CORRELATION BETWEEN EXCHANGE CONSTANT AND CURIE TEMPERATURE OF Fe—Cr—B AND Fe—V—B GLASSY ALLOYS[1])

KOVÁČ, J.,[2]) POTOCKÝ, L.,[3]) NOVÁK, L.,[2]) Košice
KISDI-KOSZÓ, É.,[4]) Budapest

The Curie temperature and the exchange constant in ferromagnets are in a direct connection, the proportional factor depends on the atomic structure of the material. In Fe—Cr—B and Fe—V—B metallic glasses the correlation between the exchange constant and the Curie temperature was found. The change of the slope of A to T_c indicates some change in the short range order of the investigated alloy series.

I. INTRODUCTION

Among the magnetic properties of ferromagnetic metallic glasses the exchange constant (A) and the Curie temperature (T_c) are the most sensitive quantities of the atomic structure [1]. In the same structure a linear relation between A and T_c can be found [2]. In Fe—Cr—B (series a) the investigation was performed in a relative wide Cr concentration range [3]. It was found that this linear relation exists with a given slope till about 10 at% Cr. At higher Cr concentrations another linear dependence can be determined, with quite another slope. The extrapolation of the latter straight line goes to 0. From this it was concluded that there must be a difference in the amorphous atomic scale structure between the alloys with smaller and higher Cr concentrations. In this paper we show this dependence on a new Fe—Cr—B series prepared by different parameters than the first series (see Table 1). Another ternary series, Fe—V—B, was also investigated.

II. EXPERIMENTAL

Amorphous ribbons were produced by the melt spinning technique. The ribbons were 1 to 2 mm wide and 20 to 40 μm thick. The amorphicity of the ribbons was checked by X-ray diffraction, chemical composition was determined by atomic absorption method (Table 1). Magnetic measurements were carried out by a vibrating sample magnetometer between 4.2 and 300 K and by Förster-type magnetometer at higher temperatures. The exchange constant was determined from the low temperature magnetization measurements.

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[2]) Institute of Experimental Physics, Slov. Acad. Sci., KOŠICE, Czecho-Slovak Federative Republic

[3]) Faculty of Sciences, P. J. Šafárik University, KOŠICE, Czecho-Slovak Federative Republic

[4]) Centrum Research Institute for Physics Hung. Acad. Sci., BUDAPEST, Hungary

Table 1

Concentration and preparing cooling rate of investigated metallic glasses

Type	x	V/V_0
$Fe_{86-x}Cr_xB_{14}$		
series a	0	15
	1.9	15
	3.0	15
	4.9	15
	6.7	15
	9.0	15
	11.5	15
	14.2	15
	14.2	15
	21.5	15
series b	0	1
	0.8	1
	2.4	1
	4.5	1
	4.5	1
	6.6	1
	9.0	1
	11.0	1
	13.0	1
	15.0	1
	17.0	1
$Fe_{80-x}V_xB_{20}$	0	4
	0.5	4
	2.2	4
	4.6	4
	8.9	4

III. RESULTS AND DISCUSSION

In both Fe—Cr—B and Fe—V—B metallic glasses Cr and V lower the mean magnetic moment of the transition metal atoms. This can be seen in Fig. 1. For Fe—Cr—B the slope of the moment decrease is 0.03 μ_B/at% Cr in low Cr content alloys, for Fe—V—B this slope is 0.05 μ_B/at% V.

In the case of the Cr alloy the atomic number of the solute transition metal atom differs from the matrix element by two ($Z = -2$), therefore a simple rigid band model can be assumed in the momentum interpretation. In Fe—V—B $Z = -3$ and therefore Friedel's virtual bound state model should be more appropriate [4, 5]. According to the first model $\mu = \mu_{matrix} - 0.02\,x\,\mu_B$ and $\mu = \mu_{matrix} - 0.03\,x\,\mu_B$ could be expected, which is smaller than the measured value (x is at% concentration). From the latter model the $\mu = \mu_{matrix} - 0.07\,x\,\mu_B$ can be obtained as the steepest decrease.

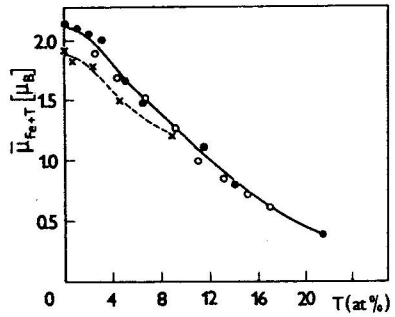

Fig. 1. Mean magnetic moment for $Fe_{86-x}Cr_xB_{14}$ and $Fe_{80-x}V_xB_{20}$ metallic glasses.

The exchange constant determined from the saturation dependence at low temperature and the Curie temperature taken from the thermomagnetic curve are given in Figs. 2 and 3. Both values are decreasing with increasing Cr and V concentrations, respectively.

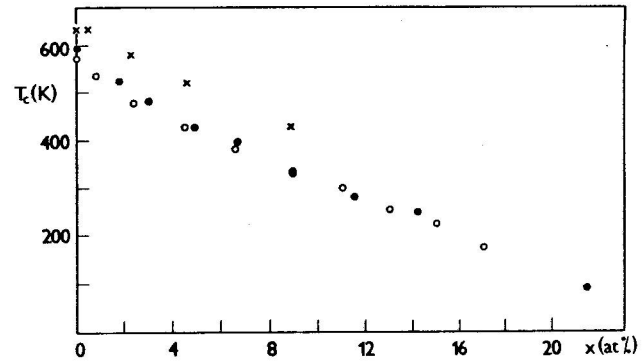

Fig. 2. Exchange constant for Fe—Cr—B and Fe—V—B metallic glass series.

In Fig. 4 the correlation between A ant T_c is shown for the two Fe—Cr—B series and for Fe—V—B. The two Cr containing series show the abrupt change in the slope at 11 and 13.5 at% Cr, respectively. This small difference in the critical concentration may be due to a different preparation [6]. For Fe—V—B be hawe concentrations only below 10 at% V but it can be seen that in this low concentration range there is a linear correlation between A and T_c and this line extrapolated does not go through 0. From this we conclude that also in this amorphous alloy series there must be a change in the slope and therefore also in the amorphous structure at higher concentrations.

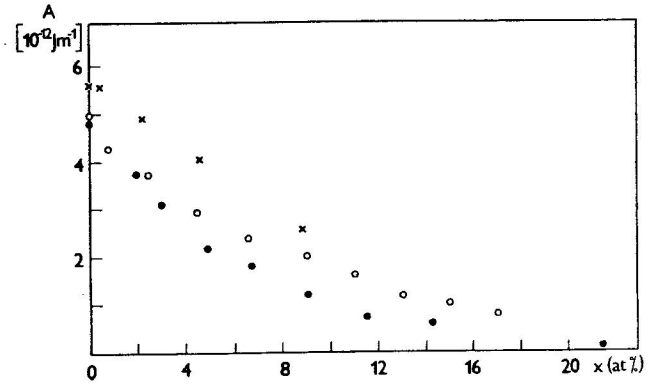

Fig. 3. Curie temperature for Fe—Cr—B and Fe—V—B metallic glass series.

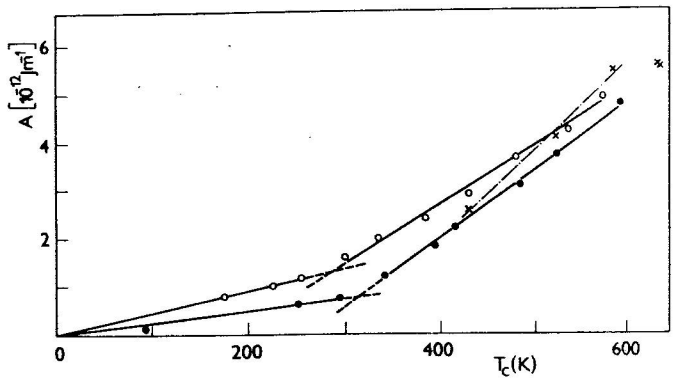

Fig. 4. Exchange constant as a function of Curie temperature for Fe—Cr—B and Fe—V—B metallic glass series; —.— Fe—Cr—B, series a, —O— Fe—Cr—B, series b. X Fe—V—B.

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КОРРЕЛЯЦИЯ МЕЖДУ ОБМЕННОЙ КОНСТАНТОЙ И ТЕМПЕРАТУРОЙ КЮРИ В СПЛАВАХ Fe—Cr—B И Fe—V—B

Температура Кюри и обменная константа в ферромагнетиках находятся в прямой связи — пропорциональный фактор зависит от атомной структуры материала. В работе была найдена корреляция между обменной константой и температурой Кюри в Fe—Cr—B и Fe—V—B металлических стеклах. Изменение наклона от A к T_c указывает на некоторые изменение в короткодействующем порядке в исследуемых сериях сплавов.