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EFFECT OF SMALL Ni ADDITIONS ON TRANSPORT PROPERTIES OF AMORPHOUS $\text{Fe}_{76-x}\text{Ni}_x\text{Cr}_4\text{B}_{12}\text{Si}_8$ ALLOYS

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Abstract. - The measurement of resistivity and longitudinal magnetoresistance is reported in amorphous $\text{Fe}_{76-x}\text{Ni}_x\text{Cr}_4\text{B}_{12}\text{Si}_8$ ($0 < x < 20$) alloys. The presence of Ni shows a significant effect on the high temperature minimum observed in a-Fe-Cr-B-Si alloys. Also it is found that with addition of Ni, magnetoresistance seems to become temperature dependent.

Introduction

In Fe based Cr containing glasses one usually observes double minima in resistivity for certain dilute concentrations of Cr [1]. In Fe-Ni glasses, the presence of Cr, on the other hand, produces only a single minimum at temperatures varying from 50 to 250 K depending upon Cr concentration [2]. In view of similar concentration dependences of high temperature minimum in former and the single minimum in latter; it is usually believed that the resistivity behaviour in a-FeCrM ($M \equiv$ metalloid) and a-FeNiCrM alloys is identical. This was more so because Ni does not cause any major change in the resistivity behaviour of non-Cr containing alloys [3]. Recently we had found that in a-FeCrBSi alloys containing small percentage of Ni (5 to 10 %) only a single minimum in resistivity is observed at ~ 20 K like in non-Cr containing alloys showing that FeNiM system behaves differently from FeCrM [4]. In the present paper we report our resistivity (4.2-300 K) and magnetoresistance studies (in the fields upto 45 kOe) on a- $\text{Fe}_{76-x}\text{Ni}_x\text{Cr}_4\text{B}_{12}\text{Si}_8$ alloys with smaller concentrations of Ni.

Results and discussion

Figure 1 shows the resistivity results for some of our samples. It shows that the higher temperature minimum is quite sensitive to x and keeps on reducing as x increases. Finally, between $x = 5$ and 10, the high temperature minimum gets completely eliminated. The low temperature minimum, on the other hand, does not seem to be affected much, neither in intensity nor in position upto $x = 10$. At higher values of x , one observes, on the other hand that this single minimum shifts to higher temperatures. This indicates that the origin of the low temperature minimum in FeCrM alloys and the single minimum observed in

FeNiCrM alloys for $x > 20$ is the same. If this had not been the case, then even in FeNiCrM alloys one would have observed double minimum.

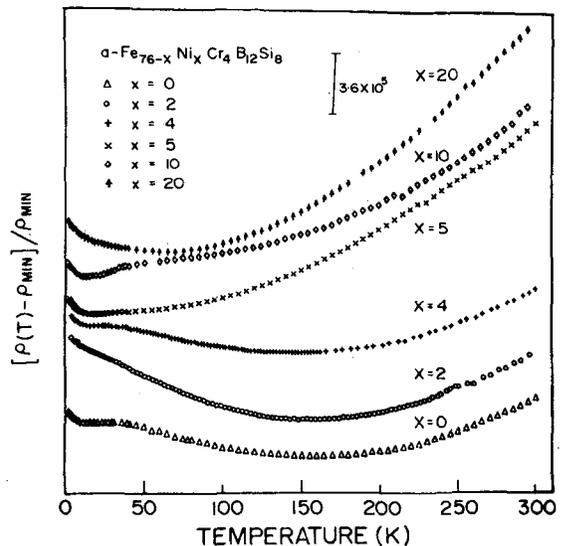


Fig. 1. - $(\Delta\rho / \rho_{\min})$ as a function of T . The various plots have been offset along the ordinate for clarity. (ρ_{\min} is the resistivity at the temperature where minimum occurs).

As the size of Ni atoms (or ions) is not expected to be very much different from that of Fe and because Ni concentration is quite small, it is unlikely that the presence of Ni would cause structural changes so as to alter the higher temperature minimum significantly. We feel, therefore, that the high temperature minimum should be of magnetic origin, as was pointed out by Olivier *et al.* [1]. In our earlier paper [4], we had discussed various possibilities regarding this. However, the low temperature minimum observed in FeCrM alloys can be either structural or magnetic. If this mini-

mum is structural, then its shift to higher temperature with Ni concentration would mean significant structural changes in the FeNiCrM alloys. As the presence of Ni does not change T_{min} much in the FeNiM alloys, the presence of Cr seems to be a must in order to create these structural changes. It is also possible that the low temperature minimum could be of magnetic origin. From the present study it is difficult to ascertain its origin. We did not measure the temperature dependence of resistivity at fixed fields. However, the field variation does not prima facie indicate any change in the negative temperature coefficient of resistivity in the presence of magnetic fields.

One of the most interesting features observed in the present system is the relaxation in the resistivity behaviour. The resistivity behaviour of the same alloy measured after a lapse of a few months showed a remarkable difference in the resistivity behaviour at low temperatures. Figure 2 shows the resistivity behaviour of $x = 2$ and $x = 10$ samples at different intervals of time. Following conclusions can be tentatively drawn from this study: 1) after a lapse of time the sample shows a temperature dependence of resistivity at low temperatures which is similar to an alloy of higher concentration of Ni in the as received state; 2) the positive temperature coefficient of resistivity does not seem to be affected much by this relaxation as a function of time.

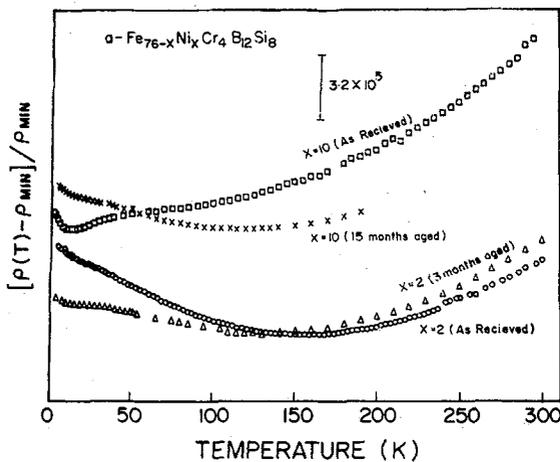


Fig. 2. - $(\Delta\rho / \rho_{min})$ versus temperature for $x = 2$ and $x = 10$ samples at different times.

The magnetic field dependence of longitudinal magnetoresistance has been studied in two of the alloys with $x = 2$ and $x = 10$. In figure 3, the field dependence of magnetoresistance $[\Delta\rho / \rho = (\rho(H) - \rho(0)) / \rho(0)]$ is shown at different temperatures for $x = 10$ alloys. The following features are noticeable: a) after technical saturation, the magnetoresistance is positive as against a negative one found in

non-chromium containing alloys; b) the temperature dependence of $[d(\Delta\rho / \rho) / dH]$ is shown in the inset of figure 3. One finds here a relatively stronger temperature dependence as compared to that in a- $Fe_{80-y}Cr_yB_{12}Si_8$ alloys when $y < 8$ [5].

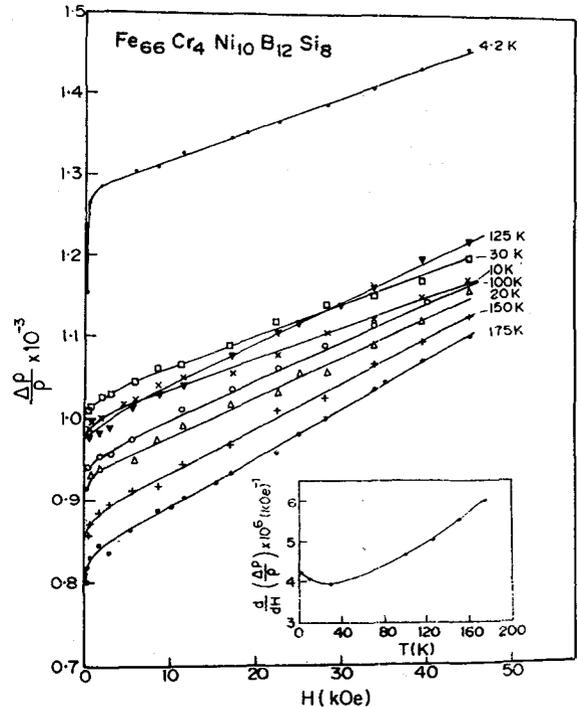


Fig. 3. - Magnetic field dependence of magnetoresistance at different temperatures.

Several models have been proposed to explain the magnetoresistance behaviour of chromium containing amorphous alloys but none of them seems to fit the data [1, 6]. A more systematic study would be required to explain such a behaviour.

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