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INFLUENCE OF Cr ON MAGNETIC AND STRUCTURAL PROPERTIES OF AMORPHOUS $Fe_{80-x}Cr_xSi_6B_{14}$ (x=0-14) ALLOYS*

R. Varga, P. Vojtaník
Dept.Exp.Phys., Fac.Sci.,UPJŠ, Park Angelinum 9, 041 54 Košice, Slovakia

J.Kováč
IEP SAS Košice, Slovakia

P.Agudo, M. Vázquez
Instituto de Magnetismo Aplicado, UCM, RENFE, CSIC, Madrid, Spain

A. Lovas
Central Research Institute for Physics, Budapest,Hungary

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The influence of Cr on the magnetic as well as on the structural properties has been investigated. Thermomagnetic analysis is made in order to find the influence of Cr on the Curie temperature and the DSC measurements are used to study the crystallization behaviour. It was found that Cr decreases the Curie themperature and linearizes the temperature dependence of the susceptibility that results in the decrease of relaxation. From the DSC measurements, two crystallization peaks were found for lower Cr concentrations. Increasing the Cr concentration reduces crystallization into one crystallization step. The crystallization temperature increases when the Cr concentration increases.

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1 Introduction

Amorphous alloys hold promise for various applications such as transformers, magnetic shields, recording heads and so on. The Cr addition is often used to improve magnetic as well as mechanical properties of amorphous alloys. In our contribution we have studied the influence of Cr addition on structural and magnetic properties of FeSiB amorphous system.

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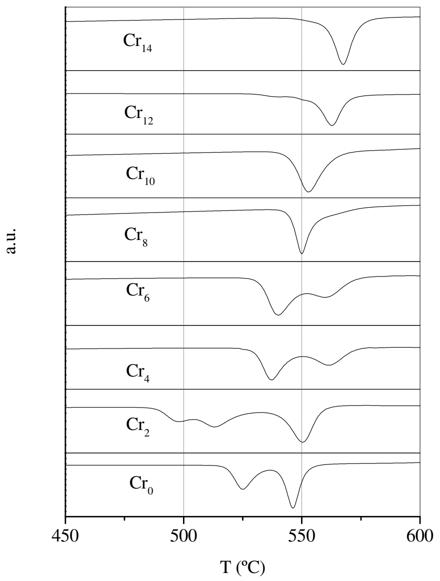

Fig.1: DSC of $Fe_{80-x}Cr_xSi_6B_{14}$ alloy

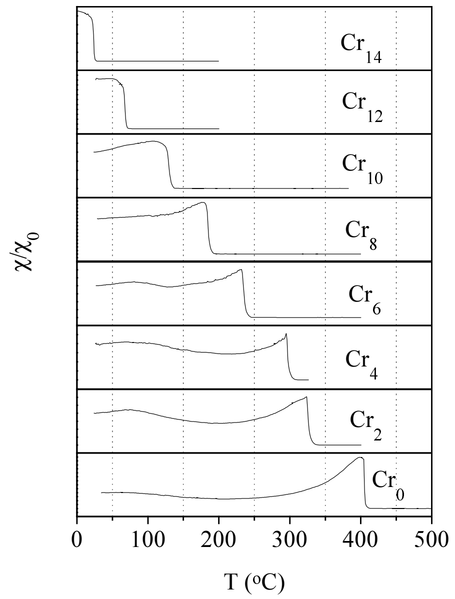

Fig.2: TMA of amorphous $Fe_{80-x}Cr_xSi_6B_{14}$ alloy

2 Experimental

The amorphous $Fe_{80-x}Cr_xSi_6B_{14}$ (x=0-14) ribbons were produced by the melt-spinning method. Thermomagnetic analysis (TMA) were made to obtain the Curie temperature. DSC measurements at 10 K/min were taken to study the effect of Cr on the structure of the FeCrSiB amorphous alloys. Magnetization as well as magnetic after-effect (MAE) measurements were used to study the influence of Cr on magnetic properties. MAE is represented by the relative change of the reluctivity (r=1/χ):

$$\frac{\Delta r(t)}{r} = \frac{r(t) - r(t = 1s)}{r(t = 1s)}, \tag{1}$$

where t is the time after demagnetization of the sample.

3 Results and Discussion

The DSC measurements show two exothermal peaks for $Fe_{80}Si_6B_{14}$ alloy. It was shown [1] that this alloy crystallizes in two steps, firstly, the α -Fe phase will occur at 514^{o}C and, in the second step, some borides will be formed at 537^{o}C. It was found that the addition of 2 at.% Cr decreases the crystallization temperature and increases the number of the crystallization steps, whereas another addition enhances the crystallization temperature and reduces the crystallization steps. The reason for this could be the higher Cr affinity to boron [2]. Since the crystallization process is

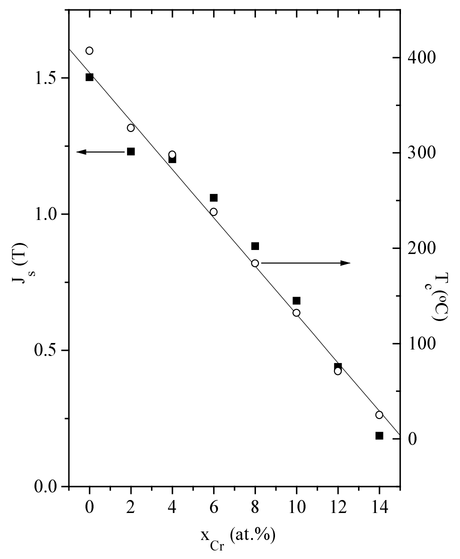

Fig.3: T_c and J_s of amorphous $Fe_{80-x}Cr_xSi_6B_{14}$ alloy

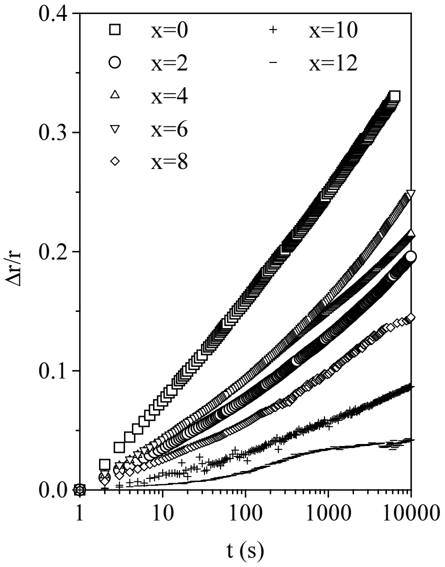

Fig.4: MAE of amorphous $Fe_{80-x}Cr_xSi_6B_{14}$ alloy

controlled by the boron atoms mobility, addition of the Cr could hinders the diffusion of B because of its higher affinity to B. Moreover, the higher Cr concentration ($x > 6$) reduces the two crystallization steps into one. From the thermomagnetic analysis we can see (Fig. 2) that the Cr addition decreases the temperature of the phase transition from ferromagnetic to paramagnetic state of the amorphous FeSiB alloy. The similar results were obtained by the previous investigation [3]. Moreover, we can see the anomalous decrease of the susceptibility in the temperature region from 50^{o}C up to about 200^{o}C which is connected to the magnetic relaxation when the domain structure is stabilized. This stabilization leads to the decrease of the domain wall movements which is the reason for the decrease of the susceptibility [4]. Since the addition of Cr decreases the amplitude of the MR [5], the temperature dependence of the susceptibility becomes almost linear. The T_c decreases with the slope -26.8 ^{o}C/at.%. From extrapolation to T_c= 0 K the value xpx$_{Cr}$ = 25 at.% is obtained. This value corresponds well to the investigation of FeCrB alloys [6], where the onset of ferromagnetism is expected for the concentration of Fe atoms around 60 at.%. These results correspond to those obtained for FeCrSiBCuNb alloys [7].

From the magnetization measurements (Fig 3) it turns out that the Cr reduces the saturation polarization J_s at room temperature of the FeSiB amorphous alloy with the rate 0.09T/at.% from 1.5T for $Fe_{80}Si_6B_{14}$ to 0.18 T for $Fe_{66}Cr_{14}Si_6B_{14}$ alloy.

Finally we have studied the time evolution of the AC-susceptibility after demagnetization (MAE). In Fig.4 we can see that the reluctivity after demagnetization starts to increase and after 10000 s its change reaches 33 %. Addition of Cr decreases the magnitude of the relaxation. It decreases with Cr concentration in the sequence: 0, 6, 4, 2, 8, 10, 12 at.%. This fact results from the temperature dependences of the MAE for the given samples. It was shown [5] , that MAE of amorphous $Fe_{80-x}Cr_xSi_6B_{14}$ alloys is temperature dependent and reaches the maximum at given temperature. The maximum for x_{Cr}=2 and 4 at.% is shifted to the higher temperature and therefore the magnitude of relaxation is smaller at room temperature than that for x_{Cr} = 0 or 6 at.%. Computer analysis of the MAE confirmes that MAE is caused by the short-range reorientation of the mobile defects [5]. Since the DSC measurements showed us the stabilisation of the amorphous structure with the increasing Cr content, the decrease of the MAE should be ascribed to the decrease of the number of the mobile defects which are responsible for MR.

4 Conclusion

The influence of Cr on magnetic as well as on structural properties has been investigated. It was found that the Cr addition above 2 at.% stabilizes the amorphous structure of $Fe_{80-x}Cr_xSi_6B_{14}$ alloys since it increases the crystallization temperature and reduces the crystallization steps. Addition of Cr decreases the T_c of amorphous $Fe_{80-x}Cr_xSi_6B_{14}$ alloys with the rate 26.8 ^{o}C/at.%. The onset of ferromagnetism in amorphous $Fe_{80-x}Cr_xSi_6B_{14}$ alloys was estimated to 25 at.% of Cr. It was shown that 2 at.% Cr stabilizes the initial susceptibility more than 4 and 6 but the degradation of other magnetic properties (J_s, T_c) increases monotonously with the Cr content. The decrease of the MAE is proposed to be due to higher Cr affinity to B atoms which results in the decrease in the number of the mobile defects involved in MR.

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