PHYSICS AND CHEMISTRY OF SOLID STATE
V. 23, No. 3 (2022) pp. 478-483
Section: Physics

DOI: 10.15330/pcss.23.3.478-483

Vasyl Stefanyk Precarpathian National University

ФІЗИКА І ХІМІЯ ТВЕРДОГО ТІЛА
Т. 23, № 3 (2022) С. 478-483
Фізико-математичні науки

PACS number 63.22.Dc

ISSN 1729-4428

Yu. Lutsiuk[1], V. Kramar[1], I. Petryk[2]

Frequency spectrum and group velocities of acoustic phonons in PbI_2 nanofilms

[1]Yuriy Fedkovych Chernivtsi National University Kotsjubynskyi Str. 2, Chernivtsi, 58012, Ukraine, v.kramar@chnu.edu.ua
[2]Ivano-Frankivsk National Technical University of Oil and Gas, Karpatska Str. 15, Ivano-Frankivsk, 76019, Ukraine, iyap@ukr.net

Using the elastic continuum approach, an energy spectrum and spectral dependences of a group velocities of confined acoustic phonons in planar quasi-two-dimensional nanostructures (nanofilms) of hexagonal symmetry of the 2H-PbI_2 type were studied by methods of the theory of elasticity. It is shown that the energy and propagation velocity of vibrational modes for all branches of the phonon spectrum in these type nanostructures are nonlinear functions of a magnitude of a wave vector and a thickness of the nanofilm.

The obtained results can be used to analyze an influence of acoustic phonons on a course of phenomena of thermal and electrical conductivity, carrier scattering and optical absorption in nanostructures, components of which are thin layers of lead iodide.

Keywords: nanostructure, nanofilm, phonon, spectrum, frequency, group velocity.

Received 03 February 2022; Accepted 24 July 2022.

Introduction

Despite the fact that the properties of lead iodide and nanostructures based on it have been studied for a long time the interest in them has not decreased today. This is due to the fact that the combination of unique properties of this layered semiconductor with unique properties of low-dimensional structures is a very promising direction in the design of new generations of electronic and electro-optical devices for a wide range of purposes [1-4]. The need to develop this area stimulated an in-depth study of peculiarities of physical processes in such structures. As a result, a number of works have been published in recent years, in which the results of both experimental and theoretical studies of various properties of ultrathin films of lead iodide are presented. In particular, the structure of the phonon spectrum and regularities of the heat transfer phenomenon were studied in works [5-7], and the transformation of the energy spectrum of the electronic system due to its interaction with optical phonons and changes in the exciton absorption band in such structures were studied in works [8-10].

However, the theoretical aspects of the influence on the interaction of electrons with acoustic phonons, what is an important factor influencing the processes of electrical conductivity, optical absorption, radiation, luminescence and Raman scattering in quasi-two-dimensional structures are currently poorly covered.

The reason for this is the presence of certain difficulties in the calculation to describe the influence of acoustic phonons on these processes. These include the difficulties associated with divergence of integrals series contained in the structure of the corresponding electron-phonon interaction functions, as well as the absence of explicit laws of dispersion for different branches of the acoustic phonons spectrum in quasi-two-dimensional nanostructures.

To construct dispersion curves in such structures, numerical calculations are usually used (see, for example, [11, 12]), and when calculating quantities that characterize a phenomenon or process, are limited to regularities valid for bulk (three-dimensional) crystals. However, to consistently describe the electron-phonon interaction, it is