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ON THE ANOMALOUS HIGH TEMPERATURE ELECTRICAL RESISTIVITY BEHAVIOUR OF Cu55-Ni45 ALLOY

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1. INTRODUCTION

It has been known (1) that Cu-Ni alloys near the critical composition for ferromagnetism show a high temperature minimum in electrical resistivity. This was attributed to giant magnetic polarization clouds which cause, scattering of the electrons in the temperature interval of 2-200°K.

At the temperature interval 200-600°K and above the mechanism proposed is a combination of an increasing term due to phonon scattering and a decreasing term due to spin disorder scattering from the local clouds (2).

Houghton et al. (3) studied further the Ni-Rh alloy system, which was anticipated to behave the same way. The resistivity behaviour of those alloys in contrast to the complex resistivity behaviour of Cu-Ni alloys, failed to confirm the existence of the polarization clouds.

Ahmad and Greig (5) working on the chemically equivalent system of $Pd_{1-x}Ag_x$, which is magnetically different from the Cu-Ni alloy system, reported a temperature dependent resistivity behaviour on a $Pd_{40}Ag_{60}$ sample with a striking similarity to the Cu-Ni system. They attributed this to a temperature dependent decrease in the impurity resistivity.

In a subsequent paper Arajs et al. (6) working on the same alloy system as Ahmad and Greig, in the temperature interval 300-800°K and for a wide range of composition of $Pd_{1-x}Ag_x$ alloys ($x = 30.0$, 34.8, 40.0, 44.3, 49.9 at %), failed to confirm resistivity minima in this alloy system.

2. EXPERIMENTAL RESULTS AND DISCUSSION

The samples used were prepared by melting of the 99.99% pure components in a high vacuum induction furnace.

A conventional four-probe d.c. technique was used for resistivity measurements (7).

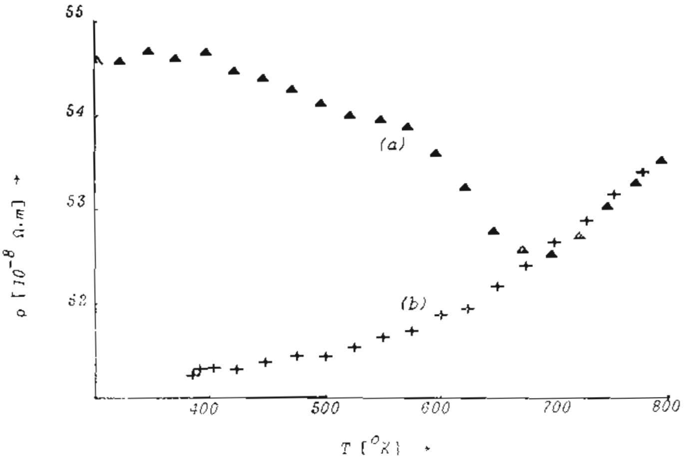

Fig. 1a. Temperature dependence of the resistivity of Cu_{55}-Ni_{45} alloy in the as rolled state. Curve (a) is followed upon heating whereas curve (b) on cooling.

In Fig. 1a resistivity versus temperature curve is presented for samples in the rolled state. A resistivity minimum is apparent at approximatelly 400°C. The curve upon cooling follows path (b).

In order to obtain more information about the behaviour Transmis sion Electron Microscopy investigation was undertaken.

Specimens of the same starting material as those used for resistivity experiments were thinned and placed on the heating stage of a JEM 120 CX. Before heating the appearance of the sample was the typical of a cold worked alloy. The specimens were heated up slowly. At about 400°C the electron diffraction patterns started to show diffuse scattering (Fig. 1b). The specimens were not allowed to complete recrystallization and by cooling to room temperature, the diffuse remained so the effect is not reversible with the same velocity.

In Fig. 1b, [111] section of the system, is evident that the diffuse intensity maxima correspond to the special points of the Brillouin zone. Such a behaviour can be attributed to a formation of a transition state, due to short range order (8), (9).

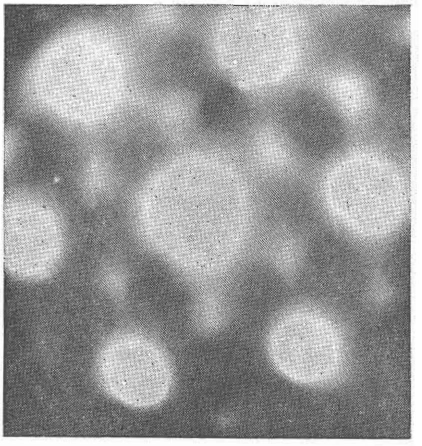

Fig. 1b. Diffraction pattern of (111) section, showing diffuse intensity maxima at $\frac{420}{3}$.

However a similar behaviour has been observed in order-disorder transformations, since the diffuse intensity maxima coorespond to $g = \frac{420}{3}$ (10).

It should be noted tbat no long-range order formation was observed.

A similar resistance behaviour was observed in the disordered Cu-Pt alloy (11) and was attributted to the formation of microdomains due to long range order.

One could suggest that the cold worked specimens have the Ni atoms dispersed randomly within the Cu matrix. With the increase in temperature a recrystallization process, starts which at the beginning exhibits microstructural changes under the formation of short range clusters of the Ni atoms responsible for the diffuse scattering. This results in a decrease of resistivity. A regular response is then followed by increasing the temperature, whereas a disordered state has been observed above the temperature of 900°C while the temperature decrease should lead to a further ordering of the clusters.

Thus we can say that there is evidence that the resistivity minimum of Cu_{55}-Ni_{45} can be attributed to the effect of short range order cluster formation of the Ni atoms.

A further experimental investigation is now on progress.

REFERENCES

1. R. W. HOUGHTON, M. P. SARACHIK and J. S. KOUVEL. Phys. Rev. Lett., **25** 238 (1970).
2. T. J. HICKS, B. D. RAINFORD, J. S. KOUVEL, G. G. LOW and J. B. COMPLY. Phys. Rev. Lett., **22**, 531 (1969).
3. R. W. HOUGHTON, M. P. SARACHIK and J. S. KOUVEL. Solid State Commun **10**, 369 (1972).
4. Preliminary results, mentioned by the authors in Ref. 2.
5. H. M. AHMAD and D. GREIG. Phys. Rev. Lett., **32**, 833 (1974).
6. S. ARAJS, K. V. RAO, Y. D. YAO and W. TEOH. Phys. Rev. **B15**, 2429 (1977).
7. J. A. TSOUKALAS. Phys. Stat. Sol. (a) **22**, K59 (1974).
8. D. DE FONTAINE. Acta Metall., **23**, 553 (1975).
9. G. L. BLERIS, TH. KARAKOSTAS, J. STOEMENOS and N. A. ECONOMOU. Phys. Sta Sol., (a) **34**, 243 (1976).
10. G. L. BLERIS, TH. KARAKOSTAS, N. A. ECONOMOU and R. DE RIDDER. Phys Stat. Sol., (a) **50**, 579 (1978).
11. E. TOHES, L. STALS, J. VAN LANDUYT, P. DELAVIGNETTE and S. AMELINCKX Phys. Stat. Sol., (a) **22**, 45 (1974).

ΠΕΡΙΛΗΨΗ

Η ΑΝΩΜΑΛΗ ΣΥΜΠΕΡΙΦΟΡΑ ΤΗΣ ΕΙΔΙΚΗΣ ΗΛΕΚΤΡΙΚΗΣ ΑΝΤΙΣΤΑΣΗΣ ΤΟΥ ΚΡΑΜΑΤΟΣ Cu_{55}-Ni_{45}

Ὑπὸ

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Στὴν ἐργασία αὐτὴ μελετήθηκε ἡ συμπεριφορὰ τῆς εἰδικῆς ἠλεκτρικῆς ἀντιστάσεως κράματος Cu_{55}-Ni_{45} σὲ ὑψηλὴ θερμοκρασία. Ἡ εἰδικὴ ἠλεκτρικὴ ἀντίσταση παρουσιάζει ἕνα ἐλάχιστο ποὺ δὲν εἶναι δυνατὸ νὰ ἑρμηνευτεῖ μὲ τοὺς συνήθεις μηχανισμοὺς σκεδασμοῦ στὴν περιοχὴ αὐτὴ τῶν θερμοκρασιῶν.

Μελέτη τῶν δειγμάτων μὲ τὴν βοήθεια τοῦ ἠλεκτρονικοῦ μικροσκοπίου ἔδειξε ὅτι σχηματίζεται τάξη περιορισμένης ἔκτασης ἀπὸ τὸ σχηματισμὸ συσσωματώσεων ἀτόμων Ni.