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Abstract

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ON THE PHOTOELECTRIC PROPERTIES OF CRYSTALS OF p-ZnSiAs$_2$ AND p-CdGeAs$_2$

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The photoelectric properties of compounds of the type $A^{II}B^{IV}C_2^{V}$ had not been studied until recently. We have recently observed photoconductivity in one of the crystals of this type, n-ZnSiP$_2$ ([1]). In the present work we give the results of a study of the spectral distribution of photoconductivity and its temperature dependence for single crystals of ZnSiAs$_2$ and CdGeAs$_2$ of p-type. The spectral characteristics were recorded using a ZMR-2 monochromator with different prisms and a calibrated tungsten lamp as the radiation source. The apparatus used for measuring the photoresponse is described in ([2]).

The p-ZnSiAs$_2$ crystals had a natural shiny surface, which was not subjected to any treatment; after grinding, the p-CdGeAs$_2$ crystals were polished in a hot mixture of hydrofluoric and nitric acids in a ratio of 1 : 3. The dimensions of the samples were on average $5 \times 2 \times 0.3$ mm^3. Electrical contacts were made in the same way as in ZnSiP$_2$ crystals ([1]). At room temperature, the p-ZnSiAs$_2$ single crystals had a current-carrier concentration ($p = 1/eR$) $\sim 4 \cdot 10^{14}$ cm^{-3} and a Hall mobility of holes of 45 cm^2/V $\cdot$ sec. The Hall constant and the specific electrical conductivity in this compound depend strongly on temperature ([3]). The electrical properties of CdGeAs$_2$ single crystals are described in ([3], [4], [6]).

Figure 1 gives the curves of the spectral distribution of photoconductivity for ZnSiAs$_2$, taken at temperatures of 200 and 295° K. When the temperature is lowered, the photoconductivity decreases sharply, and therefore measurements below 200° K (both with modulated and unmodulated radiation) could not be carried out. From Fig. 1 it is seen that in the investigated temperature interval there is only intrinsic photoconductivity, associated with direct transitions of current carriers from the valence band to the conduction band. The maximum photosensitivity at room temperature for all samples corresponds to 2.29 eV, and at 200° K to 2.33 eV. The band-gap width E_g, found at $\lambda_{1/2}$, proved equal to 2.10 eV at 295° K and 2.14 eV at 200° K. This value of E_g agrees with data determined from optical measurements ([5]). The average value of the temperature coefficient of change of E_g is $4.2 \cdot 10^{-4}$ eV/°K. The short-circuit current in the interval 200–300° K increases with increasing temperature. From the temperature dependence of the short-circuit current for ZnSiAs$_2$ crystals, the activation energy of impurities was determined to be 0.15 eV. This value of the activation

Fig. 1. Spectral distribution of photoconductivity for single crystals of p-$ZnSiAs_2$: 1—295° K; 2—200° K

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energy was also obtained from electrical measurements. It remains unclear with what chemical or structural-defect impurities the observed acceptor level of 0.15 eV is associated. The temperature dependence of photoconductivity can be explained phenomenologically. With increasing temperature the Fermi level rises, as a result of which the effective number of recombination centers decreases and the photoconductivity increases.

The curves of the spectral distribution of photoconductivity for p-$CdGeAs_2$ single crystals at temperatures of 80 and 295° K are shown in Fig. 2. On the curve taken at 295° K, in addition to the short-wavelength maximum, caused by transitions from the valence band to the conduction band, a second maximum is observed at $h\nu = 0.51$ eV. The maximum of intrinsic photo-

conductivity at room temperature corresponds to 0.53 eV, and at 80° K to 0.61 eV. By Moss' s rule, E_g was determined (at room temperature the long-wavelength edge of intrinsic photoconductivity is extrapolated in Fig. 2 by a dashed line): at 80° K, $E_g = 0.54$ eV; at 295° K, $E_g = 0.50$ eV. The value of E_g determined from the spectral distribution of photoconductivity is lower than the corresponding values found from the absorption edge (6); however, these latter values coincide exactly with the position of the peaks of intrinsic photoconductivity on the wavelength scale at 80 and 295° K. The average value of α for $CdGeAs_2$ is $1.9 \cdot 10^{-4}$ eV/°K. The short-circuit current in p-$CdGeAs_2$ crystals with decreasing temperature from room temperature to 200° K increases only slightly, while with further lowering of temperature to 80° K it increases sharply (by two orders of magnitude). From the temperature dependence of the short-circuit current, two levels were found: 0.06 and 0.13 eV. In the crystals, in addition to direct band-to-band transitions, band-to-impurity-level transitions occur. These shallow impurity centers are located below the bottom of the conduction band, and because of their considerable density and, chiefly, the long lifetimes corresponding to these transitions, the impurity maximum of photosensitivity is comparable with the intrinsic one. With a high efficiency of these centers, the optical narrowing of the forbidden band observed experimentally may sometimes occur (7). The increase of photocurrent with decreasing temperature can also be explained by the phenomenological theory (8), if one takes into account that, in addition to shallow levels, deep centers are also present in these crystals. Lowering the temperature leads to an increase in the role of "sensitizing" trapping centers, which is manifested in the behavior of the photoconductivity.

Fig. 1. Spectral distribution of photoconductivity for single crystals of p-$ZnSiAs_2$: 1—295° K; 2—200° K

Fig. 2. Spectral distribution of photoconductivity for single crystals of p-$CdGeAs_2$: 1—80° K; 2—295° K

Figure 2: Fig. 2. Spectral distribution of photoconductivity for single crystals of p-$CdGeAs_2$: 1—80° K; 2—295° K

Fig. 2. Spectral distribution of photoconductivity for single crystals of p-$CdGeAs_2$: 1—80° K; 2—295° K

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