EFFECT OF REVERSIBLE LIGHT CONVERSION OF CONDUCTIVITY IN Ge SAMPLES IRRADIATED BY ACCELERATED ELECTRONS WITH ENERGY 3 MeV

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Large attention is attended to the problems of the semiconductor materials production, which show high sensitivity to influence of light radiation, in connection with wide progress of the optoelectronics. Specifically, certain efforts were undertaken for obtaining material the type conductivity of which depend on level of crystal lighting. For example, in Japan (see the patent № 4544 and № 4545 in the bulletin of application for patents of Japan, series VI, vol. 1631, 1971) at obtaining semiconductor material with fixed properties was proposed the method of doping from melt or by the mean of the diffusion of dopants into the wide-band semiconductors (CdS, CdSe, ZnSe and etc.). These dopants generate deep acceptors or donors levels into the band gap of the semiconductors. The deep acceptors into the electronic semiconductor gripped the electrons from valence band, which are excited by lighting to generate the fields with strongly expressed p-type conductivity, while non-lighted part of the crystal conserves initial electronic conductivity. Similarly, the semiconductor with initial p-type conductivity in the dark may be obtained at the lighting of semiconductor with electronic conductivity, if into the p-type material to inject dopants, which can generate into the band-gap the deep acceptor levels.

However, it is more suitable to generate the system of deep levels into the band-gap of the semiconductor by the means of its irradiation, for example, by accelerated electrons or y-quanta with energy sufficient for the generation of stable structure defects. Hence, the super-pure n-type Ge samples ($n_o=3.2\cdot10^{12}$ sm $^{-3}$) have been irradiated by accelerated electrons up to "medium" integral stream ($F_m=20\cdot n_o$ el/sm^2). As a result, the samples underwent n $\rightarrow$ p conversion of the conductivity and after annealing at 350 - 420K they transfer to the high-resistance condition.

The sample transfers into the n-type by faint white lighting if further, to light it at 93K. The sample returns into the p-type at stopped action of lighting. Thus, we observed the effect of reversible light conversion of conductivity type. The sample acquires again p-type conductivity at certain temperature, if it is heated under constant action of lighting. The more light intensity, the higher temperature of n $\rightarrow$ p conversion. The temperature dependence of Hall coefficient Rx for Ge sample, which has tested the conversion of the type conductivity as a result of irradiation by "medium" integral stream of electrons, has been shown in figure 1.

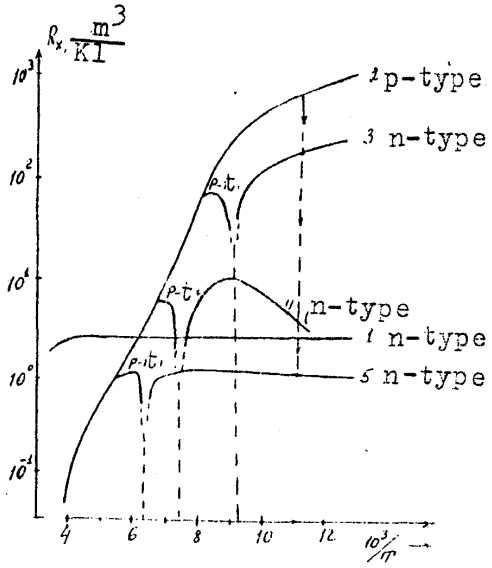


Figure 1 - The temperature dependences of Hall coefficient R_x of Ge sample which has tested the conversion of the type conductivity as a result of irradiation by "medium" integral stream of electrons, where curve 1 - up to irradiation; curve 2 - after irradiation at 93K (in dark) and annealing at 373K; curves 3, 4, 5 - at constant action of white light with various intensities ($I_3<I_4<I_5$)

As is obvious of the figure, the temperature at which n⟶ p conversion is occurred at heating sample depends on the lighting level. The temperature, which is necessary for n ⟶ p conversion, is increased, with increasing light intensity. The effect of light conversion of the type conductivity may have practical application. Specifically, on its base may be developed the device for measuring value of the faint light fluxes without using special compensate instruments. However, unfortunately, the effect occurs up to temperatures about 170K. Thus, the temperature of the sample in the device must not exceed 170K. It needs development of the low temperatures in the volume where the sample is situated and it makes difficult production of the compact devices. It is necessary to achieve such state of the samples at which the effect would be observed at room temperature.

To this end, we have investigated the samples having several more high initial concentrations of the charge carriers. It was known beforehand, that in the samples having high initial concentrations of electrons the indicated effect is not observed. Therefore, it is necessary to investigate the samples with initial concentration of electrons which in some times more than ($n_o=3.2\cdot10^{12}$ sm^{-3}) at which the effect of reversible light conversion of the type conductivity has been detected.

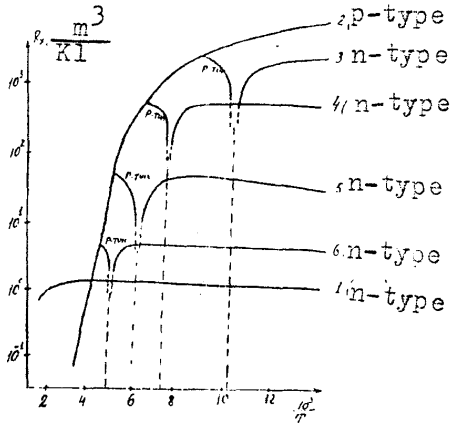


Figure 2 - The temperature dependences of Hall coefficient R_x for Ge sample with initial concentration of electrons $n_o = 8.3 \cdot 10^{12}$ sm $^{-3}$ of irradiated up to "medium" integral stream of the accelerated electrons ($F_{med} \approx 20n_o$ el/sm^2) and annealed at 400K during 35 minutes, where curve 1 - up to irradiation; curve 2 - after irradiation at 93K (in dark) and annealing at 400K; curves 3, 4, 5, 6 - at constant action of white light with various intensities ($I_3<I_4<I_5<I_6$)

As is obvious of the figure 2, the maximum temperature at which the effect is still observed to translocate towards the side of more high temperatures in comparison with the sample having initial concentration of the charge carriers $n_o = 3.2 \cdot 10^{12}$ sm $^{-3}$.

The dependence of conversion temperature of the type conductivity on relative intensity of faint white light for the sample with initial concentration of the charge carriers $n_o = 8.3 \cdot 10^{12}$ sm $^{-3}$ has been shown in the figure 3.

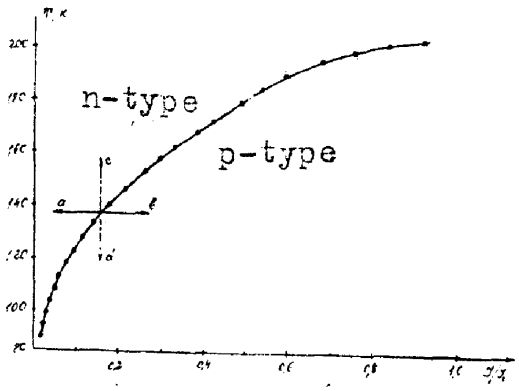


Figure 3 - The dependence of conversion temperature from relative light intensity

The curve in this figure separates n-field from p-field. The sample is p-type beyond this curve and it is n-type below the curve. As is obvious of the figure 3, to change type of the sample conductivity is possible by the means of two ways: 1 - at the fixed temperature by changing light intensity (line ab); 2 - at the fixed light flux by changing temperature (line cd).

On the basis of above-mentioned experimental results is follows that by the means of changing initial concentration of the charge carriers in small limits is possible to increase maximum temperature at which the effect of reversible light conversion of the type conductivity is still observed. However, as is obvious of figure 3, the temperature of conversion of the type conductivity (n ⟶ p conversion) may be increased up to 208K by the means of changing initial electrons concentration. The maximum temperature at which the indicated effect is still observed to translocate towards the side of more low temperatures at using the samples with more high initial concentration of charge carriers. The effect is not observed generally at further increasing concentration of charge carriers. It is assumed for explanation of the effect that as a result of irradiation and annealing of the converted samples into p-type the systems of radiation defects introduced into bad-gap of germanium deep donor and acceptor levels that is generated. These levels are cause both

p⟶n light reconversion and n⟶ p thermal conversion of type conductivity [1,2].

REFERENCES

1. A.R. Basman, A.B. Gerasimov, M.K. Gogotoschvili and others - J. Physics and Techniques of Semiconductors, v. 7, series 7, 1973, p. 1377
2. Patent № 4544 and 4545 - in the bulletin of application for patents of Japan, series VI, vol. 1631, 1971