EFFECT OF A MAGNETIC FIELD ON THE RECOMBINATION RADIATION FROM Ge AND ITS QUENCHING BY INFRARED RADIATION

I. K. KIKOIN and Yu. P. KOZYREV

Submitted to JETP editor May 18, 1963

J. Exptl. Theoret. Phys. (U.S.S.R.) **45**, 1393-1395 (November, 1963)

The recombination radiation from Ge was studied with the specimen in a magnetic field. All the experiments were made at 77°K. The intensity of the recombination radiation decreased under the influence of the magnetic field. The change of intensity did not depend on the sign of the field. When, in addition, the specimen was illuminated by infrared radiation in the spectral region outside the absorption edge of germanium (but not further than $\lambda = 3\mu$), quenching of the recombination radiation was observed; under these conditions the relative change in the intensity of recombination radiation in the magnetic field remained unaltered.

It is well known that in semiconductors the recombination of minority carriers proceeds simultaneously with their generation, this recombination being accompanied by the emission of light. This recombination radiation has been studied by a number of workers.[1-3] To investigate the mechanism of recombination radiation we studied it when the specimen was in a magnetic field.

The experiments were carried out on specimens of n type Ge with resistivity $\rho \cong 40\Omega\cdot$ cm and diffusion length $L \cong 2.7$ mm. Minority carriers were injected by illuminating the specimen with white light (from an incandescent lamp) which had passed through a water filter 100 mm thick.

The experimental arrangement is clear from Fig. 1. The Ge specimens (1), in the form of discs of about 12 mm diameter and thicknesses from 0.3—5 mm, were held in a special cell, and were illuminated in a direction perpendicular to the specimen surface. A PbS photoconductor (2) which served as a detector of the infrared recombination radiation was placed close to the surface of the specimen on the opposite side to the illuminated surface. The intensity of the recombination radiation could be estimated from the change of current in the supply circuit of the photoconductor. The entire system was placed in a Dewar containing liquid nitrogen between the poles of an electromagnet, so that the magnetic field was perpendicular to the illumination direction (parallel to the specimen plane).

The experiments showed that under the influence of the magnetic field the intensity of recombination radiation recorded by the photoconductor was decreased, and this change of intensity did not depend on the sign of the magnetic field. The relative change in intensity of recombination radiation caused by the magnetic field increased with increasing field and with increasing specimen thickness.

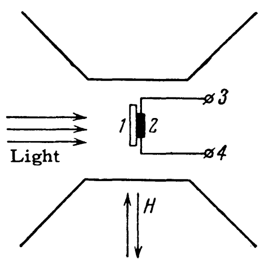

FIG. 1

Control experiments made when illuminating the specimen without the water filter gave an unexpected result: it was found that the effect of the magnetic field on the intensity of the recombination radiation was then sharply decreased. This could be explained by the effect of the additional illumination of the specimen by infrared radiation (which is absorbed almost completely by a water filter[1]). In this connection special experiments were made to study the effect of background illumination by infrared radiation on the decrease of recombination radiation intensity by a magnetic field.

These experiments were as follows. The surface of the specimen was illuminated as before by white light passed through a water filter, but the same surface was simultaneously illuminated from another source of light passed successively through a KS-19 filter and a germanium filter of thickness 0.4 mm. By this means the spectrum of the background illumination was limited to the range of wavelengths $1.7 - 3\mu$ (it is well known that the absorption edge of Ge at a temperature of 300°K lies at about 1.8 μ). The infrared beam of background illumination not absorbed by the specimen under study was, of course, directly recorded by the PbS detector, and the corresponding change of resistance was electrically compensated by the measuring circuit (in Fig. 1 3, 4 lead to the measurement circuit).

The results of the experiments are illustrated by the curves in Fig. 2. In this figure is plotted along the abscissa axis in relative units the intensity of specimen illumination by the short wavelength (white) light G passed through the water filter. Along the ordinate axis is plotted the change of voltage ΔV across the standard resistor in series with the photoconductor in the supply circuit. The voltage V is itself proportional to the current through the photoconductor, and its change ΔV due to the radiation falling on the photoconductor is proportional to the intensity of this radiation.

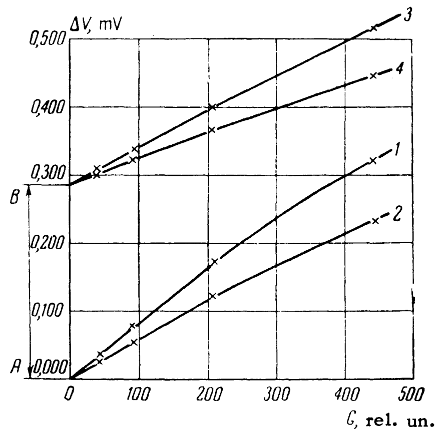

FIG. 2

Curve 1 was obtained when the specimen was illuminated by the short wavelength light alone without the magnetic field. The reduction of recombination radiation in a magnetic field of strength 10,000 Oe is illustrated by curve 2. The relative reduction of recombination radiation by such a magnetic field was about 30%. Curves 3 and 4 show how curves 1 and 2 are changed when the specimen is illuminated by the infrared radiation as well. The intercept AB is a measure of the infrared background illumination.

A comparison of curves 3 and 4 with 1 and 2 shows that, for a fixed intensity of short wavelength light, the infrared background illumination, while significantly reducing the absolute change of recombination radiation by the magnetic field, does not affect the relative change of radiation.

It can be concluded from this that background illumination of the specimen by infrared radiation causes quenching of the recombination radiation itself (without a magnetic field). This was confirmed by independent experiments.

The reduction of recombination radiation by a magnetic field apparently owes its origin to the change of carrier concentration distribution with depth in the specimen and the associated increase of effective absorption path for radiation in the specimen material.

[1] J. R. Haynes and H. B. Briggs, Phys. Rev. **86**, 647 (1952).

[2] R. Newman, Phys. Rev. **91**, 1313 (1953).

[3] J. R. Haynes, Phys. Rev. **98**, 1866 (1953).

Translated by K. F. Hulme
229