However, the numerical value of the g-factor, which can be determined in this case from the formula $g\mu_B H = \hbar\omega$, turns out to be too high ($|g| = 3$) compared with the results of paramagnetic-resonance investigations of Te [5] [1)].

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ELECTROOPTICAL EFFECT IN GaAs

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The optical properties of semiconductors placed in strong electric fields have been the subject of many theoretical and experimental studies. Most of them describe the behavior of the absorption edge. Some papers present also data on the variation of the refractive index of homogeneous Ge [1] and Si [2] in an external electric field and in the field of a p-n junction in GaP [3] and GaAs [4,6]. We have investigated the change in the refractive index n in homogeneous semi-insulating GaAs placed in an external electrostatic field, and observed also the shift of the absorption-band edge.

As noted many times by a number of authors [1,2,5-7], a change in the absorption in an electric field should be accompanied, by virtue of the Kramers-Kronig relations, by a change in the refractive index. In general, however, a direct substitution of the formulas of [8-10] into the dispersion relations does not yield the correct results, since the dispersion relation between the imaginary and real parts of the dielectric constant $\epsilon_{ik}(\omega)$ is integral in the frequency, whereas the formulas of [8-10] are valid only in a narrow range of frequencies near the absorption edge. On the other hand, a direct calculation for semiconductors with cubic lattice, having no inversion center and having isotropic effective mass, leads to the following dependence of $\epsilon_{ik}(\omega)$ on the field $\vec{E}$ and on the frequency ω when $\hbar\omega < \Delta$:

$$\epsilon_{ik}(\omega) - \epsilon_{ik}^{(0)}(\omega) = \tfrac{1}{3}(e^3/\hbar^2\omega^2)(2m_{\parallel}/m_0)^{3/2}\{P_{cv}[m_0(\Delta - \hbar\omega)]^{-1/2}\}C_{ijk}E_k, \quad (1)$$

where $\epsilon_{ik}(\omega)$ and $\epsilon_{ik}^{(0)}(\omega)$ are the dielectric constants in an external electric field and in the absence of a field, e is the electron charge, $m_{\parallel} = (m_n m_p)/(m_n + m_p)$ is the reduced mass of the carriers in the crystal, where m_n and m_p are the effective masses of the electron and of the hole and m_0 is the mass of the free electron. P_{cv} is the matrix element of the momentum for transitions from the valence to the conduction band, Δ is the width of the forbidden band, and C_{ijk} are quantities of the order of unity which are equal to one another by virtue of symmetry requirements when the indices i, j, and k are different, and which vanish when any two indices are equal. Formula (1) was obtained by considering a single valence band and a single conduction band.

To determine the change in the refractive index, monochromatic light modulated at 1 kHz was passed through the GaAs sample. The signal from the light receiver was amplified with a narrow-band amplifier and then fed to an automatic plotter through a synchronous detector. The samples of the semi-insulating GaAs were in the form of parallelepipeds 1 cm long with resistivity ~5 x 10^9 ohm-cm at 80°K.

The cryostat with the sample were placed between two polaroid films. When no field was applied to the sample and the polaroids were crossed, the recorded signal was practically equal to zero. Application of the field produced birefringence in the sample. When the external electric field was applied to the crystal in the [100] direction, and the light ray was in the [010] direction, then the resultant ray path difference was $l(n_{\parallel} - n_{\perp})$, where $n_{\parallel}$ and $n_{\perp}$ are the refractive indices for the ordinary and extraordinary rays and l is the length of the sample. Therefore the light, which was linearly polarized with intenstiy I_0 and with the $\vec{e}$ vector at an angle α to the direction of the electric field, became elliptically polarized after passing through the sample, and the intensity of the light passing through the crossed polaroids became

$$I = I_0 \sin^2 2\alpha \sin^2 \frac{\delta^0}{2} \quad (2)$$

where the phase difference is

$$\delta^0 = \frac{2\pi l}{\lambda}(n_{\parallel} - n_{\perp}), \quad (3)$$

and λ is the wavelength of the light.

The measurements yielded the dependence of δ^0 on the intensity $\vec{E}$ of the external electric field for different energies $\hbar\omega$.

The experimentally obtained plot of δ^0 vs. the electric field intensity $\vec{E}$ is a straight line (Fig. 1). This was to be expected from an analysis of Eq. (1), expressed more conveniently in the form

$$\delta^0 = \pm \frac{1}{6}(2\pi e^2 l/\hbar c n_0)(2m_{\parallel}/m_0)^{3/2}[P_{cv}^2/m_0(\Delta - \hbar\omega)]^{1/2}(eE_z/\hbar\omega)c_{xyz}, \quad (4)$$

where $n_0 = \sqrt{\epsilon_0}$ is the refractive index in the absence of the field and c is the speed of

light in vacuum.

As seen from the figure, the plot of δ^0 vs. $\vec{E}$ does not extrapolate to zero at E = 0. The value $\delta^0 \sim 4°$ at E = 0 is due to the presence of strains in the crystal, which lead to the

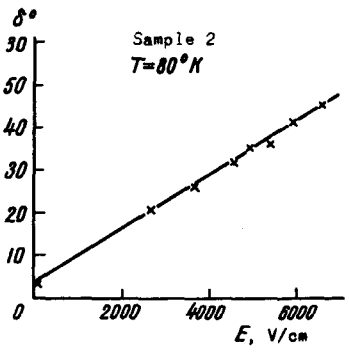

Fig. 1. Plot of δ^0 vs. electric field intensity $\vec{E}$ at $\hbar\omega$ = 1.19 eV.

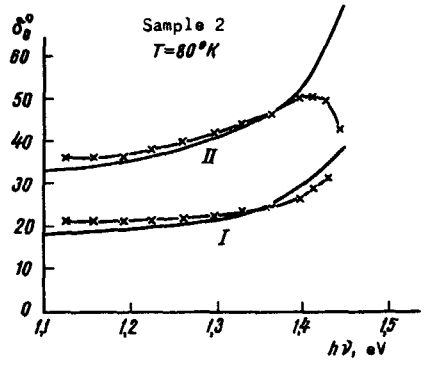

Fig. 2. Plot of δ^0 vs. $\hbar\omega$ at E = 2.6 x 10^3 V/cm (I) and E = 4.9 x 10^3 V/cm (II). The continuous curves are theoretical.

appearance of birefringence even in the absence of an external field. The absolute value of δ^0 at an electric field intensity 6000 V/cm is ~40°, which agrees with the value obtained from (4) if we put $m_{\parallel} \sim 0.07m_0$, $c_{xyz} = 0.31$, $\Delta = 1.5$ eV, and

$$\frac{P_{cv}^2}{m_0} = \frac{\Delta}{2m_{\parallel}} m_0 = 10.5 \text{ eV}.$$

Figure 2 shows a plot of δ^0 vs. $\hbar\omega$ for two electric field intensities, 2.6 x 10^3 V/cm and 4.9 x 10^3 V/cm, compared with the theoretical curves obtained from (4). Although formula (4) allows for only one valence and one conduction band, it agrees well with the experimental data. It can therefore be stated that in this energy range, at $\hbar\omega$ close to Δ, the main contribution to the change of $\epsilon_{ik}(\omega)$ with changing field is made by the transitions between the maximum of the valence band and the minimum of the conduction band at K = 0.

The appreciable disparity between the experimental data and the values obtained from the theoretical estimate (4) at the very edge of the absorption band, a discrepancy especially pronounced in strong electric fields, is due to smearing of the edge in such fields and to the appreciable increase of absorption in this energy region.

In addition, it must be noted that formula (1) was obtained by using the vector potential $\vec{A} = (ic/\omega)\vec{E}$ to describe the interaction between the light and the electrons. If, on the other hand, we describe it by the scalar potential $\vec{\Phi} = -\vec{E}\cdot\vec{r}$, then the result differs from (1) by a factor $(\hbar\omega/\Delta)^2$. In the frequency region $\hbar\omega \sim \Delta$ of interest to us the difference between these results is immaterial, but the frequency dependence turns out to be different, and this may spoil the agreement between the experimental and theoretical curves on Fig. 1. The difference between these results is due to the fact that we are taking into account only one

conduction band, whereas when all the transitions are taken into account the result would naturally not depend on the gauge of the potentials.

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EFFECT OF IMPURITIES ON THE TOPOLOGY OF THE FERMI SURFACE OF INDIUM

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We report here the results of an investigation of the effect of Cd impurity on the behavior of T_c of In under pressure. Experiments of this type were performed so far only on Tl [1], where a nonlinear dependence of $\partial T_c/\partial p$ on the impurity concentration was observed. It was shown that this nonlinear dependence is connected with a change in the number of cavities (topology) of the Fermi surface of the metal [2]. Indium is the second metal in which a change in the Fermi-surface topology is observed.

We investigated In-Cd solid solutions with up to 4.5 at.% Cd. In this concentration range, the residual resistance is linear in the impurity concentration. The initial In and Cd had residual resistances $r = 0.6 \times 10^{-4}$ and 2×10^{-5}, respectively. The solid solutions were produced as follows: A solution with maximum impurity concentration 4.5 at.% was prepared, and the solutions with lower concentration were obtained by diluting the maximum solution with pure In. The samples were annealed for 7 - 12 days at 130°C. The investigated solutions were sufficiently homogeneous, as evidenced by the small difference between the widths of the superconducting transitions of the pure In (2×10^{-3} °K) and of the samples ($2 - 5 \times 10^{-3}$ °K). The plot of the superconducting transition under pressure was similar to that without pressure. The pressure was produced by an "ice" technique [3].

The shift of the transition temperature T_c from the residual resistance without and with pressure was measured relative to T_c of a pure indium sample in one experiment. The temperature of the superconducting transition was determined accurate to $(1 - 2) \times 10^{-3}$ °K. In the pressure interval 0 - 1730 kg/cm^2, a linear decrease of the superconducting-transition temperature was observed for both the In-Cd alloys and the pure In.