pressures are in units of Mbar, volumes in cm^3/g, speeds in cm/μsec, and energies in Mbar cm^3/g.

A. Resistivity Theory and Analysis

To understand the resistivity change in a metal under shock compression, we first need an understanding of the effect of hydrostatic pressure on resistivity. It turns out that for a number of metals the main effect is a change in scattering of electrons by lattice vibrations. Changes in electronic band structure, the Fermi surface, and crystal structure can also be important.

1. Volume Dependence of Resistivity due to Lattice Vibrations

We can get a physical picture of the change in resistivity due to the lattice vibrations by using an Einstein model of a solid. In an Einstein model a solid consisting of N atoms is represented by 3N one-dimensional harmonic oscillators all vibrating with the same characteristic frequency, ω_E. The characteristic temperature θ_E is defined by

$$\hbar \omega_E = k_B \theta_E$$

($\hbar$ is Planck's constant and k_B is Boltzmann's constant). At high temperature where the classical equipartition theorem holds, the energy

$$E = k_B T = 2 \overline{V} = m \omega_E^2 \overline{x^2}$$

where here $\overline{V}$ is the mean potential energy and the virial theorem has been used. It is reasonable to expect that the cross-section of the vibrating atom for scattering electrons would be proportional to the mean squared amplitude of vibration. This conclusion was first reached by Wien (Mott, 1934). Then

$$\rho \propto \overline{x^2} = \frac{k_B T}{m\omega_E^2} = \frac{\hbar^2}{mk_B} \frac{T}{\theta_E^2}$$

where θ_E will be dependent on the volume through ω_E. We find that the main volume dependence of resistivity may be expressed as

$$\left(\frac{\partial \ln \rho}{\partial \ln V}\right)_T = -2 \frac{\partial \ln \theta_E}{\partial \ln V} .$$

In the more complete Bloch-Gruneisen theory of resistivity, the resistivity is expressed as

$$\rho = \frac{K}{\theta_R} \left(\frac{T}{\theta_R}\right)^5 J\left(\frac{\theta_R}{T}\right)$$

where

$$J = \int_0^{\theta_R/T} \frac{x^3 dx}{(e^x-1)(1-e^{-x})} .$$

(See Ziman (1960) for a detailed treatment of this approach.) The quantity K depends on the crystal structure and other factors independent of T and θ. At temperatures large compared to θ_R, $J \propto \left(\frac{\theta_R}{T}\right)^4$ so that again we find $\rho \propto \frac{T}{\theta_R^2}$.

The Bloch-Gruneisen results are derived for a monovalent metal with a spherical Fermi surface, a Debye model for the lattice vibrations, and a deformation potential model for the change of potential of both ions and electrons as an ion moves off a lattice site in its thermal motion.