acta phys. slov. 35 (1985), No. 4—5

LOW TEMPERATURE MAGNETIC PROPERTIES OF AMORPHOUS Fe-Cr-B ALLOYS[1])

KOVÁČ[2]), L. POTOCKÝ[2]), Košice, E. KISDI-KOSZÓ[3]), A. LOVAS[3]), Budapest, L. NOVÁK[2]), Košice

Saturation magnetic polarization of $Fe_{85-x}Cr_xB_{15}$ $(0 \leqq x \leqq 21.5)$ amorphous ribbons in the temperature range 4.2—300 K was investigated. The influence of chromium on the absolute saturation polarization (σ_s), the mean magnetic moment $(\bar{\mu}_{Fe+Cr})$ and the exchange constant (A) was determined. The results are discussed in terms of the electron transfer and the magnetic properties of chromium atoms.

НИЗКОТЕМПЕРАТУРНЫЕ МАГНИТНЫЕ СВОЙСТВА АМОРФНЫХ СПЛАВОВ Fe-Cr-B

Исследовано насыщение магнитной поляризации аморфных металлических лент типа $Fe_{85-x}Cr_xB_{15}$ $(P \leqq x \leqq 21{,}5)$ в диапазоне температур 4,2 – 300 K. Определено влияние хрома на абсолютное насыщение поляризации (σ_s), средний магнитний момент $(\bar{\mu}_{Fe+Cr})$ и постоянная обмена (A). Проводится обсуждение результатов на основе переноса электронов и магнитных свойств атомов хрома.

I. INTRODUCTION

The magnetic properties of amorphous iron-boron can vary due to the alloying of other transition metal (T) elements even in a few atomic percent [1]. In [2] the ferromagnetic exchange in $Fe_{80}T_3B_{17}$ amorphous alloys was studied. Interesting results were obtained in the case of $Fe_{80}Cr_3B_{17}$. Though Cr has almost the same electron configuration, mass and atomic radius as Fe and the density of Fe-Cr-B does not depend on the Cr content [3], the magnetic properties are changed significantly due to the alloying of 3 at. % Cr to Fe-B. It was observed that chromium lowers the saturation magnetic polarization, the mean magnetic moment and the ferromagnetic exchange. In the present paper the given magnetic properties are correlated with the chromium content in the Fe-Cr-B amorphous alloys.

[1]) Contribution presented at the 7th Conference on Magnetism, KOŠICE, June 5—8, 1984.
[2]) Faculty of Sciences, P. J. Šafárik University, 040 54 KOŠICE, Czechoslovakia.
[3]) Central Research Institute for Physics, Hung. Acad. Sci., 1525 BUDAPEST, Hungary.

II. EXPERIMENTAL

Amorphous $Fe_{85-x}Cr_xB_{15}$ $(0 \leqq x \leqq 21.5)$ robbons were prepared by the melt-spinning technique.

Magnetic measurements were carried out at low temperatures in the range from 4.2 to 300 K. Magnetic polarization was measured by a vibrating sample magnetometer working in a superconducting magnet up to 7 T. From the measured data the absolute saturation magnetic polarization, σ_s, i.e. $\sigma/T \to 0$, $H^{-1} \to 0$, the mean magnetic moment, $\bar{\mu}_{Fe+Cr}$ and the exchange constant A were determined.

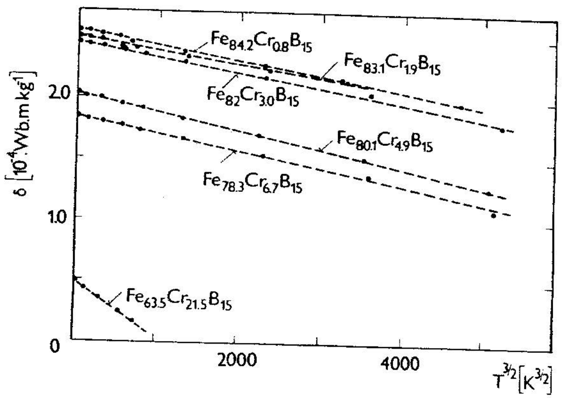

Fig. 1. Saturation magnetic polarization σ as a function of $T^{3/2}$ with chromium content as parameter.

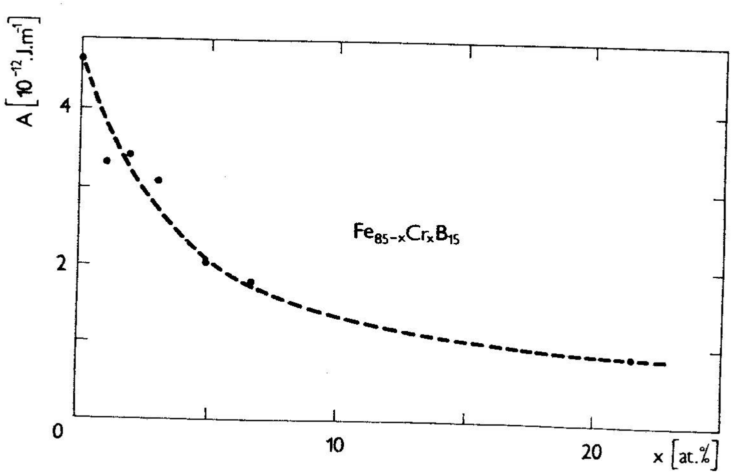

Fig. 2. Exchange constant A as a function of chromium content.

III. RESULTS AND DISCUSSION

The saturation magnetic polarization, σ vs $T^{3/2}$ is given in Fig. 1 for all the investigated alloys. We found a linear dependence of σ vs $T^{3/2}$ in all the alloys. From these dependences the exchange constant A given in Fig. 2 were determined [4]. As one can see, A strongly decreases with an increasing chromium content, which means that chromium significantly lowers the ferromagnetic exchange between iron atoms. This is supported also by Curie temperature investigations [5].

From the absolute saturation magnetic polarization (Fig. 3) the mean magnetic moment of the transition metals iron and chromium ($\bar{\mu}_{Fe+Cr}$) was also determined. This can be seen in Fig. 4 as a function of chromium content. The measured values ($\bar{\mu}^{meas}_{Fe+Cr}$) are compared with that of the crystalline bcc Fe-Cr [6] and with two sets of

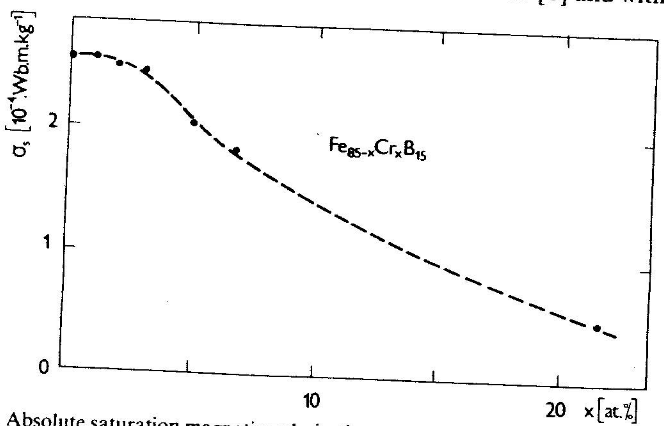

Fig. 3. Absolute saturation magnetic polarization σ_s as a function of chromium content.

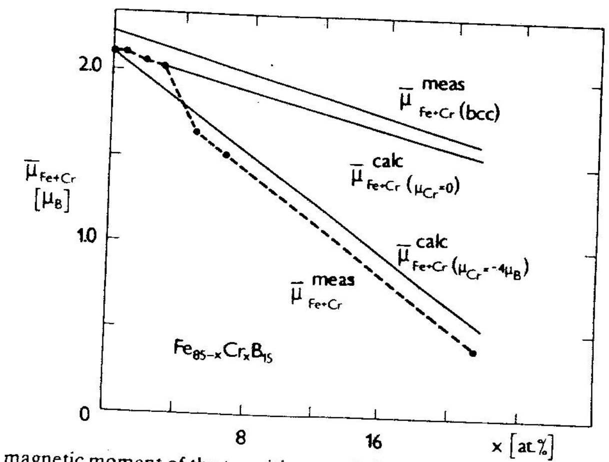

Fig. 4. Mean magnetic moment of the transition metals ($\bar{\mu}_{Fe+Cr}$) as a function of chromium content.

calculated data. First we took into account the influence of the electron transfer from boron to iron [7] and a simple dilution of Fe-B by chromium (supposing $\mu_{Cr} = 0$), so we obtained $\bar{\mu}^{calc}_{Fe+Cr(\mu_{Cr}=0)}$. As it is seen the measured data for amorphous $Fe_{85-x}Cr_xB_{15}$, $x \leqq 3$, are fitted wery well by the calculated line mentioned. Therefore it may be proposed that in low chromium content alloys the decrease of the mean magnetic moment is mainly caused by the dilution effect of the added chromium; the electron transfer from boron to iron does not change significantly in this concentration range.

The measured mean magnetic moments $\bar{\mu}^{meas}_{Fe+Cr}$ for the higher concentrations of chromium ($x > 3$) show a much steeper decrease with the chromium content. The presence of an electron transfer from chromium to iron -as in crystalline alloys- may be suggested [6]. This has a much smaller influence on the mean magnetic moment than would be needed for the explanation of our experimental results. Even in the crystalline material this influence is smaller than that of the dilution effect; however, in amorphous alloys an even smaller electron transfer effect may be expected. In some amorphous ironchromium-metalloid alloys it has already been suggested that chromium may have a magnetic moment which prefers a negative coupling to iron moments. For $(Fe\text{-}Cr)_{80}B_{10}P_{10}$ amorphous alloys the chromium has roughly an atomic magnetic moment of $\mu_{Cr} \approx -4\mu_B$ [8]. We calculated for Fe-Cr-B alloys the mean magnetic moment, $\bar{\mu}^{calc}_{Fe+Cr}$ with the same $\mu_{Cr} \approx -4\mu_B$. The appropriate line is also given in Fig. 4. It can be seen that this line approaches the measured values well. Therefore also in amorphous $Fe_{85-x}Cr_xB_{15}$ alloys for $x > 3$ an antiferromagnetic coupling between iron and chromium moments can be proposed. The differences between calculated and measured values in this concentration range are probably due to the electron transfer from chromium to iron.

REFERENCES

[1] Lovas, A., Potocký, L., Novák, L., Kisdi-Koszó, É., Zámbó-Balla, K.: *Proc. Conf. Metallic Glasses: Science and Technology*, Budapest 1981, Vol. 2, p. 87.

[2] Potocký, L., Daniel-Szabó, J., Kováč, J., Kisdi-Koszó, É., Lovas, A., Zámbó-Balla, K.: J. Magn. Magn. Mater. *41* (1984), 125.

[3] Konczos, G., Kisdi-Koszó, É., Lovas, A., Kajcsos, Zs., Potocký, L., Daniel-Szabó, J., Kováč, J., Novák, L.: J. Magn. Magn. Mater. *41* (1984), 122.

[4] Kronmüller, H., Fähnle, M., Domann, M., Grimm, H., Grimm, R., Gröger, B.: J. Magn. Magn. Mater. *13* (1979), 53.

[5] Novák, L., Potocký, L., Kisdi-oszó, É., Lovas, A., Daniel-Szabó, J.: Acta Phys. Slov. (to be published).

[6] Bozort, R.: *Ferromagnetism*. Izd. inostr. lit. Moskva 1956, p. 184.

[7] Hasegawa, R., Ray, R.: J. Appl. Phys. *49* (1978), 4174.

[8] Mihoguchi, T., Yamauchi, K., Miyajima, H.: *Ferromagnetism of Amorphous Iron Alloys* in *Amorphous Magnetism*, ed. H. O. Hooper, A. M. de Graaf, Plenum Press, New York 1973, p. 325.

Received November 13th, 1984