Quenching of Lattice Vacancies in Pure Silver*

M. DOYAMA AND J. S. KOEHLER
University of Illinois, Urbana, Illinois
(Received March 30, 1960)

Quenching data on 99.999% pure silver gives the energy required to form a lattice vacancy to be 1.10±0.04 ev. In addition, the data of Simmons and Balluffi (who obtained the vacancy concentration in equilibrium near the melting temperature) together with present data give the resistivity increase per atomic percent vacancies to be 1.3±0.7 micro ohm cm.

SILVER wires, 99.999% pure, of 2-mils diameter have been quenched by turning off 93% of the heating current with the wire in an atmosphere of clean helium gas. The glass envelope containing the gas and specimen is immersed in liquid nitrogen during quenching. The temperature drops exponentially during cooling, reaching an absolute temperature which is half its initial value in 19 milliseconds. The results are shown in Fig. 1. The three curves refer to data obtained on three different specimens. One finds $\Delta\rho$ the increase in resistivity quenched in on cooling from temperature T is given by $\Delta\rho = A\exp(-E_F/kT)$, where $A = (4.5\pm1.5)\times10^{-4}$ ohm cm and $E_F = 1.10\pm0.04$ ev. The energy of formation of lattice vacancies E_F is in excellent agreement with the value found by Balluffi and Simmons[1] who measured equilibrium values for the lattice parameter and length at a succession of high temperatures. Using their value for the vacancy concentration at the melting point of silver together with an extrapolation of the curve in the present note to the melting point, one obtains $\Delta\rho(1\%) = (1.3\pm0.7)$ micro ohm cm, where $\Delta\rho(1\%)$ represents the resistivity increment produced if 1% of the lattice sites are vacant. The present observations, together with self diffusion measurements on silver by Tomizuka and Sonder,[2] predict an activation energy for vacancy motion which is 0.81 ± 0.04 ev. Great care has been taken in the present experiments to avoid contamination by oxygen. The residual resistivity of a well annealed slowly cooled specimen never exceeds 3×10^{-9} ohm cm even after as many as 9 quenches. Annealing experiments are now being done.

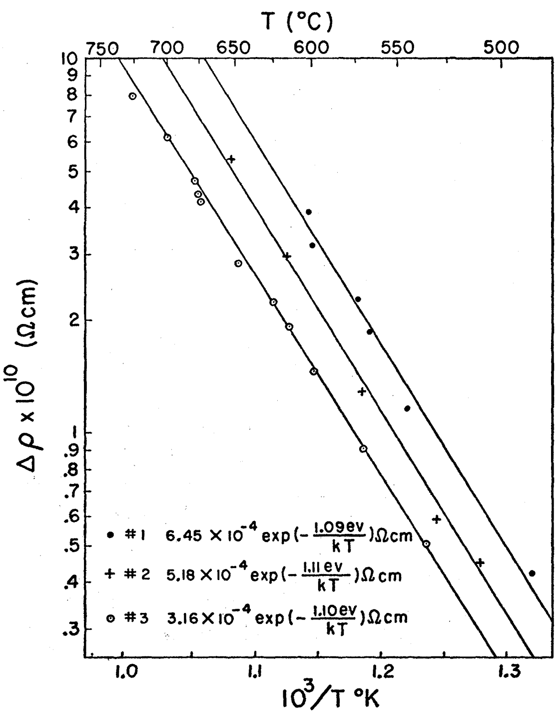

FIG. 1. The resistivity quenched into pure silver as a function of temperature. The three curves refer to different specimens.

* Partially supported by the Office of Ordnance Research.

ACKNOWLEDGMENTS

We would like to acknowledge the help of C. E. Kling and Dr. R. N. Peacock concerning vacuum technique and the aid of Y. N. Lwin and R. J. Burton in making measurements.

[1] R. O. Simmons and R. W. Balluffi, Bull. Am. Phys. Soc. **5**, 181 (1960).
[2] C. T. Tomizuka and E. Sonder, Phys. Rev. **103**, 1182 (1956).