A NOTE ON ELECTRON MOBILITIES OF 3-5 SEMICONDUCTORS

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Atomic spin-orbit splittings of the bonded atoms have been used to calculate electron mobilities of the intermetallic semiconductors. The proposed empirical relations for gallium and indium compounds give results in good agreement with experimental values.

Intermetallic compounds consisting of the elements of the third and fifth column in the periodic table have zinc blende structure. Band calculations for these compounds have been reported by Gubanov and Nra'yan[1], Bassani and Yoshimine[2]. Ehrenreich[3] has reviewed the experimental information relevant to the band structure of these compounds and suggested that the calculation for effective mass (m*) can be improved by taking into consideration the spin-orbit splitting for the material. The point is that one of the three valence bands with which the conduction band interacts is located at an energy $(E_g + \triangle)$ below the conduction band (where $\triangle$ is the spin-orbit splitting for the material). The band structure at [000] is of special importance in 3-5 compounds, because the conduction and valence band edges occur in this region of the Brillouin zone.

Small gaps lead to small effective masses which favour high electron mobilities, therefore, there is tendency for crystals with small energy gaps to have high values for the electron mobility.

Cardona[4] has reported that spin-orbit splitting for the compound can be deduced from the atomic spin-orbit splittings of the constituent atoms. Energy gaps for these materials can also be evaluated in terms of atomic spin-orbit splittings[5].

From the foregoing considerations it is apparent that electron mobility in intermetallic semiconductor is ultimately sensitive to the atomic spin-orbit splittings of the bonded atoms.

It has been observed that the analytical expression relating electron mobility with atomic spin-orbit splittings is of the form

$$\mu_e = A\,(7\triangle_0^{\text{cation}} + 2\triangle_0^{\text{anion}})^4 + B \qquad \ldots\ldots \qquad (1)$$

Where μ_e is electron mobility, $\triangle_0$ atomic spin-orbit splitting and A and B are contants characteristic of the cation.

Following are the two empirical relations which give the best fit for the experimental values.

For gallium compounds: $\mu_e = 0.02071\,(7\triangle_0^c + 2\triangle_0^a)^4 + 0{\cdot}0326$ (2)

and for indium compounds: $\mu_e = 0{\cdot}07771\,(7\triangle_0^c + 2\triangle_0^a)^4 - 0{\cdot}7375$ (3)

Electron mobilities calculated from relations 2 and 3 using spectroscopic values[6] for $\triangle_0^{\text{cation}}$ and $\triangle_0^{\text{amion}}$ are given in table 1.

The calculated values for electron mobilities are in fair agreement with the experimental results within the limits of experimental error. Fortunately the concept of using atomic spin-orbit splitting helps one to describe without ambiguity some important physical properties like, energy gap, ionicity and electron mobility of $A^{III}\,B^{V}$ semiconductors. Also the success of the simple relation given above is strong evidence for similarity of band structure at K=0.

TABLE 1

ELECTRON MOBILITIES AT ROOM TEMPERATURE

Crystal	Electron Mobility m^2/voltsec	
	Experimental[7-9]	Calculated
GaP	0·045	0·048
GaAs	0·12	0·116
GaSb	0·5	0·500
InP	0·34	0·461
InAs	2·3	2·155
InSb	7·70	7·72

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