PERMINVAR EFFECT IN AMORPHOUS Fe-B ALLOYS[1]

P. VOJTANÍK*, Košice, I. B. KEKALO**, Moscow

The stabilization of domain structure in amorphous Fe-B alloys, caused by directional ordering, as well as its influence on the magnetization processes in weak magnetic fields have been investigated. The magnetic field range in which the susceptibility value does not change with the change of field (the perminvar effect), increases with the increase of temperature and time of the stabilization of the demagnetized state. The stabilization field and energy have been determined from the unstabilized and stabilized magnetization curves.

ПЕРМИНВАРНЫЙ ЭФФЕКТ В АМОРФНЫХ СПЛАВАХ Fe-B

В работе исследована стабилизация доменной структуры в аморфных сплавах Fe-B, вызванная направленным упорядочением, а также ее влияние на процессы намагничивания в слабых магнитных полях. Диапазон магнитного поля, при котором значение восприимчивости не меняется с изменением поля (перминварный эффект), возрастает с увеличением температуры и времени стабилизации размагниченного состояния. Поле и энергия стабилизации определяются по нестабилизированным и стабилизированным кривым намагничивания.

I. INTRODUCTION

The detailed study of the time, field and temperature dependences of the initial susceptibility in iron-boron based amorphous alloys confirmed the presence of a new type of magnetic relaxation in these materials [1, 2]. This magnetic relaxation is connected with the presence of movable metalloid atoms in an amorphous structure of ferromagnetic alloys. Diffusion in amorphous ferromagnetica shows many peculiarities. The continuous distribution of the activation

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* Faculty of Sciences, P. J. Šafárik University, nám. Febr. víťazstva 9, CS-041 54 KOŠICE.
** Physical-Chemical Faculty of MISIS, Leninskij prospekt 4, MOSCOW, USSR.

energies has the upper limit [3] much above the activation energy of boron migration in crystalline iron. Directional ordering causes the stabilization of the demagnetized state in amorphous ferromagnetica. This stabilization is manifested by the perminvar effect characterized by a special form of hysteresis loops and by a constant initial susceptibility in magnetic fields below the critical intensities.

II. EXPERIMENTAL

The amplitude dependences of the initial susceptibility were measured by the mutual inductance bridge in alternating fields with a frequency of 970 Hz. The investigated samples consisted of amorphous ribbons $Fe_{80}B_{20}$ prepared by rapid melt quenching. Some samples were annealed at a temperature of 270 °C for 75 min in silicone oil to remove internal stresses.

III. RESULTS AND DISCUSSION

As seen from Fig. 1 the amplitude dependences of the reversible susceptibility of the amorphous $Fe_{80}B_{20}$ alloys is characterized by the constant value of susceptibility till a certain critical amplitude of the alternating field H_{cr} is reached. The individual curves in Fig. 1 correspond to different time periods of stabilization after demagnetization; $1-t$ = 30 s; $2-t$ = 720 s; $3-t$ = 7200 s; $4-t$ = 43200 s; $5-t$ = 64800 s. The measuring temperature was 390 K. In fields which are below the critical intensity the domain walls move reversibly without Barkhausen jumps. At the critical intensity H_{cr} the domain walls jump out of the still deeping potential walls. The intense increase of susceptibility sets in over the critical value H_{cr} owing to irreversible magnetization processes.

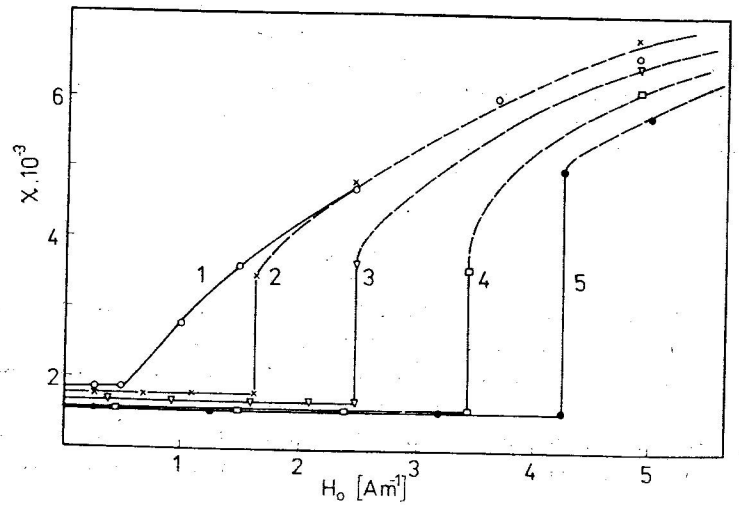

Fig. 1. Dependence of reversible susceptibility χ on the amplitude of the magnetic field M_0. The measuring temperature $T = 390$ K, stabilization time: curve 1 — $t = 30$ s; 2 — 720 s; 3 — 7200 s; 4 — 43200 s; 5 — 64800 s.

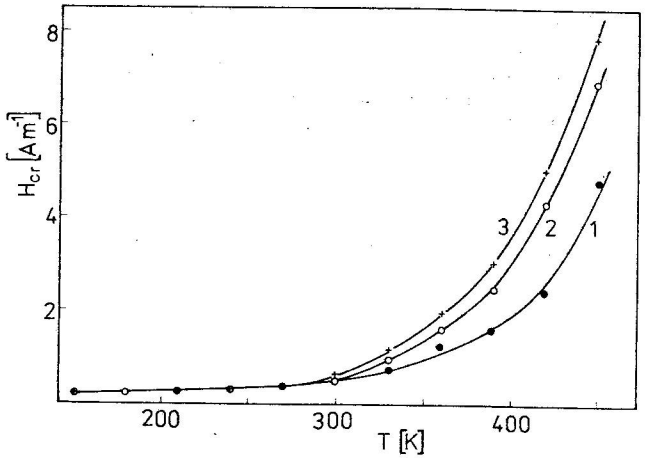

Fig. 2. The isochrones of the temperature dependence of the critical field H_{cr}, curve 1 and 2 — sample annealed at 270 °C/75 min, 3 — unannealed sample. The stabilization time: 1 $-t$ = 12 min; 2 and $3-t$ = 120 min.

The value of the critical field intensity H_{cr} depends on the stabilization time. It increases almost linearly with the logarithm of time at lower temperatures and for a not very long time. The increase of intensity of *Hcr* with time depends markedly on temperature. The value of susceptibility itself decreases simultaneously with the increasing critical field H_{cr} owing to stabilization (Fig. 1).

The dependence of the critical field H_{cr} on temperature shows an increasing slope without any tendency to saturation for constant stabilization times (Fig. 2, curve $1-t$ = 12 min., curve $2-t$ = 2 h, annealed sample, curve $3-t$ = 2 h, unannealed sample). From the comparison of curves 2 and 3 the influence of annealing on the stabilization processes can be seen. The annealing decreases the "free volume", the concentration of movable boron atoms as well as the critical field in amorphous alloys.

The magnetic relaxation significantly influences also the virgin magnetization curves in the $Fe_{80}B_{20}$ amorphous alloy. From the relaxed and unrelaxed magnetization curves the dependence of the stabilization field H_s on magnetization may be derived [4]. The maximum value of the stabilization field H_s is in direct connection

with the stabilization energy W_0. In our case the stabilization energy $W_0 = H_{s\,max} \cdot J_s$ is 7.3 J/m^3 at a temperature of 443 K. From the stabilization field characteristic $H_s = f(I)$ the assumptions of the distribution of various domain walls in amorphous $Fe_{80}B_{20}$ alloy may be made.

REFERENCES

[1] Daniel-Szabó, J., Vojtaník, P., Kekalo, I. B., Potocký, L.: *Vsesojuz. konf. po fizike magnitnych javlenij*. Charkov 1979.
[2] Kisdi-Koszó, E., Vojtaník, P., Potocký, L.: J. Magn. Magn. Mat. *19* (1980), 159.
[3] Vojtaník, P., Kekalo, I. B.: Phys. Stat. Sol. (a) *60* (1980), (to be published).
[4] Brissoneau, P.: J. Phys, Chem. Sol. *7* (1958), 22.

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