

the resistances of the three zones. If we assume (1) that all wave velocities are steady, (2) that all stress amplitudes are steady, (3) that the resistivity is not time dependent, (4) that the stressed regions of the disk are in a state of one-dimensional strain, and

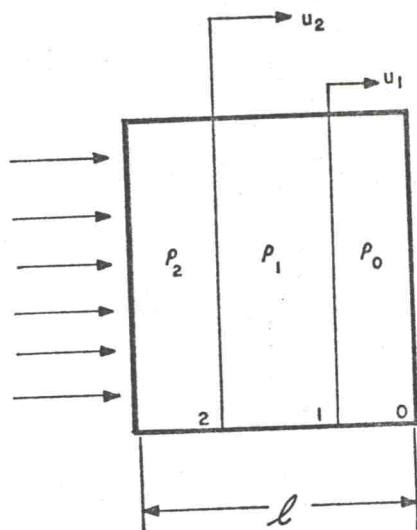


FIG. 2. Three zone resistivity model for a shock-wave loaded semiconductor. Two separate shock waves are shown as would be encountered in the stress region above the Hugoniot elastic limit.

(5) that the strains are infinitesimal;* it follows that:

$$AR(t) = \rho_0 l + U_1 t(\rho_1 - \rho_0) + U_2 t(\rho_2 - \rho_1),$$

$$0 < t < \frac{l}{U_1} \quad (1)$$

and

$$AR(t) = \rho_1 l + U_2 t(\rho_2 - \rho_1), \quad \frac{l}{U_1} < t < \frac{l}{U_2} \quad (2)$$

where: A is the area of the disk; R is the resistance between the electrodes; ρ is the resistivity; U is the wave velocity; l is the thickness of the disk; t is the time and the subscripts 0, 1 and 2 refer to the various zones.

* It is not necessary to neglect the particle velocity (strain) to develop the analysis. It has been neglected for illustrative purposes only. All reduced data include the effects of finite particle velocity.

Equations (1) and (2) show that the electrical resistance between the electrodes of the specimen at any time is equal to the sum of the resistances of the zones. After all the waves have propagated out of the specimen without reflection, the resistance-time record will exhibit a final value corresponding to the impact stress. The initial and final values of the resistance are connected by a continuous line made up of segments of different slope, each segment corresponding to the propagation of a wavefront through the specimen. The initial and final values of the resistance explicitly define the change in resistivity due to the impact stress; the discontinuities in slope show the existence of multiple waves and define transit times for each wave from which the wave velocities can be calculated. This behavior is clearly shown in the typical record given in Fig. 3. Thus, resistance-time measurements can yield explicit data on the number of wavefronts and their wave velocities as well as the resistivity associated with each wave. Further, the complications resulting from wave reflections and subsequent interactions, which are inherent in free surface velocity techniques, are avoided.

Although it was originally hoped that values for resistivity would be obtained for the full stress range and thus provide quantitative data on the resistivities associated with the phase transition and the plastic range, experimental results show an e.m.f. for stress increments above the elastic limit which precludes quantitative resistivity measurements. Also, the temperature rise for large compressions is large and not accurately known such that resistivity is governed by the uncertain temperatures rather than the compression. The resistance-time measurements are sufficient, however, to provide good measurements of the various wave velocities, and quantitative resistivity data is obtained in the elastic range.

In order to determine the stress and specific volume, the particle velocity associated with each wave must be known in addition to the wave velocity. Because of symmetry, the total particle velocity imparted to the specimen disk is one-half the experimentally measured impact velocity.† In general the division of the total particle velocity

† The instantaneous velocity of the projectile immediately prior to impact is measured to a precision of 0.5%.⁽⁸⁾

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(111) crystal plane.⁽⁶⁾ Atmospheric pressure was used and n -type carrier concentration and resistivity-temperature were maintained at 20 to 75°C. The disk was assumed to be nominally uniform. The particular experimental procedure for the specimen disks are

resulting from stress on the specimen is obtained under constant conditions. Voltage across the thickness of the specimen was measured with a Tektronix 545 oscilloscope. A current of 1.00 A is applied about 500 nsec before the impact of the disk. The impact is 0.4 V. The electrodes are entirely electroless silver. The specimen is also silver and maintained in a backup disk assembly, which serves as the electrode. As will be seen, the resistance change in the specimen is effectively constant. The electrodes are located at the ends of contact resistance. The resistance changes as a change in the specimen reaches an electrode. The resistance is observed in the stress region. It is estimated that the measurements are accurate to $\pm 10\%$.

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The range of several measurements have previously been made which indicate the presence of cusps, in the resistance-time record. To obtain an analytical resistance-time behavior for a specimen disk in which two wavefronts of different amplitudes and different velocities are present. As shown in Fig. 2, the specimen is divided into zones of different resistivity. The total resistance is then the sum of

