Abstract

This doctoral thesis presents a comprehensive investigation of group IV mono- and dichalcogenides (MX and MX_2, respectively), a family of van der Waals (vdW) crystals with significant potential in optoelectronic applications. The study focuses on the experimental characterization of the fundamental optical and electronic properties of the materials, employing various methods of optical and photoemission spectroscopy. Furthermore, potential applications of the investigated materials are explored. One of the key findings of the research is the strong linear dichroism of the optical response of MXs, which can be exploited in polarization-sensitive photodetection. For MX_2 crystals the measurements revealed a strong influence of native defects on the optical properties, indicating the possibilities of tuning them by adjusting the defect concentration.

The work is a series of five scientific publications (Chapters 2 – 6), preceded by an introduction (Chapter 1), including general information about the investigated materials and a description of the utilized experimental techniques.

In the first three reports GeSe (Chapter 2), GeS (Chapter 3), SnS, and SnSe (Chapter 4) crystals are characterized using complementary methods of optical spectroscopy, with emphasis on the in-plane anisotropy of the fundamental properties.

The fourth work (Chapter 5) is an experimental study of the electronic band structure of GeS, SnS, and SnSe by means of angle-resolved photoemission spectroscopy (ARPES), revealing characteristic features potentially responsible for high thermoelectric conversion efficiency.

The fifth work (Chapter 6) regards SnS_2 and $SnSe_2$ crystals. Alongside the investigation of the optical activity, the influence of high intrinsic concentration of native donor defects on the optical and electronic properties is discussed.

The study contributes to the general understanding of the fundamental properties of MX and MX_2, as well as phenomena related to interaction with light. The obtained results point toward the most promising future applications.