acta phys. slov. 31. (1981), No. 2—3

THE MAGNETIC BEHAVIOUR OF Fe—B AMORPHOUS ALLOYS UNDER PRESSURE[1]

МАГНИТНЫЕ СВОЙСТВА АМОРФНЫХ СПЛАВОВ Фе–Б, НАХОДЯЩИХСЯ ПОД ДАВЛЕНИЕМ

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The Curie temperature T_c of $Fe_{85}B_{15}$ and $Fe_{83}B_{17}$ amorphous alloys has been studied under pressures up to 4.5 GPa. The large linear decrease of T_c (-27 K/GPa and -26 K/GPa, resp.) was observed with an increase of the pressure. The effect of the pressure on the specific magnetization of these alloys was estimated using the known data of the forced volume magnetostriction.

The interest in the invar problem has considerably increased since the discovery of the invar-like behaviour of Fe-based amorphous alloys [1]. The experimental results of the thermal expansion, the high-field susceptibility and of the temperature dependence of magnetization in the amorphous FeB and FeP alloys [2] are comparable with those in the crystalline NiFe alloys and can be explained by Wohlfarth's theory of the very weak itinerant ferromagnets [3]. Unlike the crystalline invar alloys, the elinvar characteristics were simultaneously observed in FeB and FeP amorphous alloys [4].

The influence of pressure on the magnetic properties of the crystalline invar-like alloys is manifested by the large decrease of both T_c and the specific magnetization at 0 K σ_0 [5, 6]. The large and negative pressure shifts of T_c were estimated for $Fe_{100-x}B_x$ metallic glasses from the measured forced volume magnetostriction $d\omega/dH$. The obtained values of dT_c/dp satisfy the relation derived by Wohlfarth [7]:

$$dT_c/dp = -\alpha/T_c \tag{1}$$

with $\alpha = 3.5 \times 10^4$ K^2/GPa [2].

Our direct measurements of dT_c/dp on $Fe_{85}B_{15}$ and $Fe_{83}B_{17}$ amorphous alloys were performed in the belt-type high pressure apparatus under pressures up to 4.5 GPa. The Curie temperature was determined from the temperature dependence of the secondary voltage of microtransformer, whose core was wound from the ribbon of the amorphous alloy, the detailed description of the experimental arrangement is presented in [5, 8].

The linear decrease of T_c with the increasing pressure was observed in both samples studied, Fig. 1. The values of dT_c/dp are equal to -27 K/GPa and -26 K/GPa for $Fe_{85}B_{15}$ and $Fe_{83}B_{17}$, respectively. These values of dT_c/dp were used to calculate $\alpha = -T_c\, dT_c/dp$. The obtained value ($\alpha = 1.55 \times 10^4$ K^2/GPa) is somewhat smaller than α in the crystalline invar NiFe alloys, where $\alpha = 2 \times 10^4$ K^2/GPa.

[1] Contribution presented at the 6[th] Conference on Magnetism in Košice, September 2—5, 1980.

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These results show that the large and negative value of dT_c/dp is a characteristic invar property also in the amorphous invar-like ferromagnets.

The pressure dependence of T_c is connected with the forced volume magnetostriction $d\omega/dH$ by thermodynamic relations [9]:

$$\varrho\left(\frac{\partial\sigma_s}{\partial p}\right)_{H,T} = -\left(\frac{\partial\omega}{\partial H}\right)_{p,T} \tag{2}$$

$$\frac{1}{\sigma_s}\left(\frac{\partial\sigma_s}{\partial p}\right) = \frac{1}{\sigma_0}\left(\frac{\partial\sigma_0}{\partial p}\right) - \frac{1}{\sigma_s}\left(\frac{\partial\sigma_s}{\partial T}\right)\frac{T}{T_c}\left(\frac{\partial T_c}{\partial p}\right), \tag{3}$$

where σ_s and σ_0 are specific saturation magnetizations at temperatures T and $T = 0$ K, respectively, and ϱ is the density. These expressions can be used to compute $1/\sigma_0(\partial\sigma_0/\partial p)$ from the experimental values of other quantities. To calculate $1/\sigma_0\,(\partial\sigma_0/\partial p)$ for our $Fe_{85}B_{15}$ and $Fe_{83}B_{17}$ amorphous alloys we used our values of T_c and dT_c/dp and the corresponding values of $d\omega/dH$, and $d\sigma_s/dT$ from [2]. We obtained $1/\sigma_0(\partial\sigma_0/\partial p) = -2.1\times10^{-2}\,GPa^{-1}$ and $-2.0\times10^{-2}\,GPa^{-1}$ for $Fe_{85}B_{15}$ and $Fe_{83}B_{17}$, respectively. Nearly the same values of $1/\sigma_0(\partial\sigma_0/\partial p)$ were presented in [6] for those crystalline NiFe alloys which exhibited the same T_c as the mentioned FeB amorphous alloys.

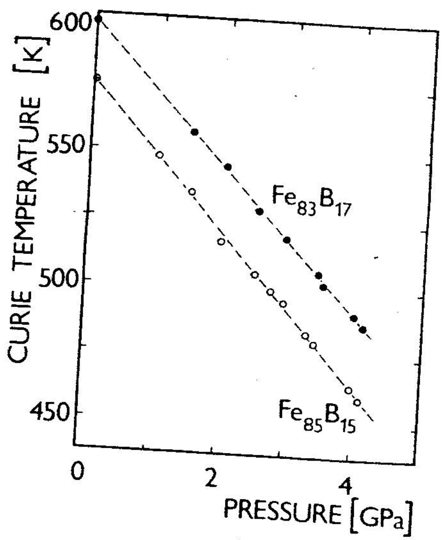

Fig. 1. T_c vs. pressure for $Fe_{85}B_{15}$ and $Fe_{83}B_{17}$ amorphous alloys.

Significantly higher values of $1/\sigma_0(\partial\sigma_0/\partial p)$ were derived from the direct measurements on NiFe-based amorphous alloys under the pressure in [10]. A low magnetic field was, however, used in these measurements. There is also a great discrepancy between the derived forced volume magnetostriction $d\omega/dH$ in [10] and the directly measured $d\omega/dH$ in [11]. The large values of $1/\sigma_0\,(\partial\sigma_0/\partial p)$ for NiFe-based amorphous alloys presented in [10] seem to be caused by the high sensitivity of the shape of the magnetization curve to the pressure.

The reported results of the pressure dependence of T_c and σ_0 show that the magnetic behaviour of both amorphous and crystalline invar-like ferromagnets under pressure is qualitatively the same. Hence, the description of these pressure effects within the band model of ferromagnetism is also applicable to the amorphous invar-like ferromagnets.

The authors are very grateful to Dr. Jagielinski for providing the samples and wish to thank Dr. K. Závěta for his reading of the manuscript and his stimulating discussions.

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Received October 28th, 1980