International Journal of Engineering and Information Systems (IJEAIS)
ISSN: 2643-640X
Vol. 4 Issue 9, September – 2020, Pages: 146-149

Extinction and Velocity Anisotropy in Cubic Crystals

F. R Akhmedjanov, J. O Qurbonov, U. Sh Abdirakhmonov

Institute of Ion Plasma and Laser Technologies of the Academy of Sciences of the Republic of Uzbekistan.
Tashkent, Uzbekistan
Email: jaxongir0903@gmail.com, devil_man_94@mail.ru

Annotation. *Acoustic wave propagation velocity and extinction coefficient in crystals GaP, GaAs, $Y_3Al_5O_{12}$ are 0.03-1 GHz in acoustic waves. Based on the measurement results, the velocity and extinction anisotropies of the elastic constants from the real and abstract components of the components were determined and analyzed.*

Keywords. Gallium phosphide, gallium arsenide, yttrium aluminum garnet, elastic coefficient tensor, crystals, anisotropy, acoustic wave velocity**.**

1. INTRODUCTION

Due to the unique physical properties of gallium phosphide (GaP - point symmetry group 43m), arsenide gallium (GaAs **-** point symmetry group $\overline{43}$m), yttrium aluminum garnet ($Y_3Al_5O_{12}$ - point symmetry group m3m) crystals have always been of interest, and are used in acoustics (acousto-optics).

Therefore, the study of their acoustic properties and the discovery of new aspects has been the main goal of many studies. In this work, the acoustic wave velocity and extinction anisotropy of the crystals were studied based on the experimental data on the extinction of acoustic waves by the Axiezor mechanism of crystals.

To accurately and completely describe the acoustic properties of crystals, it is convenient to use graphical surfaces of acoustic wave attenuation and acoustic wave propagation velocity, along with other characteristic magnitudes. The extinction of acoustic waves depends on the abstract part of the elasticity constant C''_{ijkl} tensor and the viscosity tensor η_{ijkl}

The properties of symmetry and, accordingly, the number of independent components of these tensors are the same for the real part of the elastic coefficient tensor C'_{ijkl}, which determines the speed of acoustic waves. Graphic surfaces of acoustic wave attenuation and velocity for cubic crystals $Y_3Al_5O_{12}$,, GaP, GaAs

The tensor of these crystals was determined by measuring the extinction of two longitudinal and transverse waves during propagation along the <110> direction of the three independent components of c''ijkl. An acoustic extinction surface has been identified that fully detects the extinction of acoustic waves.

Extinction was observed during the propagation of acoustic waves in different directions in the plane [100], and a good correlation was obtained between computation and experiment.

These crystals are cubic crystals that belong to the m3m class and have three independent components of the tensor c_{iklm} cycle. Accordingly, three independent extinction measurements were required to determine all components of the viscosity tensor.

2. EXPERIENCE AND RESULTS

The viscosity tensor η_{ijkl} , which describes the extinction of acoustic waves, is included in the equation related to deformation, and deformation rate.

$$\sigma_{ik} = c'_{ijkl}S_{kl} + \eta_{ijkl}\dot{S_{kl}} \qquad (1)$$

By substituting this expression for the equation of motion of the theory of elasticity, hence

$$\rho\ddot{u}_i = (c'_{ijkl} + i\Omega\eta_{ijkl}) \cdot \frac{\partial^2 u_l}{\partial x_m \partial x_k} \qquad (2)$$

where $\ddot{u}_i$ is the shear component, Ω is the complex modulus of frequency and flexibility, and is expressed as follows.

$$c_{ijkl} = \left(c'_{ijkl} + i\Omega\eta_{ijkl}\right) = (c'_{ijkl} + i \cdot c''_{ijkl}) \qquad (3)$$

The solution of equation (2) can be written in the form

$$u_i = u_{0i} \cdot exp\,[i\,(\Omega t - q_k x_k) - \alpha t]\,, \qquad (4)$$

here α is the extinction coefficient,

It is convenient to write this equation [4] in terms of real and abstract components using the Green-Christoffel tensor.

International Journal of Engineering and Information Systems (IJEAIS)
ISSN: 2643-640X
Vol. 4 Issue 9, September – 2020, Pages: 146-149

$$\Gamma'_{ik} = c'_{ijkl}\kappa_j\kappa_l \qquad (5)$$

$$\Gamma''_{ik} = c''_{ijkl}\kappa_j\kappa_l \qquad (6)$$

Real (in units of 10^{10} N / m^2) and abstract parts of the elasticity coefficient tensor ($c''_{эфф}$, 10^7,Н·м$^{-2}$)

Table 1. This table gives the elastic constants of the crystals.

Crystals	c_{11}	c_{12}	c_{44}	c''_{11}	c''_{12}	c''_{44}
$Y_3A1_5O_{12}$	33.32	11.07	11.5	2,68	0,89	0,93
GaP	14.14	6.4	7.03	6.48	4.86	1.3
GaAs	12.26	5.71	6	8.93	7.70	0.94

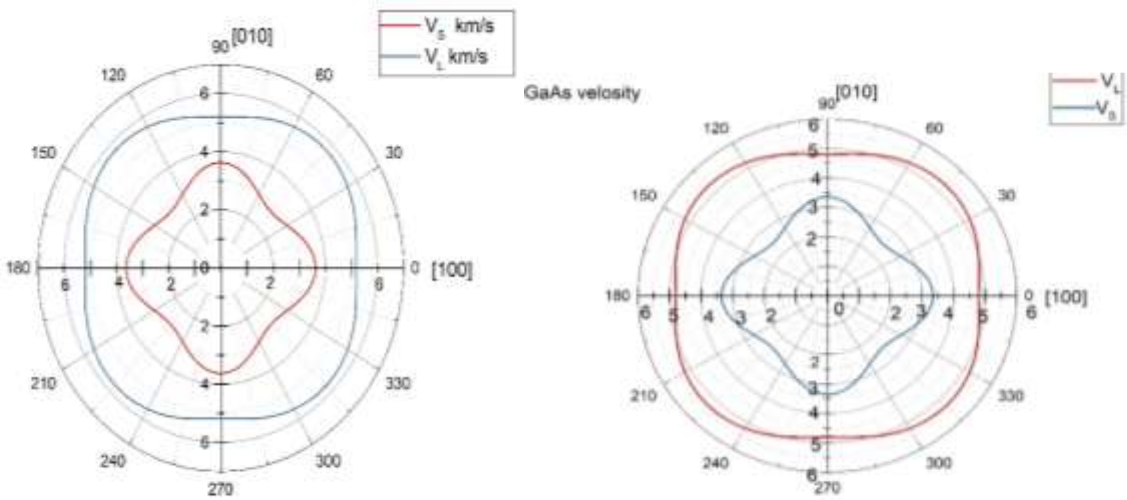
$$c'_{eff} = c'_{ijkl}\kappa_j\kappa_l\gamma_i\gamma_k = \Gamma'_{ik}\gamma_i\gamma_k, \qquad (7)$$

$$c''_{eff} = c''_{ijkl}\kappa_j\kappa_l\gamma_i\gamma_k = \Gamma''_{ik}\gamma_i\gamma_k, \qquad (8)$$

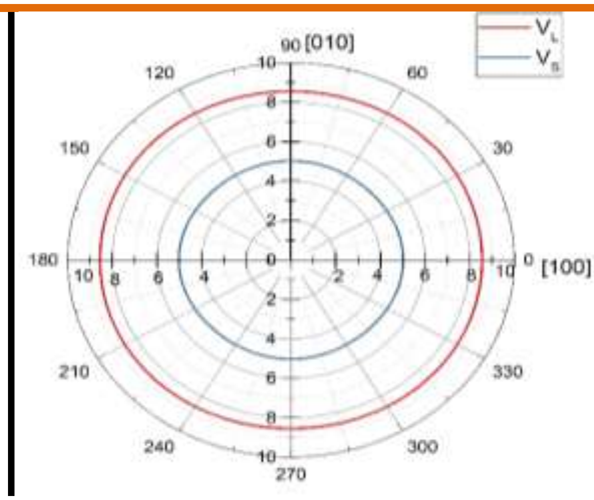
Here, κ_k, γ_i - are the cosines of the direction of the wave vector and the cosine of the direction of the displacement vector. From the solution of the general Christoffel equation, the velocity can be calculated as follows.

$$\rho v^2 = \frac{c_{11}+c_{44}\pm\sqrt{(c_{11}-c_{44})^2\cos^2 2\varphi+(c_{12}+c_{44})^2\sin^2 2\varphi}}{2} \qquad (9)$$

$$v = \sqrt{\frac{c_{11}+c_{44}\pm\sqrt{(c_{11}-c_{44})^2\cos^2 2\varphi+(c_{12}+c_{44})^2\sin^2 2\varphi}}{2\rho}} \qquad (10)$$



a) b)



c)

Fig. 1 *a) Phosphide gallium b) Arsenic gallium c) Velocity anisotropy for yttrium aluminum garnet. v_L is the longitudinal acoustic wave velocity, v is the transverse acoustic wave velocity. The unit of speed was taken as km /s.*

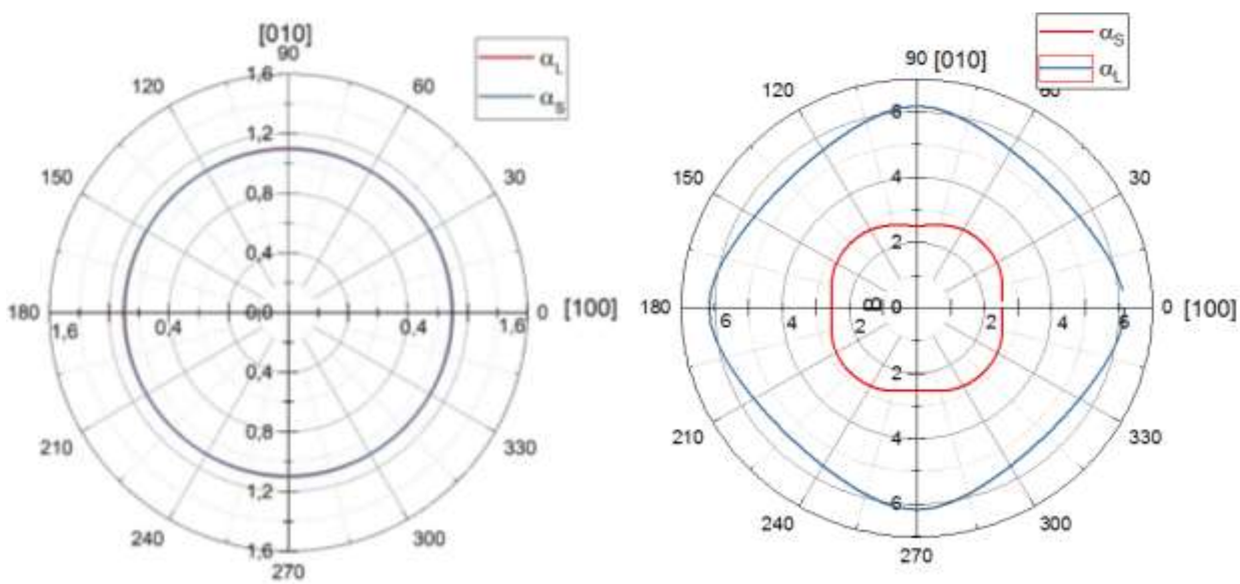
The velocities of the acoustic waves in the crystals vary greatly in direction. The surfaces of the gallium phosphide and gallium arsenide are curved, while the yttrium aluminum garnet is circular, the velocities are very close to each other.

The extinction coefficient can be written from the real and abstract parts of the elastic modulus.

$$\rho v^2 = c'_{eff}, \qquad \alpha = \frac{1}{2}\cdot\frac{c''_{eff}}{c'_{eff}}\cdot\omega. \qquad (11)$$

We can get the following from formulas 9) and (10)

$$\alpha = \frac{1}{2}\cdot\frac{c''_{11} + c''_{44} \pm \sqrt{(c''_{11} - c''_{44})^2\cos^2 2\varphi + (c''_{12} + c''_{44})^2\sin^2 2\varphi}}{c'_{11} + c'_{44} \pm \sqrt{(c'_{11} - c'_{44})^2\cos^2 2\varphi + (c'_{12} + c'_{44})^2\sin^2 2\varphi}}\cdot\omega$$



a) b)

Fig. 2 *a) Gallium phosphide, b) Counting coefficient in yttrium aluminum garnet crystals. Here, the counting coefficient was taken as dB / mks*

3. CONCLUSION

From these graphs it can be seen that the extinction coefficient of the longitudinal waves α_L in the gallium crystal of phosphide is almost two and a half times greater than the extinction coefficient of the transverse wave α_S. From the graph of the extinction coefficient of yttrium aluminum garnet it can be seen that the extinction coefficients of the transverse and longitudinal waves are almost indistinguishable from each other.

REFERENCES.

[1]. V. V. Lemanov, V. S. Kim, A. N. Nasyrov. Acoustic attenuation surfaces in cubic crystals. Physics of Solids, Volume 26, v. 4.1984

[2]. Akhmedzhanov F.R., Lemanov V. £ .., Natroy A. N. Letters in ZhTF, 1980, vol. 6, v. 10, p. 589-592.

[3]. Sirotin Yu.G., Shaskolskaya M.P. Basics of crystallophysics. - M .; Nauka, 1979. - 680 p.

[4]. F.R. Akhmedzhanov1, U.A. Saidvaliev1, J.O. Kurbanov. ANISOTROPY OF Attenuation of acoustic waves in photorefractive bso and bgo crystals. Uzbek Journal of Physics. Vol.20 (№4) 2018 PP.232-235

[5]. Lyamov V.E. Polarization effects and anisotropy of the interaction of acoustic waves in crystals. -M .: MGU, 1983. - 224 p.

[6]. Damon R., Maloney V., McMahon D. Interaction of light with ultrasound: the phenomenon and its applications. // Sat. Physical acoustics. Ed. W. Mason and R. Thurston. M .: Mir, 1974. - T. 7. - Ch. 5. - S. 311-420.

[7]. Gulyaev Yu.V., Proklov V.V., Shkerdin G.N. Diffraction of light into sound in solid telax // UFN. 1978. T. 124. № 1. - S. 61-71.

[8]. Mezon U. Influence of primes and phonon processes on the absorption of ultrasound in germanium, quartz and silicon. // Sb. Physical acoustics. Under the editorship of U. Mezona. 1968. M .: Mir, T. 3, Gl. 6. - S. 285-341.

[9]. Lemanov V.V., Smolensky G.A. Hypersonic waves in crystals // Phys. - Moscow, 1972. - T. 108. - No. 3. - S. 465-501.

[10]. Landau LD, Lifshits EM Theoretical physics. - Edition 5, - M .: Nauka, 2007. - T. VII. Elasticity theory.

[11]. Fedorov F.I. The theory of elastic waves in crystals. - M .: Nauka, 1965.

[12]. Tucker J., Rampton V. Hypersound in solid state physics. - M .: Mir, 1975.

[13]. Dielesan ED, Royer D. Elastic waves in solid bodies. Application for signal processing. - M .: Nauka, 1982.