ELECTRICAL RESISTIVITY OF AMORPHOUS Pd-Cu-P ALLOYS

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ABSTRACT

The electrical resistivity has been measured for the amorphous phase compositions of $(\text{Pd}_{100-x}\text{Cu}_x)_{100-y}\text{P}_y$ alloys for $y = 20$ and $10 \leq x \leq 50$ and for $x = 35$ and $15 \leq y \leq 24$ between 4.2°K and the crystallization temperature ($\sim 550^\circ\text{K}$). The behavior of $\rho(T)$ is similar to that observed for amorphous Pd-Ni-P and Pt-Ni-P alloys. This behavior is attributed to the effect of phonons modifying the density of states.

The electrical resistivity of Pd-Cu-P amorphous alloys corresponding to the general formula $(\text{Pd}_{100-x}\text{Cu}_x)_{100-x}\text{P}_y$ has been measured. In one series of alloys the P concentration y was kept constant at 20 at.% and x varied from 10 to 50. In another series x was kept constant at either 15 or 35 and y varied from 15 to 24 at.%. The extreme values of x and y were the limits within which the amorphous phase can be obtained amorphous by quenching from the liquid state. All measurements were carried out from 4.2 to about 550°K, the temperature at which the alloys crystallize rapidly. The shape of the resistance vs. temperature curves is very similar to that observed previously for Pd-Ni-P [1] and Pt-Ni-P [2] amorphous alloys, in that ρ increases linearly with decreasing temperature from 550°K to about 120°K and then increases as T^2 at lower temperatures. The variation of the temperature coefficient of resistivity α with the resistivity at room temperature for various amorphous alloys is shown in fig. 1.

Following the suggestion of Kaiser and Doniach [3], Hasegawa [4] proposed that the $\rho(T)$ behavior of Pd-Ni-P and Pt-Ni-P alloys is accounted for by the existence of high temperature spin fluctuation which modify the resonance scattering component of the total resistivity. In these alloys such spin fluctuations are conceivable, especially in the vicinity of the Ni sites where strong exchange enhancement effects may occur. It is unlikely that the same holds for Pd-Cu-P alloys. From fig. 1 it is evident that, for the same resistivity, alloys containing Cu have larger negative temperature coefficients of resistivity than those containing Ni. Furthermore the measured values of α for Pd-Cu-P alloys are increasingly more negative with increasing Cu concentrations [5]. This is in marked contrast to the insensitivity

Fig. 1. Temperature coefficient of resistivity vs. resistivity at room temperature.

of α to Ni concentration in the $(\text{Pd}_{100-x}\text{Ni}_x)_{100-y}\text{P}_y$ alloys over a range of 10 to 90% for x. From these observations the conclusion is made that spin fluctuation resistive effects are not the dominant scattering mechanisms here.

The need to reexamine the spin fluctuation model of $\rho(T)$ behavior for Pd-Ni-P and Pt-Ni-P amorphous alloys in the light of the Pd-Cu-P data is quite analogous to the recent observations of Ahmad and Grieg [6] that the resistivity anomalies in $\text{Ni}_{35}\text{Cu}_{65}$ alloys, where the dispersion of giant moment clouds is presumably the dominant scattering mechanism, are reproduced in $\text{Pd}_{60}\text{Ag}_{40}$ alloys. Two different approaches have been taken to understand these phenomena. The first emphasizes that the effective density of states is given by $N_d(E)f_{FD}(E)$ and that blurring of the Fermi level can yield T^2 modification of ρ at low T and T behavior at high T [7]. The second approach, taken very recently by Brouers and Brauwiers [8], proceeds from the experimental observation of Mooij [9] of the α vs. ρ behavior of numerous disordered transition metal alloys. Mooij found that the coefficient α is less than $100 \times 10^{-6} \text{ }^\circ\text{K}^{-1}$ when ρ is greater than $50 \mu\Omega\text{cm}$ and that α is generally negative when ρ is greater than $150 \mu\Omega\text{cm}$. Brouers and Brauwiers discuss the effect of phonons in modifying the density of states $N_d(E)$, which is found to be significant for transition-metal alloys. Their calculations show that a high resistivity can be associated with the occurrence of negative temperature coefficients of resistivity. The α vs. ρ data for the amorphous alloys discussed here are in accord with Mooij's correlation. Thus the modification of the density of states by phonons may be the dominant mechanism determining the resistivity behavior of these amorphous alloys.

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