MoS_2)

Abstract

Studies of the transition metal dichalcogenides, conducted within the framework of this thesis, concern the intensively developing area of semiconductor physics. Nanolayers of these materials exhibit interesting technological properties with regard to their low dimensionality. The transition metal dichalcogenides, depending on their composition and structure, could be potentially used in a wide range of devices such as solar cells, light emitting diodes or transistors.

The subject of this dissertation is an extensive characterization of the optical properties of molybdenum disulfide layers of different thicknesses, in particular understanding the mechanisms responsible for the thin atomic MoS_2 layers' crystal lattice dynamics. Standard microscopic methods of materials' optical characterization, including absorption, transmission, photoluminescence and Raman scattering over a wide temperature range are applied in the study.

The first chapter presents the basics of two-dimensional materials' physical description. The focus is primarily on the properties of transition metal dichalcogenides, especially on the examined molybdenum disulfide material. The application of MoS_2, as well as its crystal and band structure, are presented.

The second chapter describes experimental techniques used in research. The exfoliation methods of preparing single molybdenum disulfide layers, as well as techniques used to identify thin layers of examined material, are discussed

The third chapter is divided into two parts - the first concerning the research on the bulk material and the second one comprising the study of thin molybdenum disulfide layers. It presents a detailed analysis of measurements: absorption, photoluminescence, transmission and Raman scattering in two modes of excitation. Results of the performed low-temperature research allowed identification of the multiphonon resonant Raman scattering processes. The chapter also includes analysis of the Au metallization's

influence on Raman scattering processes, as well as examination of low frequency vibrational modes in atomically thin molybdenum disulfide layers. Further it presents the benefits of using Raman spectroscopy to identify the single layers of the transition metal dichalcogenides.

The fourth chapter briefly summarizes the most important results obtained on the bulk material and thin molybdenum disulfide layers.

The fifth chapter presents conclusions based on previous studies and observations.

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