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Transverse Magnetoresistance of nType Germanium for High Electric Fields Applied in the 111 Direction

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velocity of the arc "wind" is shown in Fig. 4. By extrapolating the curves, the arc "wind" velocity in the gap between the electrodes appears to be between 3.5×10^3 and 7.0×10^3 cm/sec if the magnetic induction is between 520 to 2000 G, respectively. The linear velocity of the rotating arc was measured with an electronic pulse counter triggered by a photomultiplier tube. This velocity was found to vary between 7×10^3 and 1.1×10^4 cm/sec for B fields ranging from 520 to 1500 G, respectively, and a constant pressure of 10 Torr. The arc "wind" velocity with respect to the arc discharge is thus seen to vary between 1.05×10^4 and 1.7×10^4 cm/sec for B fields ranging from 520 to 1500 G, respectively. These results have recently been verified with data obtained from streak photographs of the arc aureole.

The increase of the arc "wind" velocity with an increase in magnetic field strength has been explained[5] in terms of a magnetic pressure differential across the arc cross section which is due to the interaction of the arc's self-induced magnetic field with the external magnetic field. The superpositioning of these two fields results in a distorted radial pressure distribution within the discharge which gives rise to a gas flow (i.e., the arc "wind") in the Amperian direction, since the net magnetic field strength is weakest on that side.

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Transverse Magnetoresistance of *n*-Type Germanium for High Electric Fields Applied in the ⟨111⟩ Direction

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The transverse magnetoresistance of 5-Ω·cm *n*-type germanium at different magnetic fields for an electric field applied in the ⟨111⟩ direction up to 5 kV/cm has been measured. It has been found that (i) magnetoresistance at a particular electric field decreases with increase of magnetic fields, (ii) at small magnetic fields magnetoresistance decreases with increase of electric field, and (iii) the ratio of the square root of magnetoresistance and the conductivity mobility is independent of electric fields up to 5 kV/cm.

TRANSVERSE magnetoresistance of 5-Ω·cm *n*-type germanium for an electric field applied in the ⟨111⟩ direction up to 5 kV/cm has been measured and the experimental results are presented in this paper.

The sample for the experiment was prepared in an L-shape and was cut having its length along the ⟨111⟩ axis of the crystal. (This particular direction was chosen as the magnetoresistance has a maximum value in this direction and best experimental accuracy may be ensured.) The dimensions of the thick end were made such that its resistance was a small fraction of the total resistance of the sample and also its length was sufficient to allow for recombination of the minority carriers which may be injected from the end. The resistance of the sample was measured using a Wheatstone bridge arrangement, three arms of which were decade resistance boxes consisting of high-stability (0.5%) carbon resistors. Voltage pulses of 5.4-μsec duration and 1-cps repetition rate were applied between the ends. The null condition was detected by an oscilloscope with a balanced pulse transformer at the input. The resistance of the sample could be determined with an accuracy better than 1 in 10^3.

For obtaining data on magnetoresistance of the sample, a voltage pulse was applied and the bridge was balanced. The amplitude of the voltage pulse across the sample was measured with the help of an oscilloscope with an accuracy of about 5%. A magnetic field B was then applied transverse to the electric field and the resistance of the sample was again determined.

The magnetoresistance was calculated from these resistance values using the equation

$$R_m=\frac{R_B-R_0}{R_0}, \tag{1}$$

where R_B and R_0 are, respectively, the resistance of the thin arm of the sample in the presence and absence of the magnetic field. The effect of the resistance of the thick end of the sample was taken into account when calculating the resistance of the thin arm of the sample or the field.

The experimental values of R_m/B^2 for different values of B are plotted in Fig. 1. It should be noted that R_m/B^2 was found to be independent of the direction of the magnetic field provided it was in the transverse plane.

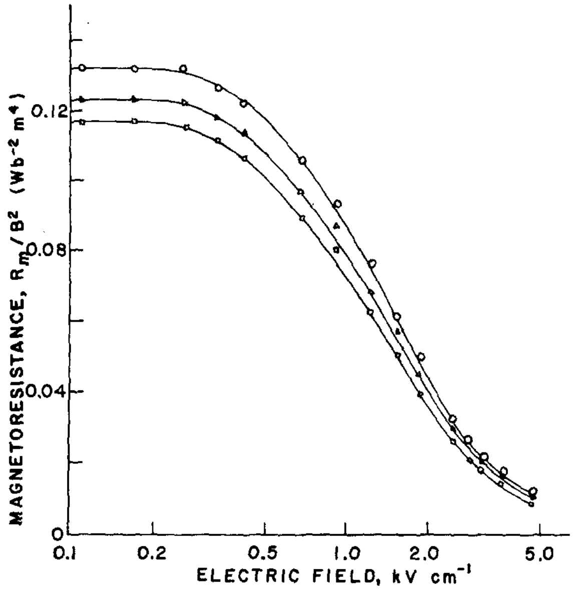

FIG. 1. Variation of magnetoresistance R_m/B^2 with electric field for different magnetic field, for 0–0.7 Wb/m^2, △—0.8 Wb/m^2, □—0.9 Wb/m^2.

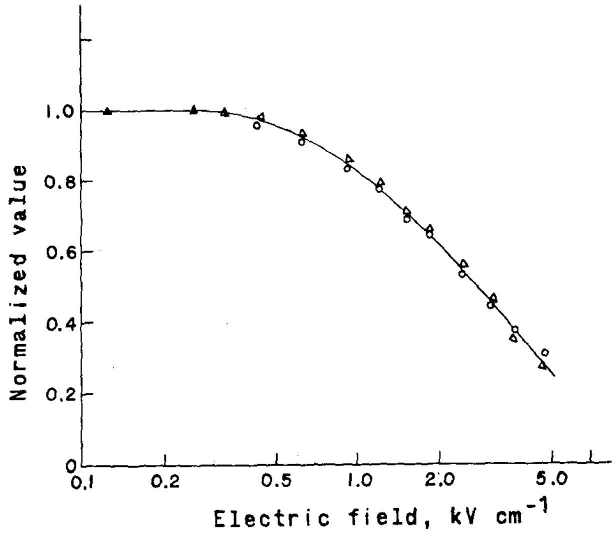

FIG. 3. Variation of conductivity mobility and square root of magnetoresistance with electric field: ○—Conductivity mobility normalized by small field value. △—Square root of magnetoresistance $(R_m/B^2)^{\frac{1}{2}}$ normalized by small field value.

This result agrees with the low-field characteristic, since the electric field is in the ⟨111⟩ direction. The plots in Fig. 1, however, show that for any particular electric field, R_m/B^2 decreases with increase in the magnetic field. In fact, when R_m/B^2 for any electric field was plotted against B^2, straight lines were obtained; the intercepts of these lines on the ordinate may hence be assumed to give the values of R_m/B^2 for B^2 tending to zero. The values of $(R_m/B^2)_{B\to 0}$ so extrapolated are given in Fig. 2. It is found that (R_m/B^2) decreases with increase in the strength of the electric field. Its magnitude is reduced to about half the low-field value for an electric field of 1.6 kV/cm.

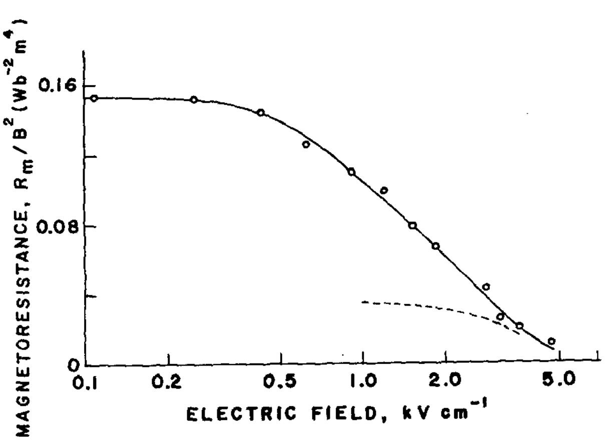

FIG. 2. Variation of magnetoresistance R_m/B^2, with electric field extrapolated to magnetic field tending to zero: —— experimental curve, - - - - theoretical curve (Das[1]).

The magnetoresistance characteristic also shows a significant feature, namely, that the ratio of the square root of magnetoresistance to the conductivity mobility is independent of the field. This is evident from the plots of the square root of the magnetoresistance normalized by the low-field value and of the conductivity mobility, which are given in Fig. 3.

The full significance of the above-mentioned results cannot be discussed at this stage, as no detailed theory of hot-carrier magnetoresistance has yet been worked out. Some numerical values of magnetoresistance of n-type germanium have been obtained by Das[1] with the assumptions which have been used by Yamashita and Inoue[2] to successfully explain in the high-electric-field conductivity-mobility data. These calculated values are also shown in Fig. 2. It is seen that the nature of variation of the theoretical values with the electric field agrees with the experimental result, but the quantitative agreement between the theoretical and experimental values is comparatively poor. The experimental values of magnetoresistance decrease much more rapidly than is indicated by theory and are for some fields more than four times the theoretical values. In view of this discrepancy, one may perhaps conclude that the theory from which calculations were made by Das and which explains the conductivity characteristics does not fully explain the magnetoresistance characteristics.

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[2] J. Yamashita and K. Inoue, J. Phys. Chem. Solids **12**, 1 (1959).