(1) Diffusion
(2) Gold

DICK RH65 0719

Reprinted from The Physical Review, Vol. 137, No. 2A, A613–A619, 18 January 1965
Printed in U. S. A.

Effect of Hydrost[illegible] [illegible]n the S[illegible] Diff[illegible]on Rate in Single Crystals of Gold*†

[illegible]on,‡ R. C. [illegible]owe[illegible] [illegible]nd C. T. Tomizuka
De[illegible] Physics, Univ[illegible]sity of [illegible]ona, Tucson, Arizona
(Received [illegible] August 1964)

The rate of self-d[illegible] was measured by the radioactive-tracer-la[illegible]ing technique at 860, 910, and 96[illegible] at h[illegible]ostatic pressures from 2.00 to 9.08 kbar. The diffus[illegible] was observed to decrease with inc[illegible] pressure, and the activation volume for self-diffusion was dete[illegible]ed to be 7.2±0.4 cm³/mole. This value is in good agreement with the sum of the experimental values of the activation volumes of formation and motion in gold, the experimental values of the activation volumes in other fcc metals, and many of the theoretical values calculated for copper. The present value also is in fair-to-excellent agreement with the various expressions relating the activation volume to other experimentally derived quantities. The limiting source of error in pressure-diffusion experiments of the present type was found to be in controlling the measurement, reproducibility, and uniformity of the temperature.

I. INTRODUCTION

Many experiments have been carried out in recent years in an effort to clarify the nature of atomic defects in metals. A series of such experiments by Simmons and Balluffi[1–4] has convincingly established that the predominant thermally-generated defects in the noble met[illegible] and aluminum are v[illegible]ant sites, reinforcing the [illegible]ready general belief [illegible] diffusi[illegible] limited phenom[illegible] proceed by the vacancy mech[illegible] in these metals. However, many of the details pertaining to the [illegible]ure of these defects are still not well defined, [illegible]d [illegible] are some important gaps in the experime[illegible]al v[illegible]es of some of the basic properties of vaca[illegible]s in [illegible]tals.

Of [illegible]ula[illegible] in clarifying the detailed nature of the de[illegible] in [illegible]tals are the values of the total activation ene[illegible]y an[illegible] the total [illegible]ion volume of the defects, [illegible] well as the indepe[illegible]y determined values of the [illegible]rgies and volumes of formation and motion. Self-dif[illegible]on experiments are [illegible]propriate for me[illegible]ing th[illegible] values of the total activation energy [illegible] volume. The radioactive tracer and sectioning tec[illegible]nique may be used for most metals in such measurements, although other techniques are sometimes used, such as measurements of anelastic relaxation in certain alloys, or nuclear-magnetic-resonance techniques in certain metals. Diffusion rates have been measured for many of the pure metals at atmospheric pressure, yielding values of the activation energy for these metals. Relatively few of these metals have been subjected to self-diffusion studies at elevated pressures because of the technical difficulties involved. For the lower melting-point metals, liquid pressure systems and external furnaces may be utilized. Nachtrieb and co-workers have thus determined the activation volumes for sodium,[6] alpha-white phosphorus,[7] and lead.[8] Hudson and Hoffman[9] used a "belt"-type pressure system[10] in their determination of the activation volume in lead; they used silicone oil as the pressure fluid and an internal heater to maintain the diffusion temperature. However, self-diffusion measurements of the high-melting-point metals, such as the noble metals, require the use of a gas pressure system to insure both hydrostaticity, and chemical stability of the pressure medium at high temperatures. An internal [illegible] also is required in order to make it possible to m[illegible]tain the temperature of the pressure vessel sufficiently low by forced external cooling. Tomizuka[11] used such an arrangement to determine the activation volume of silver, and Albrecht and Tomizuka,[12] with the appa[illegible]us in this laboratory, have recently completed a dete[illegible]tion of the activation volumes for diffusion of g[illegible] and silver tracers in a gold-34 atomic percent s[illegible] alloy.

Most of the theoretical calculations on point defects have been done for copper,[13] which is representative of the face-centered cubic crystal structure, but for which

* This work was originally sponsored in part by the U. S. Air Force Office of Scientific Research under Contract No. AF 49(638)-790 and later by the U. S. Atomic Energy Commission under Co[illegible]act No. AT(11-1)-1041.

† Based [illegible] a [illegible]sis submitted to the University of Arizona in partial [illegible]lfillm[illegible]nt of the requirements for the Ph.D. degree in physics [illegible] RH

‡ Prese[illegible] addr[illegible] Department of Physics, University of Illinois, U[illegible]na, Illinois.

[1] R. O. [illegible]mons and R. W. Balluffi, Phys. Rev. 117, 52 (196[illegible]).

[2] R. O. [illegible]mons and R. W. Balluffi, Phys. Rev. 119, 600 (1960).

[3] R. O. [illegible]mons and R. W. Balluffi, Phys. Rev. 125, 862 (1962).

[4] R. O. [illegible]mmons and R. W. Balluffi, Phys. Rev. 129, 1533 (1963).

[5] See, f[illegible] example, F. Seitz, in *Phase Transformations in Soli[illegible]* edited b[illegible] R. Smoluchowski *et al.* (John Wiley & Sons, Inc., New Yor[illegible], 1951), p. 77.

[6] [illegible] H. Nachtrieb, J. A. Weil, E. Catalano, and A. W. Lawson, J. C[illegible]em. Phys. 20, 1189 (1952).

[7] N. H. Nachtrieb and A. W. Lawson, J. Chem. Phys. 23, 1193 (1955).

[8] N. H. Nachtrieb, H. A. Resing, and S. A. Rice, J. [illegible]em. Phys. 31, 135 (1959).

[9] J. B. Hudson and R. E. Hoffman, Trans. Met. Soc. AIME 221 761 (1961).

[10] H. T. Hall, Rev. Sci. Instr. 31, 125 (1960).

[11] C. T. Tomizuka, in *Progress in Very High Pressure R[illegible]* edited by F. Bundy *et al.* (John Wiley & Sons, Inc., New [illegible] 1961), p. 266.

[12] E. D. Albrecht and C. T. Tomizuka, J. Appl. Phys. (to be pub[illegible]shed).

[13] [illegible] a list of references see R. A. Johnson and E. Brown, Phys. Rev. 127, 446 (1962).