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CURIE TEMPERATURE OF Fe-Cr-B AND Fe-W-B METALLIC GLASSES[1])

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The change of the Curie temperature due to the partial substitution of iron by another transition metal in iron-boron ($Fe_{85-x}Cr_xB_{15}$ and $Fe_{85-x}W_xB_{15}$, $0 \leqq x < 10$) was investigated. Both chromium and tungsten lower the amorphous Curie temperature. The role of dilution, that of the size effect and the change in the atomic magnetic moment in this decrease are discussed. In each alloy system a correlation between the Curie temperature and the exchange constant was found.

ТЕМПЕРАТУРА КЮРИ МЕТАЛЛИЧЕСКИХ СТЕКОЛ Fe-Cr-B и Fe-W-B

В работе исследовано изменение температуры Кюри, обусловленное частичным замещением железа другим металлом переходной группы в сплавах $Fe_{85-x}Cr_xB_{15}$ и $Fe_{85-x}W_xB_{15}$ ($0 \leqq x < 10$). Как хром, так и вольфрам снижают температуру Кюри аморфного сплава. Обсуждается роль степени разбавления, размеров образца и изменения магнитного момента атома в этом снижении температуры Кюри. Обнаружено, что во всех образцах сплавов существует корреляция между температурой Кюри и постоянной обмена.

I. INTRODUCTION

The Curie temperature of metallic glasses differs significantly from that of its crystalline counterpart [1, 2]. It is influenced by many parameters such as the composition, the conditions of preparation, the thermo- and/or mechanical treatments, etc. In the present paper we shall deal with the alteration of the Curie temperature due to a partial substitution of iron by chromium or tungsten in Fe-Cr-B and Fe-W-B metallic glasses.

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II. EXPERIMENTAL

Amorphous ribbons were prepared by the melt-spun method with the composition of $Fe_{85-x}T_xB_{15}$, $0 \leqq x < 10$, where T = Cr, W.

Magnetic measurements were carried out in the temperature range 300—650 K; using the Förster probes the heating rate was 1.7 K/min. The Curie temperature (T_C) was determined from measured thermomagnetic curves.

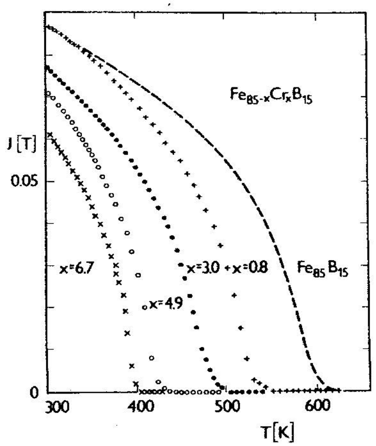

Fig. 1. Thermomagnetic curves of $Fe_{85-x}Cr_xB_{15}$ ($0 \leqq x < 10$).

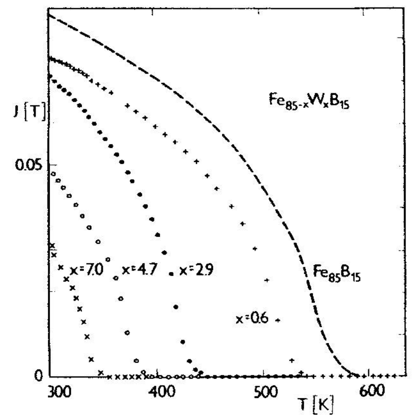

Fig. 2. Thermomagnetic curves $Fe_{85-x}W_xB_{15}$ ($0 \leqq x < 10$).

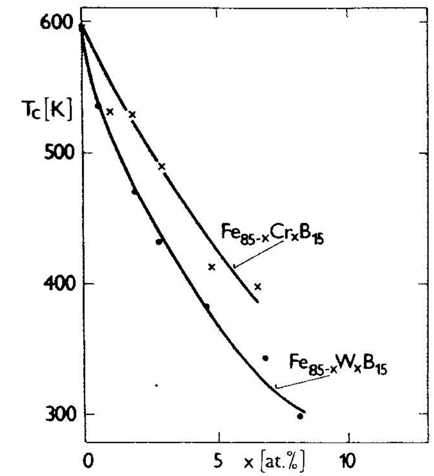

Fig. 3. The Curie temperature (T_C) as a function of the alloying transition metal content (x) in $Fe_{85-x}T_xB_{15}$, T: Cr, W.

III. RESULTS AND DISCUSSION

In Fig. 1 we give the thermomagnetic curves of $Fe_{85-x}Cr_xB_{15}$ and the curve of the binary iron-boron. The same dependences for tungsten are given in Fig. 2. As it is seen both alloying transition metals lower the ferromagnetic stability. This may be caused 1. by the increase of the average distance between the iron atoms due to the

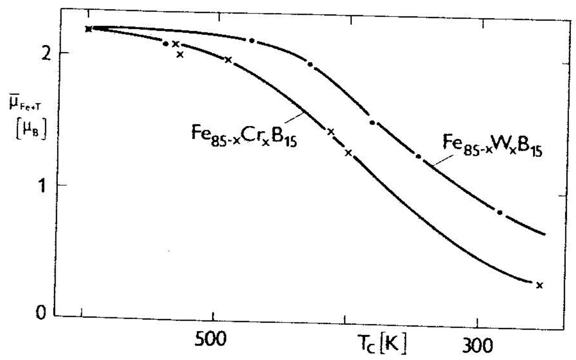

Fig. 4. Mean magnetic moment ($\bar{\mu}_{Fe+T}$) as a function of the Curie temperature (T_C) for $Fe_{85-x}T_xB_{15}$, T: Cr, W.

distance dependence of the ferromagnetic interaction, 2. by the increase of the relative boron concentration with respect to iron and 3. by the decrease of the atomic moment of iron. The different influence of the two alloying elements on T_C is shown in Fig. 3. As one can see tungsten lowers the Curie temperature more than chromium does. In the chromium containing alloys a simple dilution effect may be expected as a first approximation because Cr has a similar atomic radius and atomic weight as iron. This is reflected also by density investigations according to which the density of $Fe_{85-x}Cr_xB_{15}$ is independent of the Cr content. Therefore the free volume in these chromium alloys does not change, as also positron annihilation investigations show [3]. On the other hand tungsten atoms have a much larger atomic radius and atomic weight than iron, therefore in addition to the dilution effect a significant size effect may be expected. The density of $Fe_{85-x}W_xB_{15}$ alloys changes with the tungsten content; the positron annihilation investigations show a simultaneous variation of the character and the size of the free volume. In our measurements the influence of the changes of free volume on T_C was negligible.

In both Fe-Cr-B and Fe-W-B alloys the mean magnetic moment ($\bar{\mu}_{Fe+T}$) decreases increasing the alloying transition metal (T) content [4, 5]. In Fig. 4 the dependence of the mean magnetic moment on the Curie temperature of the corresponding alloy is given. In order to get the same decrease of T_C a higher decrease of the magnetic moment is needed in the chromium containing alloy.

As the Curie temperature is a measure of the stability of the ferromagnetic state we tried to compare T_C with the exchange constant A which was determined from low temperature magnetic polarization measurements. The result of this comparison can be seen in Fig. 5. There is a good correlation between T_C and A but the slope of the obtained lines varies with the kind of the alloying element.

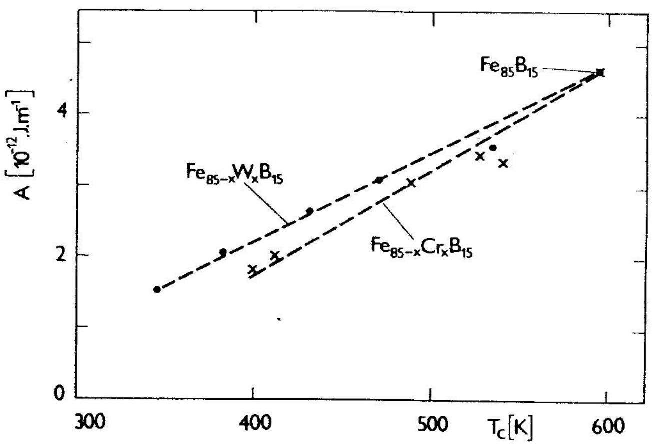

Fig. 5. Exchange constant (A) as a function of the Curie temperature (T_C) for $Fe_{85-x}T_xB_{15}$, T: Cr, W.

IV. CONCLUSION

Replacing iron atoms in the $Fe_{85}B_{15}$ by chromium or tungsten in the concentration range 0—10 at. % a significant lowering of the Curie temperature can be obtained. The origin of this may be found in a dilution effect and a size effect of the alloying-elements and in the alteration of atomic magnetic moments. The higher influence of tungsten can be interpreted by its large size effect as both alloying elements cause almost the same decrease of the mean magnetic moment.

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