STRESS AND MAGNETIC FIELD DEPENDENCES OF THE SATURATION MAGNETOSTRICTION IN Co-RICH AMORPHOUS ALLOYS

A. Hernando, M. Vázquez, J. Barandiarán, W. Van Hattum

To cite this version:
A. Hernando, M. Vázquez, J. Barandiarán, W. Van Hattum. STRESS AND MAGNETIC FIELD DEPENDENCES OF THE SATURATION MAGNETOSTRICTION IN Co-RICH AMORPHOUS ALLOYS. Journal de Physique Colloques, 1988, 49 (C8), pp.C8-1333-C8-1334. <10.1051/jphyscol:19888609>. <jpa-00228833>

HAL Id: jpa-00228833
https://hal.archives-ouvertes.fr/jpa-00228833
Submitted on 1 Jan 1988

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L’archive ouverte pluridisciplinaire HAL, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d’enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.
STRESS AND MAGNETIC FIELD DEPENDENCES OF THE SATURATION MAGNETOSTRICTION IN Co-RICH AMORPHOUS ALLOYS

A. Hernando (1), M. Vázquez (1), J. M. Barandiarán (2) and W. J. van Hattum (1)

(1) Dpto. Fisica de Materiales, F. Fisicas. U. Complutense, 28040, Madrid, Spain
(2) Dpto. Electricidad y Electrónica, F. Ciencias. U. País Vasco, 48080, Vizcaya, Spain

Abstract. As has been recently shown the magnetostriction constant, \( \lambda_s \), of nearly zero magnetostriction Co-rich amorphous alloys depends on applied stress. It is shown here that this dependence also occurs at 77 K. Furthermore a noticeable dependence of \( \lambda_s \) on the magnetic field is reported.

Introduction

The magnetostriction constant \( \lambda_s \) of some Co-rich amorphous alloys exhibit very low values (order of magnitude of 10\(^{-7}\) or even less). These alloys can be obtained by adding small amounts of some metals (e.g., Fe) to the Co-based glass [1, 2]. They are very interesting since they allowed us the study of the dependence of \( \lambda_s \) on some variables as quenching rate and structural relaxation [3, 4]. Some of them exhibit a peculiar temperature dependence with compensation temperature below the Curie point indicating the contribution to \( \lambda_s \) of different mechanisms [1, 5].

More recently, it has been shown that \( \lambda_s \) decreases upon applied stress at a typical rate of 10\(^{-10}\) MPa\(^{-1}\) [6, 7]. It has been interpreted as produced by local atomic rearrangements produced by the applied stress [8]. The aim of this work has been to study in further detail the influence of applied stress and magnetic field on \( \lambda_s \).

Experimental and discussion

The studied sample was a ribbon of \((\text{Co}_{0.94}\text{Fe}_{0.06})_{75}\text{Si}_{15}\text{B}_{10}\) obtained by single-roller quenching technique. Their dimensions were 21 \(\mu\)m thick and 0.55 mm wide. Experiments were performed by measuring the voltage \( V_{2\omega} \) induced in a pick-up coil wounded around the ribbon when a saturating dc axial field \( H_z \), a tensile stress, \( \sigma \), and a small ac transverse field, \( H_y \sin\omega t \), were simultaneously applied [9, 10]:

\[
V_{2\omega} = A \frac{H_y^2}{\left( H_z + 3\lambda_s \sigma \mu_0 M_s \right)^2}.
\]

(1)

A being a constant. In our measurements \( H_y \) is held constant, thereby equation (2) can be rewritten as

\[
V_{2\omega}^{-1/2} = B \left| H_z + 3\lambda_s \sigma \mu_0 M_s \right|
\]

(2)

\( B \) being a constant.

Figure 1 shows the evolution of \( V_{2\omega}^{-1/2} \) with the applied tensile stress keeping constant the magnetic field \( H_z = 1600 \text{ Am}^{-1} \) and \( H_y = 40 \text{ Am}^{-1} \), at room temperature. The axial field was high enough to produce saturation of the magnetization in the longitudinal direction when neither transverse field nor tensile stress are applied.

As can be observed the slope of the \( V_{2\omega}^{-1/2} \) versus \( \sigma \), instead of being constant as predicted by equation (2), changes sign for \( \sigma \) close to 200 MPa. This effect which corresponds to a change of sign of the magnetostriction on \( \sigma \) is originated by the previously reported stress dependence of \( \lambda_s \) [7].

A new result, which has not been reported before as far as we know, is that shown in figure 2. \( V_{2\omega}^{-1/2} \) has been plotted as a function of \( H_z \) with applied stress as a parameter. According to equation (2) a linear behavior of \( V_{2\omega}^{-1/2} \) versus \( H_z \), with \( B \) as proportionality constant was expected. However the derivative of \( V_{2\omega}^{-1/2} \) respect to \( H_z \) rises linearly with \( \sigma \), for \( H_z > 2000 \text{ Am}^{-1} \), which indicates that \( \lambda_s \) in the high stress range possesses a term proportional to \( H_z \) in equation (2).

---

**Figure 1.** \( V_{2\omega}^{-1/2} \) is plotted as a function of \( \sigma \).
Therefore the results plotted in figures 1 and 2 leads to write $\lambda_\ell$ as

$$\lambda_\ell = \lambda_{00} - a\sigma + bH_s$$  \hspace{1cm} (3)

where $\lambda_{00}$ is the magnetostriction value extrapolated at zero applied both stress and magnetic field. $a$ and $b$ are positive and from the experimental results their values are $10^{-10}$ MPa$^{-1}$ and $10^{-10}$ (Am$^{-1}$)$^{-1}$ respectively.

Two important remarks must be emphasised, i) the stress and field dependence of $\lambda_\ell$ has been observed in all composition checked with nearly-zero magnetostriction and ii) the qualitative characteristics of this dependence do not exhibit any change by lowering the temperature up to liquid nitrogen. Figure 3 shows $V_{2\omega}^{-1/2}$ as a function of $\sigma$ for different $H_s$ values. The measurements were performed at 77 K on a sample of composition $(Co_{0.95}Fe_{0.05})_{75}Si_{15}B_{10}$. This behavior observed at low temperature allows us to disregard any thermally activated process to account for the stress and field dependence of $\lambda_\ell$.

It will be shown in detail in a paper in preparation that the coexistence of two amorphous phases, elastically coupled, with different magnetostriction to each other leads to the stress and field dependence of $\lambda_\ell$ reported here.

Acknowledgments

This work has been supported by the CAICYT project PA840365 and by the Comité Conjunto Hispano-Norteamericano project CCA8411006