acta phys. slov. 31. (1981), No. 2—3

EFFECT OF ANNEALING ON THE BARKHAUSEN EFFECT IN AMORPHOUS Fe—Ni—B—Si ALLOYS[1]

ВЛИЯНИЕ ОТЖИГА НА ЭФФЕКТ БАРКГАУЗЕНА В АМОРФНЫХ СПЛАВАХ Fe—Ni—B—Si

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It is well known that when an amorphous ferromagnetic alloy is annealed at temperature too low to cause crystallization, it can undergo significant changes in mechanical properties and in structure-sensitive magnetic properties such as H_c and χ. The present work was undertaken to see if annealing also changes the shape of the power spectrum of the Barkhausen impulses.

The amorphous alloys $Fe_{47}Ni_{25}B_{18}Si_{10}$ and $Co_{46}Fe_{21}B_{21}Si_{10}Al_2$ used in our measurements were prepared by the single roller technique. The amorphous state was verified by electron diffraction. The length of the used specimens was 3×10^{-2} m. The Barkhausen noise was measured by the usual method [1]. The magnetic field was controlled following a triangle function, the frequency of which was extremely low (1.6×10^{-3} Hz). The maximum value of the external magnetic field was identical for both specimens and was always sufficient to reach their technical saturation. For the measurement of the power spectra $W(f)$ the same experimental equipment was used as that described in paper [2]. The spectrum was always registered with an external field equal to the coercive force of the used sample.

In the case of both samples we have registered the power spectra and the total number of the registered Barkhausen impulses (B. i.) as the function of annealing time at the temperature of 200 °C (473 K).

The observed dependences of the power spectra of both samples at different annealing times τ are shown in Fig. 1 (sample $Fe_{47}Ni_{25}B_{18}Si_{10}$) and Fig. 2 (sample $Co_{46}Fe_{21}B_{21}Si_{10}Al_2$). From these dependences we obtained an exponent k of the spectrum decrease in the middle part of the spectrum. The dependences k vs. τ and the dependences of the total number of the B. i. n vs. τ for both samples are shown in Fig. 3 and Fig. 4. It is seen that the Barkhausen effect strongly depends on the annealing time.

The behaviour of the $W(f)$ functions numbered with 1 in Figs. 1 and 2 is typical for the materials with strong mechanical stresses on the magnetization processes [3]. After annealing the behaviour of the $W(f)$ functions changes, in the region of low frequencies the maximum for $\tau>5$ minutes disappears. The behaviour of $n(\tau)$ and $k(\tau)$ shown in Figs. 3 and 4 is also very interesting. The total number of the registered B. i. n decreases for $\tau<3$ minutes. For $\tau\approx3$ minutes n is minimal after that it increases with a maximum for $\tau\approx9$ minutes. For $\tau>9$ minutes the function $n(\tau)$ exponentially decreases and for $\tau>100$ min. is practically independent.

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

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In order to explain these results it is necessary to consider that in the amorphous materials there occur extended local stress centres quenched in during the solidification process [4]. These local stress centres obviously reduce the domain walls mobility and therefore decrease the tendency of the B. i. to cluster in a large Barkhausen discontinuity. The total number of the registered B. i. will rise. The observed low frequency drop (proportional to k) in the power spectrum is caused by the increase of the mean number of elementary impulses generated per unit time within a correlated domain.

From the obtained results we can conclude that with increasing τ at first (for $\tau<9$ minutes) sample annealing removes the local stress centres and further annealing causes the segregation of the metaloid atoms.

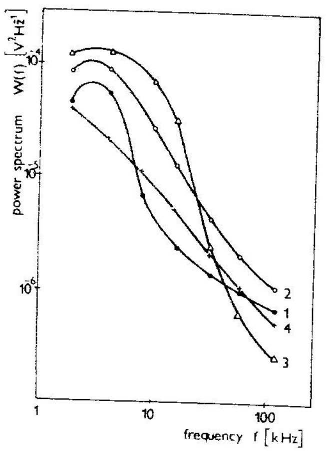

Fig. 1. Power spectra of the registered B. i. in amorphous $Fe_{47}Ni_{25}B_{18}Si_{10}$ for different annealing times τ. (1 — $\tau=0$; 2 — $\tau=3$ min.; 3 — $\tau=$ 5 min.; 4 — $\tau=200$ min.).

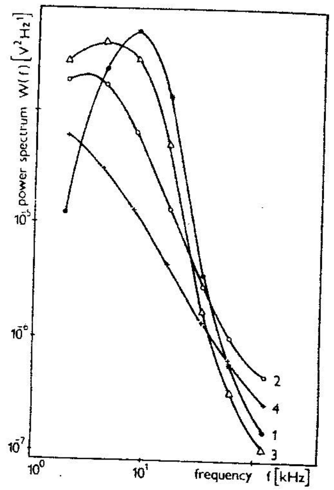

Fig. 2. Behaviour of power spectra in amorphous $Co_{46}Fe_{21}B_{21}Si_{10}Al_2$. (The curves are numbered as in Fig. 1).

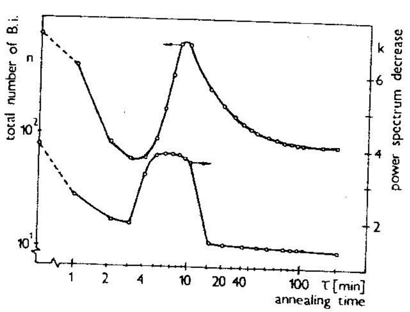

Fig. 3. Dependence of the total number of the registered B. i. n and exponent k (evaluated from Fig. 1) as a function of sample annealing time τ. ($Fe_{47}Ni_{25}B_{18}Si_{10}$).

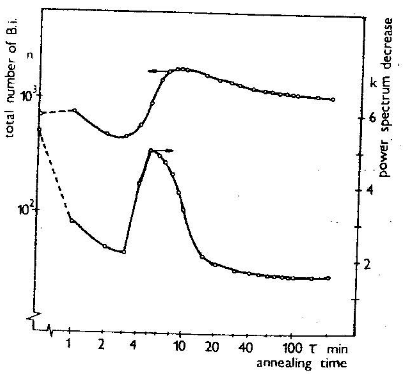

Fig. 4. Behaviour of the total number of the B. i. n and exponent k(evaluated from Fig. 2) versus sample annealing time τ ($Co_{46}Fe_{21}B_{21}Si_{10}Al_2$).

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Received October 20th, 1980