Acoustooptic Diffraction and Light Absorption in Cs_2BX_4 (B=Hg, Cd; X=Br, Cl) Crystals

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Abstract

The acoustooptic (AO) efficiency of Cs_2HgBr_4, Cs_2HgCl_4 and Cs_2CdBr_4 crystals is experimentally studied. It is shown that Cs_2HgBr_4 and Cs_2CdBr_4 crystals are quite good AO materials. From the results for the absorption coefficients of Cs_2HgBr_4 and Cs_2CdBr_4 it follows that the latter crystals are transparent in a wide spectral range (up to the light wavelength of 25μm). The AO efficiency value for Cs_2HgCl_4 crystal reaches η=40% at the power P=4W of electric drive signal of piezoelectric transducer .

Key words: acoustooptic diffraction, light absorption, Cs_2BX_4 crystals.

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Introduction

Cs_2BX_4 crystals (B=Hg, Cd and X=Br, Cl) belong to the halide family with the β–K_2SO_4 structure [1] and are described with the point symmetry group *mmm* at room temperature. As follows from the estimation of acoustooptic (AO) parameters performed on the basis of studying the photoelastic coefficients and the acoustic wave velocities, these crystals should possess a high AO figure of merit [2,3]. So, according to the calculations [2,3], the AO figures of merit reach the values of M_2=126.5×10^{-15}s^3/kg and M_2=366.9×10^{-15}s^3/kg respectively for Cs_2HgBr_4 and Cs_2CdBr_4 crystals, while M_2=114×10^{-15}s^3/kg in case of Cs_2HgCl_4. Cs_2HgCl_4 crystals (as well as, probably, Cs_2HgBr_4 and Cs_2CdBr_4) are transparent in a wide spectral range (0.32-20μm) [2]. Unfortunately, the efficiency of AO interaction in these crystals has not been ever verified experimentally. Therefore, the present work is devoted to experimental studies for the AO diffraction in Cs_2BX_4 crystals (B=Hg, Cd; X=Br, Cl).

Experimental

Single crystals of Cs_2BX_4 (B=Hg, Cd and X=Br, Cl) have been grown with the Bridgman method. The transverse acoustic wave has been excited with $LiNbO_3$ piezoelectric transducer at the frequency of 30MHz (the third harmonics of the 10MHz transducer). The incident optical radiation of He-Ne laser with the wavelength of 632.8nm has been propagated perpendicular to one of the principal crystal faces. The diffraction efficiency has been calculated with the aid of relation

$$\eta = \frac{I_d}{I_i}, \qquad (1)$$

where I_d is the intensity of the diffraction maximum and I_i the intensity of the incident light. The I_d and I_i values have been measured as functions of the drive electric power. The absorption spectra have been measured, using the Specord-M40, SF-20 and Specord-75IR spectrometers.

Results and discussion

The optical absorption spectra of Cs_2HgBr_4 and Cs_2CdBr_4 crystals are presented in Figure 1. As seen from Figure 1, the crystals are transparent in the IR spectral range up to 25μm. The absorption edge corresponds to 271nm in Cs_2HgBr_4 and 348nm in Cs_2CdBr_4 crystals.

In all the cases, we have observed the isotropic diffraction. It is seen from Figure 2 that the maximum diffraction efficiency for Cs_2HgCl_4 crystals is achieved with the light propagation along <001> axis and the acoustic wave propagation along <100> (or <010>) axis, with the acoustic polarization parallel to <010> (or <100>). At the drive power of 4W, the diffraction efficiency increases up to 40%. It is necessary to note that we have not reached the saturated value of the diffraction efficiency. Hence, one can assume that it would still increase with rising drive power. The measured angles of diffraction are as follows: 0.61deg for the case of light propagation along <011> axis, the acoustic wave propagation along <100> (or <010>) axis and the acoustic polarization <010> (or <100>) (the corresponding value calculated on the basis of the Bragg condition is 0.63deg); 0.6deg for the case of light propagation along <001> direction, the acoustic wave propagation along <010> and the acoustic polarization <001> (the calculated value is 0.8deg), and 0.5deg for the light propagation along <001> direction, the acoustic wave propagation along <100> and the acoustic polarization <001> (the calculated value is 0.6deg).

We have measured the diffraction efficiency for Cs_2CdBr_4 crystals only at the light propagation along <001> direction. The corresponding dependences are shown in Figure 3. It is interesting to notice that the dependences reach their saturation, thus making it possible to determine the limiting values of the diffraction efficiency. For the case of the acoustic wave propagation along <110>, with the polarization parallel to <001> direction, we have η=27.8% at P_{el}=12W and the diffraction angle 0.64deg (the relevant calculated value is equal to 0.68deg), whereas η=16.6% at P_{el}=10W for the case of the acoustic wave polarization $<\bar{1}10>$.

We have observed the AO diffraction for Cs_2HgBr_4 crystals at the same geometry as it has been done for Cs_2CgdBr_4. Nevertheless, because of a small size of the former sample, it has been possible to determine only the diffraction angles.

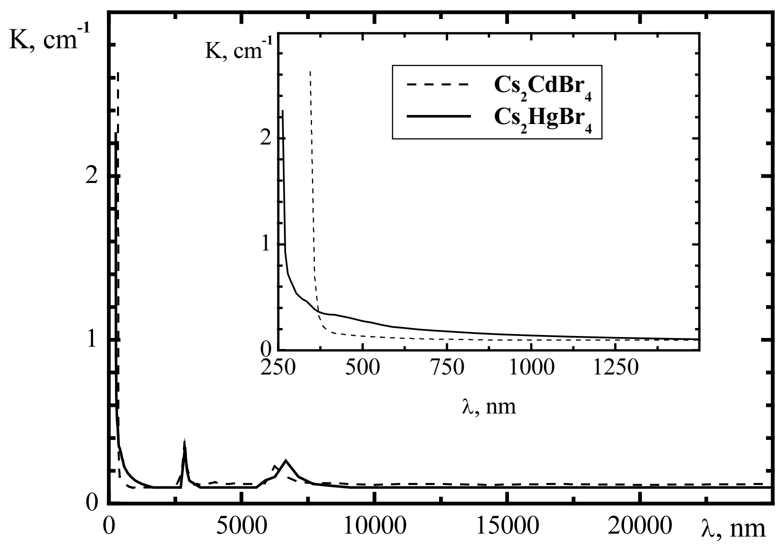

Fig. 1. Spectral dependence of the absorption coefficient for Cs_2HgBr_4 and Cs_2CdBr_4 crystals. The insert shows the same in the close vicinity of the absorption edge.

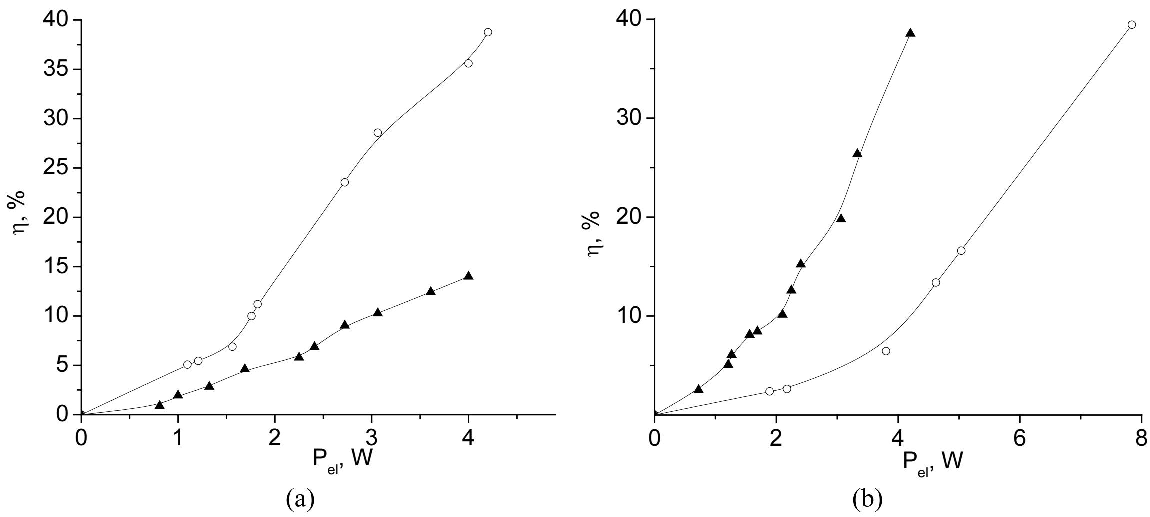

Fig. 2. Dependence of the diffraction efficiency on the electric drive power for Cs_2HgCl_4 crystals and light propagation along <001> axis: (a) the acoustic wave propagation direction <010>, the acoustic polarizations <100> (open circles) and <001> (full triangles); (b) the acoustic wave propagation direction <100>, the acoustic polarizations <001> (open circles) and <010> (full triangles).

Their values are equal to 0.75deg (the calculated one being 0.76deg) for the acoustic wave polarization parallel to $<\bar{1}10>$ direction and 0.72deg (the calculated being 0.69deg) for the acoustic wave polarization <001>.

Conclusions

As a result of the present study, one can conclude that Cs_2HgBr_4, Cs_2HgCl_4 and Cs_2CdBr_4 are transparent in the wide spectral range. In particular, Cs_2CdBr_4 and Cs_2HgBr_4 are transparent respectively from 0.348μm and 0.271μm up to 25μm. All the crystals possess high values of the diffraction efficiency. As shown experimentally, the diffraction efficiency of Cs_2HgCl_4 reaches the value of 40% at the electric drive power of 4W. It is necessary to mark that this value does not represent a limit of some kind. At higher values of the electric power, it is possible to expect further increasing in the diffraction efficiency. Thus, the crystals under test may be successfully used as efficient AO materials in a wide spectral range.

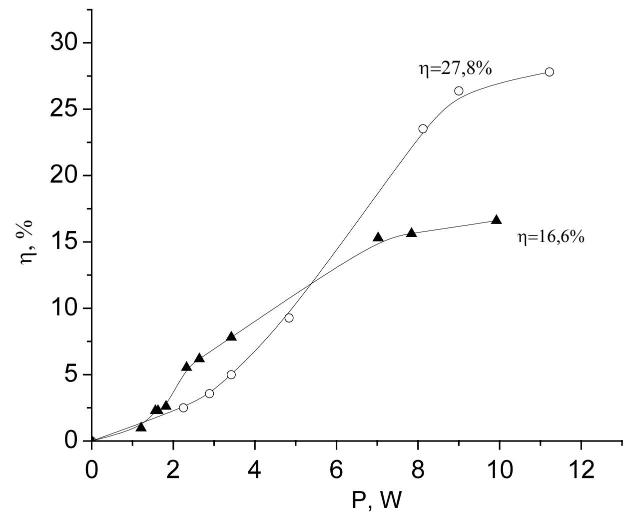

Fig. 3. Dependence of the diffraction efficiency on the electric drive power for Cs_2CdBr_4 crystals and light propagation along <001> axis: the acoustic wave propagation direction <110>, the acoustic polarizations <001> (open circles) and $<\bar{1}10>$ (full triangles).

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References

1. Plesko S., Kind R., Arend H. Phys. Stat. Sol. **61** (1980) 87.
2. Kityk A.V., Zadorozhna A.V., Sydoryk I.V., Martynyuk-Lototska I.Yu. et. al. Abstracts EMF-9, (1999) 92; Kaidan M.V., Zadorozhna A.V. et. al. Appl. Opt. **41** (2002) 5341; Kaidan M.V., Zadorozhna A.V. et. al. Opt. Mat. **22** (2003) 263.
3. Krupych O., Girnyk I., Trach I., Martynyuk-Lototska I., Vlokh R., Vlokh O. Ukr. J. Phys. Opt. **5** (2004) 8.