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C. ROSSI
E. BIANCHI

Istituto di Chimica Industriale
dell'Università,
Genova.

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Anomalous Conductivity and Lorenz Parameter in Dilute Silver–Manganese Alloys at Low Temperatures

LOW-TEMPERATURE electrical resistivity measurements by Gerritsen and Linde[1] on silver alloys containing small amounts of manganese in solid solution showed that, instead of attaining a temperature-independent 'residual' resistivity, they presented a minimum somewhat below liquid-hydrogen temperatures, followed by a maximum at still lower temperatures.

Measurements of the thermal conductivity (λ) of three dilute silver–manganese rods containing respectively 0·55, 0·32 and 0·14 atoms per cent of manganese revealed[2,3] an anomalous behaviour at liquid-helium temperatures in a zero magnetic field. This anomaly consisted in the $\lambda : T$ curve exhibiting a 'knee' at about 2·7° K., so that the values of λ below the knee were higher than would result if the curve above the knee were simply extended to the lower temperatures. The $\lambda/T : T$ curve exhibited this anomaly in the form of a 'dip' followed by a 'hump' at the lowest temperatures[2,4].

Since the shape of the $\lambda : T$ curve was not significantly altered by magnetic fields as high as 25 kilogauss, it was suggested that the zero-field thermal conductivity anomaly might be due to an extra contribution to the lattice thermal conductivity, owing probably to a partial uncoupling of the longitudinal and transverse phonons[2,5]. However, it was not understood why the $\lambda/T : T$ curves 'dipped' below the normal rectilinear behaviour, at temperatures between about 2·5 and 5° K. (Fig. 2, in ref. 4).

It has now been possible to analyse the thermal and electrical conductivity data on these alloys, in magnetic fields and in zero field, by the method of Grüneisen–de Haas[6]. The plots of $\lambda_{[H]} : \sigma_{[H]}T$ at any temperature (where $\lambda_{[H]}$ and $\sigma_{[H]}$ are the values of the thermal and electrical conductivities for different values of the transverse magnetic field H, including $H = 0$) can be considered as straight lines. This means that the electronic Lorenz parameter L_e seems to be independent of the magnetic field-strength. However, it exhibits also an interesting variation with temperature. It is found that, in these alloys, at liquid-helium temperatures: (1) L_e is less than the 'normal' Sommerfeld value ($2·45 \times 10^{-8}$ watt-ohms-deg.$^{-2}$), but approaches that value at about 1° K. or lower; (2) L_e has a minimum value at a temperature $T_{\text{min.}}$; (3) $T_{\text{min.}}$ varies with the manganese content c, shifting to a higher temperature with increasing c, and (4) the depth of the minimum is reduced with increase of c.

The fact that L_e is less than the Sommerfeld value at liquid-helium temperatures accounts for the 'dip' in the $\lambda/T : T$ curves for these alloys, between about 2·5 and 5° K.

Full details will be published elsewhere.

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M. S. R. CHARI

Low Temperature Section,
National Physical Laboratory of India,
New Delhi, 12.

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Aggregation and Dispersal of Radiation Damage in Graphite

FOLLOWING pioneering work by Grenall[1], Williamson[2] has used the technique of transmission electron microscopy to elucidate some aspects of the behaviour of dislocations in natural crystals of graphite, and Amelinckx and Delavignette[3] have demonstrated the formation of vacancy loops in quenched material. We have repeated some of these observations and applied the method to the study of neutron irradiation damage and its behaviour in crystals annealed up to 2,500° C. Our results appear to be consistent with those of Bollmann[4], who obtained photographs of defects in artificial graphite annealed up to 400° C.

Crystals of natural graphite obtained from Ticonderoga calcite were irradiated in the high-flux reactors *Dido* and *Pluto* to doses of about $4·8 \times 10^{20}$ neutrons per sq. cm. ($\sim$500 equivalent megawatt-days per tonne (of fuel)) at various temperatures in the range 150–650° C. It was found advisable to give the crystals a purifying heat treatment at 1,500° C. before irradiation. Even then, however, the unirradiated material showed some flaws, including lenticular formations with diameters in the range 0·1–3μ similar to those first seen by Rang[5] in mica. Specimens were prepared by repeated cleavage using adhesive tape, and were examined in a Siemens Elmiskop microscope at 100-kV. anode voltage.

The general behaviour of the damage effects seen is illustrated in Figs. 1 and 2, which are on a scale of 120,000 : 1. The material of Fig. 1*a* was irradiated at 200° C. and the damage is present as very fine speckling, barely resolved but quite clear in the neighbourhood of an extinction contour. The light and dark contrast is of no particular significance, as the same feature changes from one to the other when the contour is moved by tilting the specimen. At higher temperatures, damage sites are larger, rounder and more sparse, as illustrated in Fig. 1*b*, which was obtained by irradiation at 650° C. Dislocations have not been found on material irradiated at the lower temperatures and are difficult to see on material irradiated at the higher temperatures. Dark-field images show no additional features.

Annealing of the low-temperature damage causes the defects to form clusters, the effect becoming marked at about 1,000° C. as shown in Fig. 1*c*. The clusters