TEMPERATURE DEPENDENCE OF THE MAGNETOSTRICTION OF COBALT AND NICKEL – COBALT FERRITES

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The magnetostriction of the ferrites $Co_{0.9}Fe_2O_4$ and $Co_{0.5}Ni_{0.5}Fe_2O_4$ was studied from room temperature to 300°C; the parity of the effect was studied in the displacement and rotation regions.

The samples were rods with sharpened ends (for the Co ferrite, the diameter was d = 5.8 mm and the length was l = 82 mm; for the Ni–Co ferrite, the dimensions were d = 4.7 mm and l = 98 mm); the samples were prepared from "analytic grade" oxides.

The material was annealed beforehand for 3 h at 900°C; after the samples were prepared, they were annealed for 3 h at 1230°C and cooled with the oven.

The $\lambda(H)$ isotherms were recorded by the remote-pickup method of [1-3]. The relative experimental error did not exceed 5%. The magnetization was determined by a ballistic method; the demagnetizing factor was taken into account, and the vertical component of the geomagnetic field was balanced. From the $\lambda(H)$ isotherms for the two ferrites (Figs. 1 and 2), we see that as the temperature is raised the technical saturation of the magnetostriction, λ_s, is achieved in weaker fields, because of the reduction of the magnetic anisotropy.

The magnetostriction increases with increasing temperature in the nickel–cobalt ferrite in fields up to 1 kOe (Fig. 3). Since this behavior occurs in the displacement region, the magnetostriction increase can apparently be attributed to a change in the magnetic texture in the demagnetized state as the temperature is raised; in particular, there could be an increase in the number of closed 90° neighborhoods.

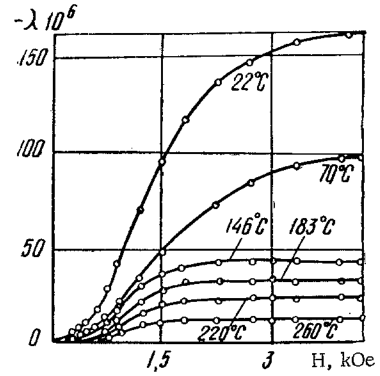

Fig. 1

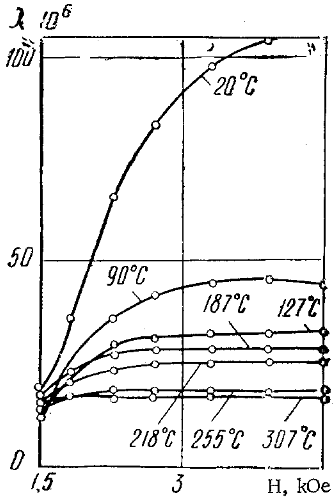

Fig. 2

Fig. 1. Magnetostriction isotherms for the cobalt ferrite.

Fig. 2. Magnetostriction isotherms for the nickel–cobalt ferrite.

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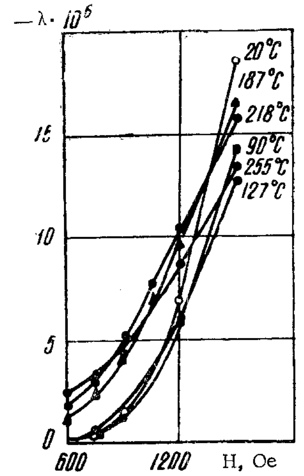

Fig. 3

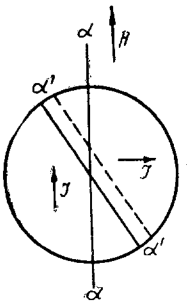

Fig. 4

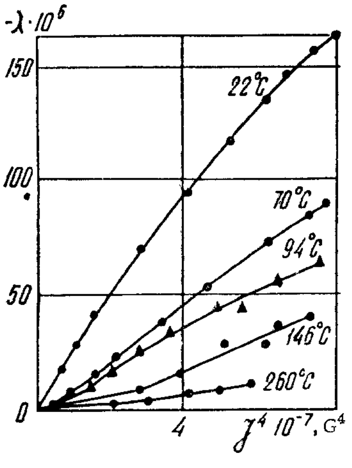

Fig. 5

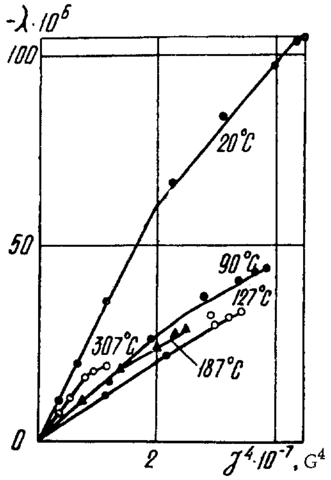

Fig. 6

Fig. 3. Initial region of the magnetostriction isotherms for the nickel–cobalt ferrite.

Fig. 4. A 90° neighborhood. The change in the magnetostriction during displacement of boundary $\alpha'\alpha'$ is governed by the direction $\alpha\alpha$.

Fig. 5. The $\lambda\,(J^4)$ isotherms for the Co ferrite.

Fig. 6. The $\lambda\,(J^4)$ isotherms for the Ni–Co ferrite.

If external field H is parallel to the spontaneous magnetization of a domain (Fig. 4), the wall boundary moves to the right. Then in the volume which the boundary moves through, the anisotropy direction of the magnetostrictive deformation rotates through 90°, so the magnetostriction along the direction $\uparrow\uparrow H$ changes by some amount $\Delta\lambda$. If, on the otherhand, we have $H\uparrow\downarrow J$, the wall of a 90° neighborhood moves to the left, and the change in the magnetostriction along direction $\alpha\alpha$ has the opposite sign. Accordingly, the sign of the magnetostriction change can be determined from the quantity $a\cos(\widehat{HJ})$, where we have $a = \pm 1$, depending on the nature of the material.

If, on the other hand, field H is parallel to wall $\alpha'\alpha'$, then even when there is a change in the wall direction the anisotropy of the magnetostrictive deformation in the wall-displacement region remains at an angle of 45° with respect to the direction $\alpha'\alpha'$ and λ does not change along this direction.

Accordingly, the sign of the change in the magnetostriction along the field can be determined from

$$\text{sign}\quad \Delta\lambda = \text{of}\ \ a\,[\text{ccs}\,(\widehat{HJ}) - \sin\,(\widehat{HJ})]. \tag{1}$$

The angle $(\widehat{HJ})$ is chosen to be less than 45°.

When there is an isotropic distribution of spontaneous-magnetization vectors along the field direction, walls separating domains having vectors parallel to and antiparallel to H are met equally frequently.

According to Eq. (1) the net change in the magnetostriction in this case vanishes. If, on the other hand, the 90° neighborhoods are closed, an increase in the field causes the volume of regions whose spontaneous magnetizations are parallel to H to become greater than that of the regions in which the magnetization is in the opposite direction. Accordingly, the average change in the magnetostriction does not vanish.

We also measured the transverse magnetostriction $\lambda_\perp = -1/2\lambda_\parallel$ for both types of samples [4].

In the displacement and rotation region the parity of the effect can be described by

$$\lambda = bJ^4. \tag{2}$$

For the Co ferrite, b decreases with increasing temperature (Fig. 5).

For the Ni–Co ferrite (Fig. 6), this decrease occurs only up to 127°C. The behavior of coefficient b reveals information about the role and sequence of 90° and 180° displacements during magnetization of the sample during heating.

LITERATURE CITED

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