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Abstract

Full Text

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ON THE EXISTENCE OF A DIAMOND-LIKE SEMICONDUCTOR IN THE GLASSY STATE

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It was previously known that semiconductors with tetrahedral coordination of atoms in the structure (silicon, germanium, compounds A^3B^5 and A^2B^6) can exist only in the crystalline state. Attempts to obtain these semiconductors in the form of glasses were unsuccessful.

Relatively recently, a glass was obtained on the basis of the compound $CdGeAs_2$, which in the crystalline state also has tetrahedral coordination of atoms in the structure. The absence of long-range order in the glass was shown by means of the X-ray method ([1]).

In view of the fact that the compound $CdGeAs_2$ was the first diamond-like semiconductor in the glassy state, we considered it necessary to prove this by another independent method–an optical study in the region of lattice reflection.

$CdGeAs_2$–a compound of the type $A^2B^4C_2^5$–is an isoelectronic analog of InAs and GaAs. The compound crystallizes in the chalcopyrite structure (space group D_{2d}^{12}, tetragonal lattice, $a = 5.943 \pm 0.001$ Å, $c/a = 1.888$).

Measurement of the reflection spectra in the region 2–25 μ was carried out on an IKS-12 spectrometer, and in the region 20–60 μ on a long-wavelength vacuum

Fig. 1. Spectrum of optical lattice vibrations of $CdGeAs_2$ at $T = 295$°K. 1 –crystalline state; 2 –glassy state

spectrometer constructed at the A. F. Ioffe Physico-Technical Institute of the Academy of Sciences of the USSR ([2]). In the region studied, scattered light did not exceed 1%.

On the basis of the investigation carried out of the infrared reflection spectra of $CdGeAs_2$ in the region 2-60 μ (at angles of incidence close to normal) at $T = 295^{\circ}$K, limiting transverse and longitudinal optical lattice vibrations were determined (see Fig. 1). The presence or absence of these vibrations in the reflection spectrum makes it possible to judge the presence or absence of long-range order in the compound under investigation.

As a result of the experiment it has been established that lattice vibrational frequencies are observed only in crystalline $CdGeAs_2$ and are absent in glassy $CdGeAs_2$, which is direct evidence for the existence of a diamond-like semiconductor in the glassy state.

A certain increase in the reflection coefficient of glassy $CdGeAs_2$, beginning at 36 μ, is associated with an additional contribution to the polarization of electrons from the polarization of nuclei.

The presence of several oscillations in the IR reflection spectrum of crystalline $CdGeAs_2$ does not contradict the results of theoretical group analysis ([3]), according to which, in the vibrational spectra of crystals with the chalcopyrite structure, 2 nondegenerate (symmetry B_1) and 6 doubly degenerate (symmetry E) normal vibrations should appear.

The almost constant value of the reflection coefficients $R_\infty = (33.7 \pm 0.3)\%$ for the crystal and the glass in the wavelength range 2-20 μ made it possible, by extrapolating R_∞ to $\lambda = 0$, to determine the high-frequency dielectric constant $\varepsilon_\infty = n^2 = 14.3 \pm 0.3$.

The calculations of n were carried out using the formula

$$R = [(n-1)^2 + k^2]/[(n+1)^2 + k^2] \quad (1)$$

under the condition that $k^2 \ll n^2$ (where $k = \alpha\lambda/4\pi$ and n are the absorption and refraction indices, respectively).

The constant value of the reflection coefficient in the wavelength range 2-20 μ is due to the absence of dispersion of the refractive index by free carriers (the crystals were of p-type conductivity with a hole concentration $p \sim 3 \cdot 10^{16}$ cm^{-3}).

The close values of ε_∞ for the crystal and the glass give grounds to suppose that the values of the intrinsic-absorption edge for crystalline and glassy $CdGeAs_2$ are rather close.

Thus, the diamond-like semiconducting compound $CdGeAs_2$ exists in the crystalline and glassy states.

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Note: Figure translations are in progress. See original paper for figures.