is removed in energy by ≤ 0.04 eV from the heavy hole band, has an appropriate influence on hot hole velocities in p-type silicon above intermediate field values. Conduction processes in this band are in effect "turned on" when the fields reach the mid 10^4 V/cm range and this relatively low mass band becomes populated. If the velocity does saturate, our data suggests that it does so above 2×10^5 V/cm with a value $\sim 1.0 \times 10^7$ cm/sec.

6. CONCLUSIONS

Hole velocities in uncompensated p-type silicon at 300°K have been found for electric fields to 1.1×10^5 V/cm and for hole densities between 10^{14} and 10^{16} cm^{-3}. The measurements of the $J(V)$ relation and the analysis in terms of the rather small but important space charge injected current give the result that the $v(E)$ relation is essentially independent of the hole density. It is important that the contribution of SCIC is maintained small since it assures the meaningfulness of the study of the effect of doping. It also avoids the difficulties in obtaining accurate velocities from measurements of predominately space charge limited currents.[22]

The onset of impact ionization in our samples is only observed for fields $\bar{E} \gtrsim 10^5$ V/cm. The effective ionization rate computed from the observed ramp on the current pulse gives a resultant α which appears to agree with the ionization rates reported by LEE and co-workers.[15] The limitation of finding the velocity above 10^5 V/cm using our $J(V)$ technique is, therefore, understood.

Because of the care taken during the measurements to use an appropriate pulse length, the results are not influenced by displacement currents, by heating or by transient space charge effects. A method of contacting was used which removes the metal semiconductor contact from the immediate proximity of the p-region under study. This arrangement conveniently avoids the necessity of considering the detailed behavior of the metal-semiconductor contact. A nearly saturated drift velocity is observed, and by extrapolation, v_s appears to occur at or above 2×10^5 V/cm with a value between 0.96×10^7 and 1.06×10^7 cm/sec. The lack of a strong dependence of v upon hole density is consistent with STRATTON's conclusions.[4]

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THE ELASTIC CONSTANTS OF CADMIUM SULFIDE BETWEEN 4.2–300°K*

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Abstract—The five independent elastic constants of single crystal CdS have been determined over the temperature range 4.2–300°K. They were calculated from measurements of the sound velocity in different crystalline directions by the pulse superposition method. All elastic constants increase with decreasing temperature, the variation being somewhat larger for the cross coupling constants than for the diagonal ones. From the low temperature values of the elastic constant, the Debye temperature at 0°K for CdS is determined as 219.3°K.

1. INTRODUCTION

THE ELECTRO-ACOUSTIC properties of CdS have been of interest for a number of years,[1-4] especially since the discovery of the effect of ultrasonic amplification[2] in this material. Since all acousto-electric effects are intimately connected with the sound velocity in the material, the knowledge of this quantity is of great interest in these investigations. Room temperature values for the sound velocities and the elastic constants of CdS have been reported,[5-8] but no results are available for other temperatures. The present report describes measurements of sound velocity and the elastic constants of CdS single crystal between 4.2 and 300°K. From the low temperature elastic constants, the Debye temperature can be computed, and their temperature dependence will indicate the extent to which anharmonic effects are present in the CdS lattice.

2. EXPERIMENTAL TECHNIQUES

Two high purity single crystals of CdS were used in the present investigation. Results of emission spectrographic analysis done on these crystals

Table 1. *Impurity contents of the* CdS *crystals*
(Amounts of impurities are in ppm by weight)

Impurity	CdS 3–125/1	CdS 3–125/2
Na	1000–10,000	1000–10,000
Ca	20–200	3–30
Al	100–1000	3–30
Pb	3–30	3–30
Mg	3–60	3–30
Si	30–300	1–10
Fe	30–300	10–100
In	100–1000	30–300
Cu	100–1000	30–300
Ag	30–300	30–300
Zn	100–1000	30–300

are presented in Table 1. The crystals were oriented by means of X-ray Laue back reflection, and then several planes were ground on each of them. On one of the crystals two pairs of parallel faces were ground, one set normal to the c axis, the other normal to the a axis. On the second crystal, one pair of parallel faces was ground, their normal being in the ac plane, and making an angle of 45° with each of the a and c axis. All faces were polished optically flat, and parallel, within a few seconds of arc.

The elastic constants were determined by measuring the velocity of ultrasonic waves in CdS.