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Acoustooptic Technique of Nondestructive Quality Control of Crystals Used in Acoustoelectronics

O. L. Balysheva*, V. V. Kludzin, S. V. Kulakov, O. V. Shakin
Saint Petersburg State University of Aerospace Instrumentation, St. Petersburg, Russia
e-mail: balysheva@mail.ru
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Abstract—Acoustooptic modification of implementation of nondestructive crystals' quality control technique is proposed. The potentials of the technique for the investigation of the properties of crystals used in acoustoelectronic devices are shown. Acoustooptic Schlieren images technique has been applied. Visualization of acoustic fields' structure has allowed us to estimate the optical homogeneity of the material and to determine the spatial characteristics of the acoustic waves, the effects of divergence and deviation of propagation direction from the wave normal.

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INTRODUCTION

Acoustoelectronics and acoustooptics are actively developing directions of modern functional electronics. Being adjacent areas with common principles of operation and singularities of acoustic waves propagation, they interact effectively, allowing one to create hybrid devices and to use techniques and approaches of one direction in solving practical problems of another.

During the development and practical implementation of acoustoelectronic devices one of the most important problems is to study the properties of materials used for substrates. In recent years special attention is paid to the search, synthesis and investigation of the properties of quartz-like crystal group [1, 2]. Thus, crystals of langasite ($La_3Ga_5SiO_{14}$) have replaced the conventional quartz in quite a number of applications. Obtaining better set of material constants, the crystals of langasite family have great prospects of application in frequency stabilization devices, in thermostable filters and in sensors of various physical quantities [3, 4].

The peculiarity of langasite crystals and other crystals of langasite family is a complex, compared with the quartz crystal, composition and the crystal structure, which is not always ordered. For a number of compounds it is difficult to choose conditions for the growth of crystals without visible defects. For all the crystals of this group their properties and parameters of acoustoelectronic devices based on them depend on the composition and growing conditions.

It is known that the surface condition of the crystals, as well as internal defects, inhomogeneities, impurities and dislocations, which occur during the crystal growth process, affect the parameters of the propagating acoustic waves, deteriorating the device specifications. In the microwave frequencies band the dislocated layer of the crystal surface, in which surface waves are forced to propagate, has a significant negative influence.

The main problem considered by authors is to perform the quality control of the grown crystals and to investigate the properties of acoustic waves propagating in them using an efficient, visual and inexpensive in terms of hardware nondestructive testing technique (optical and acoustooptical).

ACOUSTOOPTICAL TECHNIQUE OF CRYSTALS' QUALITY CONTROL

For materials investigation and measurement of their parameters one can use various in technical complexity research approaches, including static, quasi-static, piezoresonant and acoustic techniques of measurement of piezoelectric and mechanical constants of single crystals [2], optical (laser) techniques of acoustic waves sensing [5], scanning acoustic microscopy. One may measure the piezoelectric constants and control the homogeneity of crystals using X-ray diffraction techniques, that identify the singularities of micro- and nano-scale superstructure of crystals of complex compounds [6–8].