MEASUREMENTS OF PHOTOELECTRIC VOLTAGE AND PHOTOCONDUCTIVITY IN GaAs SINGLE CRYSTALS

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The photoelectric voltage of "n" type GaAs samples has been measured. The spectral distributions of photoelectric voltages $U_f = f(\lambda)$ have been obtained in the wavelength interval from 0.7 μ to 2.5 μ. The absolute sensitivity of the photovoltaic effect occurring in the samples has been estimated and it was found that it drops as the electron concentration becomes increased. Investigations also concerned photoconduction, which in most of the samples proved to be minimal.

The photoelectric voltage and photoconductivity of single-crystalline samples of "n" type GaAs have been measured in the 0.7 μ to 2.5 μ range. The samples were from 1 to 1.4 cm long, and not more than 0.4 mm thick. The sample surfaces were etched and polished, and all contacts were made with indium. The study had the purpose of finding the spectral distribution of photoelectric voltages, estimating the absolute sensitivity of the photovoltaic effect occurring in the samples and examining the longitudinal homogeneity of the samples with the latter's aid.

Of the seven samples used in the experiments, four were manufactured in the "TEWA" Semiconducting Materials Factory and two were of Czechoslovak origin. The latter were doped with selenium. The photoelectric voltage measurements were carried out with an arrangement of a Zeiss monochromator and an infrared source. The linearity of contacts was checked by measuring the sample resistivity at current direction alternation from time to time. The light probe in the shape of a rectangle from 0.5 mm to 1 mm wide was placed either near the center of the sample or at a distance of at least 0.5 mm from one its contacts. The mean diffusion path of the minority carriers in GaAs is of the order of 1 μ [1]. As seen from the data given in Table I and Figs 1, 2 and 3, the principal maxima in the $U_f = f(\lambda)$ curves are located within the interval from 0.8 μ to 0.88 μ, which corresponds to an energy interval of 1.55 eV to 1.41 eV. The long-wave edges of these peaks are steep (Fig. 1), except for the sample 4T. The edge energies agree well with the gap width for GaAs (at room temperature E_g values between 1.35 eV to 1.38 eV are usually quoted;

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TABLE I

Data obtained for "n" type GaAs samples

Sample	Electron concentration (cm^{-3})	Long-wave edge of principal maximum (eV)	Energy of principal maximum occurrence (eV)	$\frac{U_{max}}{U_{background}}$	Sensitivity of photovoltaic effffect relative to absorbed power (V/W)
1c	1.6×10^{17}	1.32	1.41	2.64	0.3
2c	2.5×10^{17}	1.35	1.54	1.84	0.6
3	3×10^{17}	1.34	1.55	2.5	4.75×10^{-2}
1T	2×10^{17}	1.35	1.55–1.41	2.14	8.2×10^{-2}
2T	4.3×10^{17}	1.38	1.55–1.41	2.08	3.2×10^{-2}
3T	5×10^{17}	1.38	1.55–1.41	1.82	2.8×10^{-2}
4T	8×10^{17}	diffused	1.55–1.41	1.75	1.7×10^{-2}

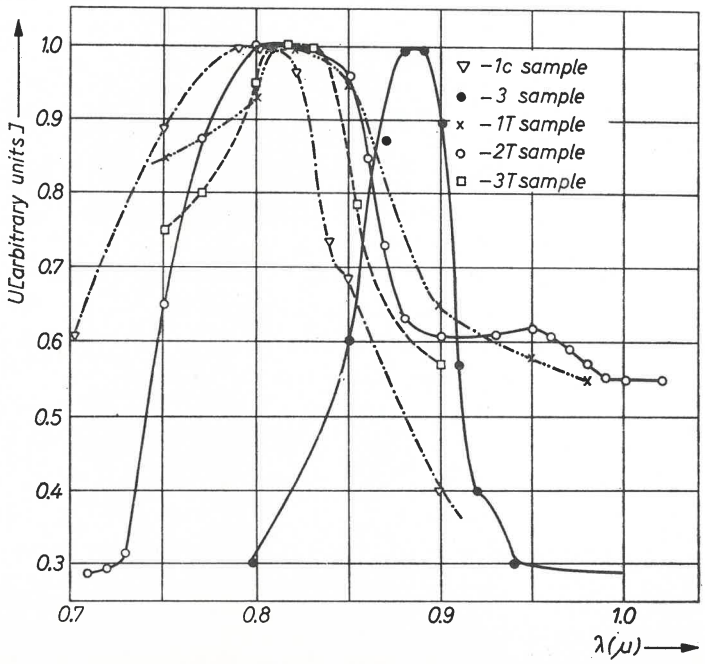

Fig. 1. Plots of photoelectric voltage *versus* wavelength of exciting radiation for five samples

see, *e. g.*, [2, 3, 4]). In the examined samples the principal photoelectric maxima appear in the spectral region where the photovoltaic effect is associated with the transition of electrons from band to band. Once the long-wave edge is shifted in the direction of even longer wavelengths, the photoelectric voltage slowly increases, going through several small peaks along the way.

Attempts were also made to measure the changes in sample conductivity due to the influence of light at an external voltage of several volts. They were, however, very small

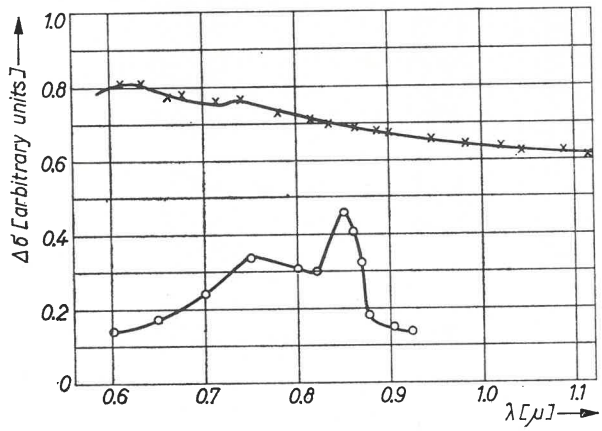

Fig. 2. Plots of conductivity changes *versus* wavelength of exciting light for two samples

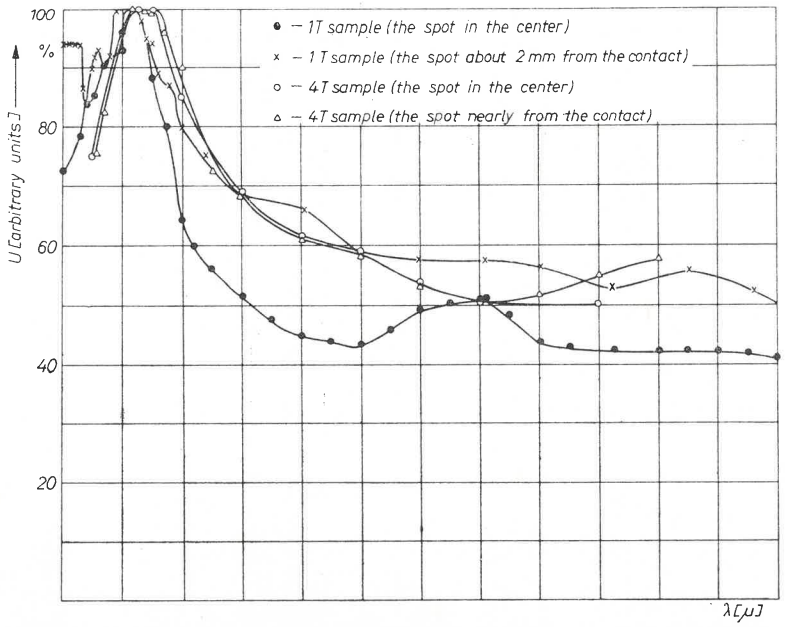

Fig. 3. Plots of photoelectric voltage *versus* wavelength of exciting light for two samples. The light spot is focused on different points of the sample

or even below the sensitivity of the measurement (Fig. 2). In other samples no change was detected.

The conclusions are as follows. 1) The photovoltaic effect of seven "n" type GaAs samples in the infrared region up to 2.5 μ has been observed. The main maximum of photoelectric voltage lies for all samples within the wavelength interval of 0.8 μ to 0.88 μ (1.55 eV to 1.41 eV). 2) The energies of the long-wave edges of the principal maximum are contained within 1.32 eV and 1.38 eV, which is in excellent agreement with quoted values of energy

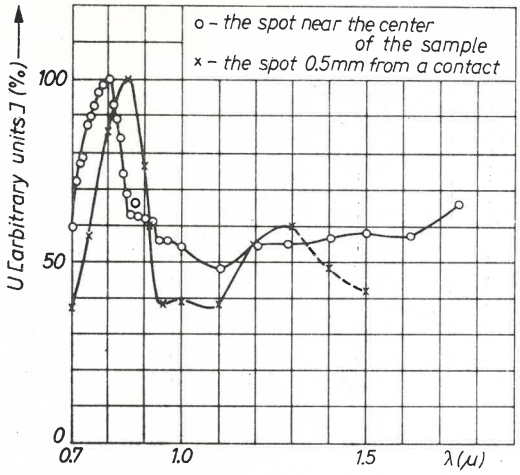

Fig. 4. Plots of photoelectric voltage *versus* wavelength of exciting light for sample 2c. The two curves correspond to different positioning of the light spot on the sample surface

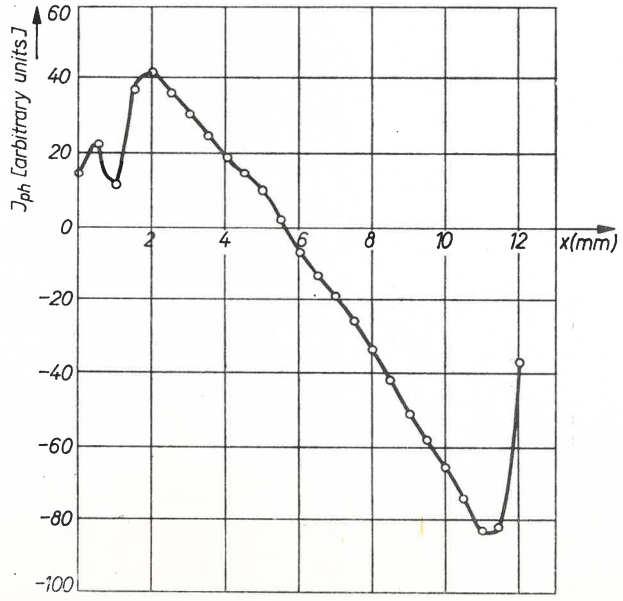

Fig. 5. The dependence of photoelectric current on the distance of the light spot from a contact ($h\nu$ = const.)

gap width for GaAs. By virtue of 1) and 2), it may be said that the principal maxima of photoelectric voltage are related with the intrinsic photovoltaic effect. 3) The ratio of the principal photoelectric maximum to the mean photoelectric voltage in the 1 to 2 μ region in four samples having electron concentrations lower than 5×10^{17} cm^{-3} is greater than two, whereas in the other samples it is smaller than two. 4) By comparing the $U_f = f(\lambda)$ distributions obtained with the middle of the samples being illuminated and those with

near-contact regions illuminated, it was found that there are distinct differences in the runs of the curves (Figs 3 and 4). This is evidence of the inhomogeneity of the samples' material, which had been ascertained before in the case of GaAs of Polish manufacture [5]. The inhomogeneity of the examined material of Czechoslovak origin is illustrated in Fig. 4 and by the distribution of the photoelectric voltage along the sample 2c (Fig. 5). 5) The

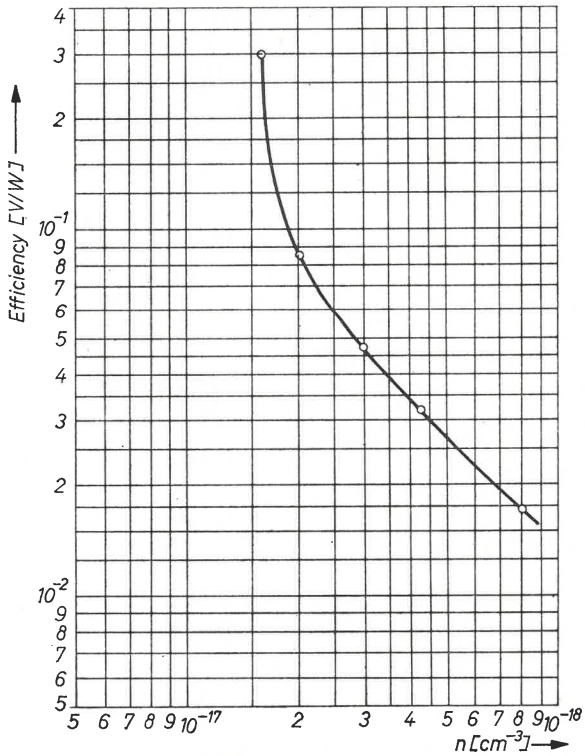

Fig. 6. Plot of absolute photoelectric sensitivity of tested samples *versus* electron concentration

maximum photoelectric sensitivity was found to drop appreciably relative to the absorbed radiation when electron concentration in the samples increases (Fig. 6).

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