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The Magnetoelastic Characteristics of $Fe_{70}Ni_8Si_{10}B_{12}$ Amorphous Alloy, Subjected to Thermo-Magnetic Treatment

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This paper presents the experimental results of the magnetic and magnetoelastic investigation on the properties of $Fe_{70}Ni_8Si_{10}B_{12}$ amorphous alloy, subjected to thermo-magnetic treatment. Samples were annealed at temperature 350°C for 1 hour, in parallel magnetic field (4 kA/m), as well as in transverse field (350 kA/m). Sample annealed without magnetic field was also tested. Magnetoelastic tests were performed under uniform compressive stress, applied to the ring-shaped core, perpendicularly to the direction of magnetizing field. The results indicated that the thermo-magnetic heat treatment changes the magnetic characteristics, but does not have a significant influence on the coarse of magnetoelastic characteristics of $Fe_{70}Ni_8Si_{10}B_{12}$ amorphous alloy.

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1. Introduction

The magnetoelastic characteristics of soft magnetic material can be described as changes of flux density B, for given magnetic field H_{m}, under the influence of mechanical stresses σ [1]. These changes of the magnetic properties are very important, from the practical point of view. Due to its large initial permeability (caused by small anisotropy), amorphous materials can be very sensitive to stresses caused by external forces [2]. Such forces can be applied to the material in assembly process of inductive component with amorphous core, or by thermal expansion of the material during the operation of the component [3].

Stresses applied to the material may be particularly large in case of miniature components, where even small forces may cause significant stresses. For this reason, the magnetoelastic characteristics should be carefully analysed in the case of new amorphous alloys, developed for practical applications.

2. Method of investigation

During the investigation, three ring-shaped samples, made of $Fe_{70}Ni_8Si_{10}B_{12}$ amorphous alloy, were tested. The samples were annealed for 1 hour at temperatures 350°C, in parallel magnetic field 4 kA/m, in transverse field 350 kA/m and without magnetic field.

During the magnetoelastic investigation, the compressive stress σ was applied to the ring-shaped sample, perpendicularly to the direction of magnetizing field H [4]. A special system of nonmagnetic, cylindrical backings was used, in order to obtain the uniform compressive stresses σ in the tested ring-shaped core, and enable it to be wound, as it is presented in Fig. 1.

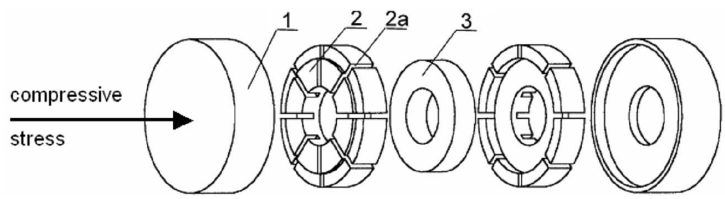

Fig. 1. Device for application of the uniform compressive stress to the ring-shaped sensing element [4]: 1 — base backings, 2 — nonmagnetic cylindrical backings, 2a — grooves or the winding, 3 — core under investigation.

Between the nonmagnetic backing (2) and the ring core (3), a special elastic spacer is placed to guarantee the uniform distribution of the stresses σ in the tested core (3). Magnetizing and measuring windings are placed in special grooved races (2a) in backings. Compressive force (F) is applied to device by hydraulic press, via the base backings (1). The ball joint is used to avoid bending of the sample, which could lead to a non-uniform stress distribution in the sample.

3. Results

The influence of the compressive stress σ on quasistatic hysteresis loop of the $Fe_{70}Ni_8Si_{10}B_{12}$ amorphous alloy sample, annealed in transverse magnetic field, is

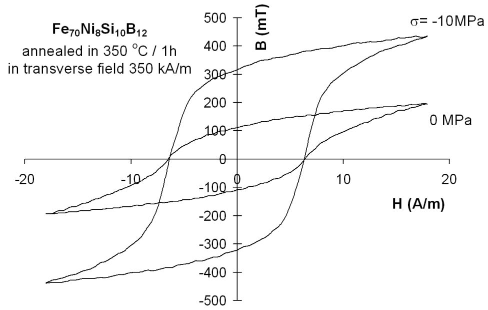

Fig. 2. The influence of the compressive stress σ on the magnetic hysteresis loop of $Fe_{70}Ni_8Si_{10}B_{12}$ amorphous alloy sample, annealed in transverse magnetic field.

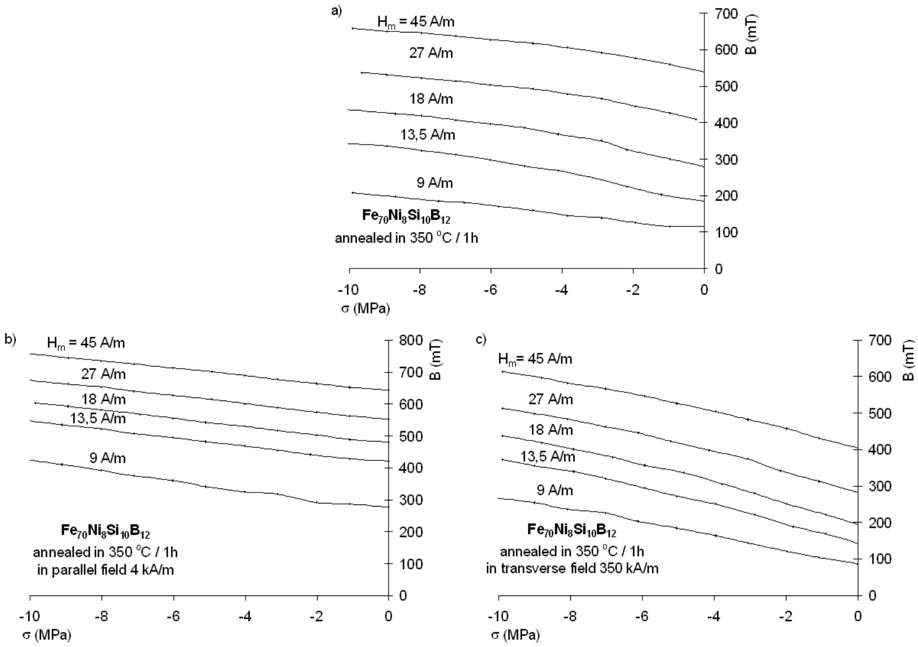

Fig. 3. The influence of the compressive stress σ on the flux density B (measured for magnetizing field H_{m}) for (a) core annealed without magnetic field, (b) core annealed in parallel magnetic field, (c) core annealed in transverse magnetic field.

presented in Fig. 2. Increase in the flux density B, from 200 mT to 430 mT, was detected in the sample subjected to compressive stresses σ up to 10 MPa.

Figure 3 presents the $B(\sigma)_{\mathrm{Hm}}$ characteristics of sample annealed without magnetic field, as well as of samples annealed in parallel and transverse magnetic field. The $B(\sigma)_{\mathrm{Hm}}$ characteristics of all samples are monotonous and nearly linear, which suggests that in spite of annealing, the residual stresses in the samples are still appreciable [5].

It should be pointed out that application of the magnetic field during the annealing does not change the coarse of magnetoelastic $B(\sigma)_{\mathrm{Hm}}$ characteristics. Due to the fact that the thermo-magnetic treatment significantly changes the magnetic characteristics of $Fe_{70}Ni_8Si_{10}B_{12}$ amorphous alloy, such treatment may be used for adjustment of operation point of magnetoelastic sensors, working in impedance bridge configuration.

4. Conclusion

The presented results indicate that the $Fe_{70}Ni_8Si_{10}B_{12}$ amorphous alloys exhibit a significant stress sensitivity, subjected both to thermo-magnetic treatment, as well as annealing without magnetic field. As it was expected, the thermo-magnetic heat treatment changes values of the flux density B, both on the magnetic and magnetoelastic characteristics. On the other hand, direction of the magnetic field, applied to the sample during the annealing, does not have a significant influence on the shape of magnetoelastic characteristics of $Fe_{70}Ni_8Si_{10}B_{12}$ amorphous alloy. For all samples the magnetoelastic characteristics are monotonous, which is useful from the point of view of magnetoelastic sensors development.

Acknowledgments

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