arranging, we see that

$$\Delta V_m{}^1 = -kT_Q\left(\frac{\partial \ln\Sigma}{\partial P}\right)_{T_Q} + kT_Q\left(\frac{\partial \ln(\nu a^2 N_d)}{\partial P}\right)_{T_Q}. \quad (7)$$

Assuming the pressure dependence of ν, a, and N_d to be small, we can interpret the pressure effect on the slopes of the loss-versus-reciprocal quench rate curves in terms of a vacancy motional volume. The value inferred from the gold data by the use of (7) turns out to be two to three times the value determined[4] from the pressure effect on the anneal of quenched-in vacancies near room temperature.

For the impurity cluster mechanism, pressure affects not only the vacancy migration rate but also r_0, the radius of the impurity nucleus. Taking the pressure derivative of the Kino and Koehler expression, we find

$$\frac{\partial \ln\Sigma}{\partial P} = \frac{\partial \ln}{\partial P}\left(\frac{\nu f(x) E_f{}^1}{a(E_m{}^1)^2}\right) + \frac{1}{r_0}\frac{\partial r_0}{\partial P} - \frac{\Delta V_m{}^1}{kT_Q}. \quad (8)$$

Although the first term may be somewhat insensitive to pressure, the radius of the nucleus will certainly be pressure-dependent, tending to decrease with increasing pressure. This term would then add to the motional volume term. Thus, unless the motional volume is temperature-dependent, the impurity cluster mechanism appears to be more compatible with these data. Further studies are being planned for specimens with larger dislocation densities and with known impurity concentrations.

Also, in agreement with the results of Kino and Koehler, we find that the fractional loss is slower than linear in τ. However, the departure from linearity does not become obvious until the quench rate is less than about 500°C sec^{-1}. At this rate, the fractional loss can no longer be considered small, as is assumed in the theory. Further studies are also being made at very slow quench rates.

B. Aluminum

1. Formation Volumes

For aluminum, there are far fewer results with which to compare. BLB have derived a single vacancy formation volume of 5.4 cm^3/mole from their thermoelectric power data and 6.0±0.6 cm^3/mole from their resistance data in the 600° to 700°K range. The latter is in particularly good agreement with the present result, which was obtained at about 700°K. Buescher and Emrick[21] have recently determined ΔV_m by pressure anneals of quenched-in resistance in aluminum and have found a value of about 1.7 cm^3/mole for both single and divacancies. The sum of these two is far less than the value of 13.5 cm^3/mole found for ΔV_{act} in aluminum by Butcher, Hutto, and Ruoff[22] and of 12.9 cm^3/mole found by Beyeler and Adda.[6] These results would support the BLB conclusion that in aluminum, divacancies are the dominant defect at temperatures above 800°K where the diffusion measurements were made. It may be possible to extend the aluminum quenches to higher temperatures in order to check this conclusion although with the vessel at −80°C, temperature fluctuations increase appreciably when the specimen temperature exceeds 700°K.

2. Vacancy-Loss Mechanisms

Dislocation densities calculated for Al 14 from Eq. (1) are about 10^6 cm^{-2}, in reasonable agreement with other experiments under similar conditions. The pressure dependence of Σ for the aluminum data yields a motional volume nearly twice that determined for either single or divacancies in low-temperature pressure anneals.[21] The large error on this value, however, just includes the low-temperature value. Until further experiments are done, it can only be said that the value is more consistent with the cluster mechanism than with the dislocation mechanism.

[21] B. J. Buescher and R. M. Emrick (unpublished).
[22] B. M. Butcher, H. Hutto, and A. L. Ruoff, Appl. Phys. Letters 7, 34 (1965).