particular gap among all the diamond semiconductors; hence, the analysis of Goroff and Kleinman might be expected to predict the behavior of Ge under *pressure*. This is not to imply that the behavior under shear strain is analogous between Ge and Si, since there is insufficient theoretical or experimental evidence to make this judgment.

The energy band structure for germanium is shown schematically in Fig. 4. The analysis of Goroff and Kleinman for silicon predicts that the

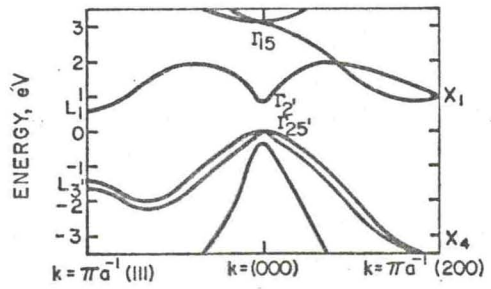

FIG. 4. Band structure of germanium. After Paul and Warschauer, Ref. 28.

conduction band minimum $L_1(111)$ is lowered with [111] one-dimensional strain,* that the degenerate $\Gamma'_{25(j=3/2)}$ valence band maximum is raised with [111] strain and that these positions retain their critical position in the band structure. The predictions are that the change, δ, in energy levels is:

$$\delta L_1(111) = 6{\cdot}20\Delta - 11{\cdot}5\epsilon, \qquad (5)$$

and

$$\delta\Gamma'_{25(j=3/2)} = 2{\cdot}09\Delta + 2{\cdot}79\epsilon, \qquad (6)$$

* A one-dimensional strain along the [111] axis as achieved in the shock wave experiment gives a strain tensor referred to the crystal axes of:

$$\frac{\epsilon}{3}\begin{bmatrix}1&1&1\\1&1&1\\1&1&1\end{bmatrix} = \frac{\epsilon}{3}\begin{bmatrix}1&0&0\\0&1&0\\0&0&1\end{bmatrix} + \frac{\epsilon}{3}\begin{bmatrix}0&1&1\\1&0&1\\1&1&0\end{bmatrix}$$

$$= \Delta + \frac{\epsilon}{3}\begin{bmatrix}0&1&1\\1&0&1\\1&1&0\end{bmatrix}$$

where ϵ is the strain along the [111] axis. This strain tensor is a combination of a dilatation, Δ, and a dilatationless shear strain.

where Δ is the dilatation and ϵ is the [111] direction strain. The first terms show the effect of the dilatation, and the second terms are due to the dilatationless shear strain. Thus the change in energy gap, δE_g, is predicted to be:

$$\delta E_g = +4{\cdot}11\Delta - 14{\cdot}29\epsilon. \qquad (7)$$

The shear strain contribution is clearly dominant for [111] one-dimensional strain. The dilatation part of the expression has been previously measured by PAUL and BROOKS,[30] hence, we look to our measurements for an evaluation of the shear strain contribution.

The results of the resistivity measurements in the elastic range are shown in Fig. 5 where the logarithm of the observed resistivity at wave transit time is plotted against strain. The logarithm of resistivity shows a linear decrease with strain indicating that the decrease of resistivity is due to an exponential term.

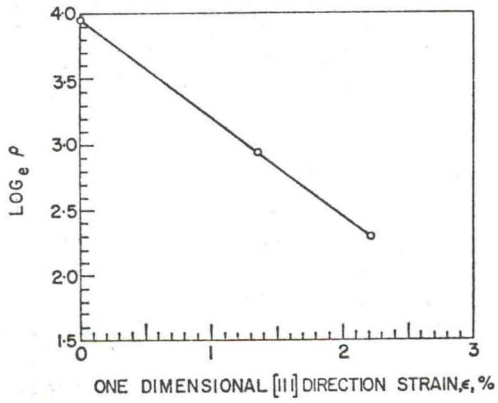

FIG. 5. Resistivity of [111] Ge in one-dimensional strain.

Since the intrinsic resistivity of a semiconductor is related to the energy gap by an exponential term, $\exp[E_g/2kT]$ and the terms involving the mobilities and effective masses of the carriers are pre-exponential factors, the exponential decrease of resistivity with strain indicates that the change is principally due to the strain-induced energy gap change. Assuming that the strained Ge exhibits intrinsic behavior and that the pre-exponential factors affecting the resistivity are unchanged from their atmospheric pressure values, an energy gap change can be calculated consistent with the measured resistivity. The value obtained is