

The analysis of the data obtained at helium temperatures is considerably simplified by the assumption of strong statistical degeneracy. An expression for the electron concentration is obtained as follows. For a spherically symmetrical conduction band the electron concentration is given by

$$n = k_F^3 / 3\pi^2, \quad (1)$$

where k_F is the electron wave vector at the Fermi surface.

The $E(\vec{k})$ relationship for the conduction band from $\vec{k} \cdot \vec{p}$ theory for the case of kP_K and E_g very much less than the spin-orbit splitting energy is⁴

$$E(k) = \frac{\hbar^2 k^2}{2m_0} + \frac{E_g + (E_g^2 + \frac{8}{3} k^2 P_K^2)^{1/2}}{2}, \quad (2)$$

where P_K is the Kane matrix element, and the energies are measured from the valence-band edge. The first term is negligible for the narrow-gap alloys. By replacing $E(k)$ and k by their values at the Fermi level, E_F and k_F , and rearranging, we obtain (for $E_F > E_g$)

$$k_F^2 = \frac{3}{2P_K^2} E_F (E_F - E_g). \quad (3)$$

Combining Eqs. (1) and (3) yields

$$n^{2/3} = \left(\frac{1}{3\pi^2} \right)^{2/3} \frac{3}{2P_K^2} E_F (E_F - E_g). \quad (4)$$

On substituting $E_g = E_0 + \alpha P$ this becomes

$$n^{2/3} = \left(\frac{1}{3\pi^2} \right)^{2/3} \frac{3}{2P_K^2} E_F (E_F - E_0 - \alpha P). \quad (5)$$

The expression is valid in both the normal- and inverted-band-structure regions, provided that the correct sign is used for E_0 (E_0 is negative for the inverted band structure).

The electron concentrations obtained experimentally at 4.2 °K for the three samples are shown in Fig. 8, plotted as $n^{2/3}$ vs P . A straight line is obtained in each case, indicating that the position of the Fermi energy relative to the valence-band edge is independent of pressure. The slope of the

line yields $\alpha E_F / P_K^2$. E_F is found by taking $\alpha = 7 \times 10^{-3}$ eV/kbar (the value obtained at 77 °K) and $P_K = 8.4 \times 10^{-8}$ eV cm.⁵ E_0 is then obtained from E_F and the intercept on the pressure axis. The values of E_F and E_0 found in this way are given in Table II. The small difference in E_0 for samples 7B1 and 7B, which were taken from the same slice of the parent crystal, could be due to an undetected difference in alloy composition. The required difference in x is 0.004, which is within the experimental error of the microprobe analysis. Values for E_0 calculated for the measured values of x from empirical expressions^{6,30} for $E_g(x, T)$ are also listed in Table II. Those obtained from the expression given by Wiley and Dexter,⁸ which assumes a linear dependence of energy gap on both composition and temperature, agree well with the experimental values.

DISCUSSION

According to the $\vec{k} \cdot \vec{p}$ analysis, at 4.2 °K the position of the Fermi level, with respect to the valence band, is independent of pressure in all three samples. It is situated more than 9 meV (or $25kT$) above the conduction-band edge at zero pressure. This must be reconciled with hole concentrations greater than 10^{17} cm⁻³ which are measured in samples 7B1 and 8B at 4.2 °K. The high values for the np product cannot be due to an overlap of the conduction and valence bands, since the high hole density is not observed in sample 7B.

A possible model to account for the observed behavior is shown in Fig. 11. The energy-band structure near the zone center is shown as a function of pressure for an alloy which is semimetallic at zero pressure. We show an acceptor level situated above the heavy-mass valence-band edge, whose energy with respect to the valence-band edge does not change with pressure. Thus, below the pressure P_c the acceptor states lie within the conduction band. Evidence for discrete impurity states lying within a band of states has been obtained in other materials. In CdTe the

TABLE II. Values at 4.2 and 77°K for the energy gap at zero pressure and the Fermi energy.

Sample	T (°K)	x	E_F (meV)	E_0 (meV)	E_0 calculated (meV) (Ref. 8)	E_0 calculated (meV) (Ref. 30)
7B	4.2	0.149 ± 0.005	9	-16	-14 ± 9	-45 ± 9
7B1	4.2	0.149 ± 0.005	16	-10	-14 ± 9	-45 ± 9
8B	4.2	0.138 ± 0.005	20	-33	-35 ± 9	-63 ± 9
7B	77	0.149 ± 0.005	23 ^a	-8.0	+11.6	-15
			31 ^b	+2.0	+11.6	-15

^aCalculated assuming a hole mass $m_h^* = 0.3$

^bHole mass $m_h^* = 0.7$.