Letters to the Editor

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Quenching-In of Lattice Vacancies in Pure Gold*

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PRELIMINARY data obtained by the quenching of 99.999 percent pure gold wires was reported in an earlier letter.[1] The quantities of interest are E_F, the energy required to produce a lattice vacancy; and E_M, the activation energy required for vacancy motion. The present letter reports on more accurate measurements.

E_F is measured by determining the increases in resistance produced by quenching a specimen from various temperatures in the range from 690°C to 900°C. One has $\Delta R = Ae^{-E_F/kT}$, where A is a constant and ΔR is the increase in the resistance at liquid nitrogen temperature produced by a quench from the high temperature T. Both 16-mil and 25-mil wires were used and the quench by a precooled jet of helium gas from the high temperature to room temperature occurred in about 10 milliseconds. The wire was then manually turned down into liquid nitrogen (time required, about a third of a second). In the case of the 25-mil wires we were unable to secure a sufficiently rapid cooling to retain all of the vacancies on quenching from temperatures above 800°C. The data from wires of both sizes showed the exponential increase in quenched in resistance but the data obtained with the 16-mil wires gave the more accurate values of E_F. The limiting low temperature which can be used for quenching appears to be determined by the amount of impurity present. The residual resistance of many of the specimens was measured at liquid helium temperature. The values obtained indicated that the wires were about 99.999 percent pure. It was noted that on specimens of rather low purity two difficulties arise: First, faster quenching rates are required to retain all of the imperfections. Second, on quenching from various temperatures below some temperature T_0 one finds that very nearly the same resistance ΔR_0 is introduced. Both T_0 and ΔR_0 increase with increasing amounts of impurity thus limiting the temperature range over which a determination of E_F can be made. No cold-work was introduced because all of the resistance increase could be annealed out by a 600°C anneal. Permanent changes in dimensions would be introduced by cold-work.

Since liquid nitrogen dissolves oxygen which changes the boiling temperature a similar dummy specimen was also measured to correct for changes in the bath temperature. R was measured to better than one part in thirty thousand.

It was found that $E_F = 1.28 \pm 0.03$ ev for gold. A quench from 816°C produced an increase of 0.21×10^{-8} ohm cm in the resistivity.

Annealing measurements were made to determine the activation energy of motion E_M for lattice vacancies in gold. Isothermal annealing measurements were made in which R was measured at liquid nitrogen temperature after various lengths of time in a constant temperature bath. At a certain stage in the annealing, the temperature of the annealing bath would be increased. The increase in the rate of annealing with increase in annealing temperature at constant R depends on E_M as follows:

$$\frac{dR_2}{dt} \Big/ \frac{dR_1}{dt} = \exp\left[-E_M\left(\frac{1}{kT_2} - \frac{1}{kT_1}\right)\right].$$

The annealing baths were operated between −30°C and +15°C. Their temperature was constant to ±0.01°C. It was found that $E_M = 0.68 \pm 0.03$ ev. About half of the quenched-in resistivity recovered after 57 hours at 25°C.

If self diffusion in gold occurs by means of vacancies, then it can be shown that the activation energy for self diffusion, Q, should be given by: $Q = E_M + E_F$. The above data give $Q = 1.96 \pm 0.06$ ev. Gatos and Kurtz[2] have recently measured Q for gold, and find $Q = 1.965$ ev. The agreement is most satisfactory.

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[1] J. W. Kauffman and J. S. Koehler, Phys. Rev. **88**, 149 (1952).
[2] H. C. Gatos and A. D. Kurtz, J. Metals **6**, 616 (1954).

Ferromagnetic Resonance in Nickel Ferrite Between One and Two Kilomegacycles

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DUE to limitations imposed by internal anisotropy fields, microwave resonance work in ferrites has largely been restricted to frequencies above 4 kMc/sec. This note describes special experimental arrangements, and observations on one of these, which make it possible to compound an applied field with the internal shape and crystalline anisotropy field to yield a particularly low effective field, and thus a low resonant frequency.

The method involved is best demonstrated for a (cubic) single-crystal, single-domain ferrite sphere, with cube axes and diagonals the hard and easy magnetization directions respectively. In zero applied field the