

III. SOLID STATE PHYSICS

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A. BREAKDOWN OF SINGLE-CRYSTAL GERMANIUM WITH ZINC IMPURITIES AT $T = 4^\circ\text{K}$ BY MICROWAVE ELECTRIC FIELDS

This work is a continuation of the study of breakdown in germanium at low temperatures by microwave electric fields that was initiated by J. B. Thomas (1). The small fields that are required to bring order of magnitude changes in conductivity gave an indication that neutral impurities in the germanium were being ionized by electron impacts. Residual electrons in the conduction band gain energy from the electric field, which they then give up through an ionizing collision with a neutral impurity.

The limits for the relations between the electric field and the conductivity in the breakdown region, for a pure single-crystal germanium sample containing zinc impurities at $T = 4^\circ\text{K}$, in a microwave electric field have been established experimentally.

The conductivity of the germanium sample remains constant until a field E_m is reached. The experimental measurements are satisfied by the formulas

$$\frac{\sigma}{\sigma_0} = \left(\frac{E}{E_m} \right)^n \quad E \geq E_m$$

$$\sigma = \sigma_0 \quad E_m \geq E$$

Here, σ_0 is the conductivity of the sample in a microwave field which is less than E_m when $T = 4^\circ\text{K}$, h is a positive number between $3 \leq h \leq \sigma$, and $E_m = 300 \text{ volts/cm} \pm 100 \text{ volts/cm}$ (2, 3). These formulas are valid up to $E = 1000 \text{ volts/cm}$. Work is in progress for obtaining a sharper precision for n .

These breakdown measurements are being extended to single crystals of germanium with gold impurities.

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References

1. J. B. Thomas, A study of electrical breakdown in germanium at microwave frequencies, Ph.D. Thesis, Department of Physics, M. I. T., May 26, 1954.
2. N. Sclar, E. Burstein, W. J. Turner, and J. W. Davisson, Low temperature "breakdown" effect in germanium, Phys. Rev. 91, 215(A) (1953).
3. N. Sclar, E. Burstein, and J. W. Davisson, Theory of low temperature "breakdown" effect in germanium, Phys. Rev. 92, 858(A) (1953).