INFLUENCE OF DIRECT CURRENT ON THE Hysteresis Loops of Fe-Based Amorphous Ribbons

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Abstract. The effects of longitudinal direct currents on the magnetization processes of Fe-based amorphous ribbons with a positive magnetostriction constant have been investigated by means of vibrating sample magnetometer. When the twisted samples are exposed to direct current, considerable changes in their hysteresis loops occur. The correlation between the changes of the hysteresis loops and the influence of direct current was explored both experimentally and by a simple realistic model.

Experiment

Direct current (I) flowing along the long axis of the amorphous ribbon causes interesting phenomena on its hysteresis loops [1-4] such as shift and narrowing of hysteresis loops. In our previous paper [5], hysteresis loops of amorphous ribbons under stress and torsion have been investigated for the case with no direct current both experimentally and theoretically. In addition to the earlier work, in this paper we report our studies of magnetic response of amorphous ribbons in the presence of direct current.

Samples with dimension 2 mm x 95 mm x 25 μm used in all measurements are commercial Metglass (Allied Signal Inc) 2826MB and 2605S3 amorphous ribbons with positive magnetostriction coefficients varying between (10-30 x 10⁻⁶). These samples have been investigated by means of the vibrating sample magnetometer. During the measurements, the value of the direct current passing along the long axis of the ribbon is not much higher in order to avoid appreciable heating of the sample. Maximum value of the direct current is 300 mA. All the data reported herein is from measurements at room temperature.

The first group of measurements has been performed on amorphous 2605S3 ribbon in the form of long straight ribbon. As can be seen from figure 1, there is no difference in the
hysteresis loops with increasing the applied direct current (0 mA, 100 mA and 300 mA). (Not all of the experimental points are shown in the figures).

In the second group of measurements, the effect of the current flowing through the sample on the loops for a fixed value of the torsion has been investigated. The experimental hysteresis loops in figure 2 correspond to three different values of the current (0 mA, 100 mA and 250 mA) for the torsion of $4\pi/96$ rad mm$^{-1}$. As seen in figure 2, the increase of the applied current causes the loops to shift more to the left. Due to the applied current, the loops in figure 2 show an asymmetric behavior, i.e., the steps exists on the left-side of the loops while they do not exist on the right-side of the loops.

![Figure 1](image1.png)

**Figure 1.** The effect of the direct current on the hysteresis loops of ribbon without stress and torsion.

![Figure 2](image2.png)

**Figure 2** The effect of the current on the hysteresis loops of a twisted ribbon.

The model is briefly given as follows:

i) The sample has been divided into small regions along its cross-section.

ii) Each region of the sample has been characterized by an angle $\alpha$ between the easy axis and the applied field $H$ that is parallel to the ribbon length.

Exchange interactions between different regions, bring about the existence of layer energy is also neglected because it is low. The field ($H_e$) produced by the current thickness. Its magnitude on the surface width and thickness, $t << w$.

Thus, the resulting energy in the case of regions to the magnetization are found.

These contributions are added together to model fields, repeated for various magnetic fields. The model hysteresis loops in figure 3 for different values of the direct current (0, 1, 10, and 100 mA) show an asymmetric behavior, and shift to the right. It was observed that the loops are a response to the flowing high current.

![Figure 3](image3.png)

**Figure 3** The dependence of the magnetization of a twisted ribbon on the applied field.
that is parallel to the ribbon length, and anisotropy constant-\(K\), iii) Magnetostatic and exchange interactions between different regions have been assumed to be either negligible or, else, bring about the existence of large single domain regions and iv) The demagnetization energy is also neglected because in long samples this energy is very low.

The field (\(H_s\)) produced by the current changes linearly and decreases with the sample thickness. Its magnitude on the surface of the sample is given [3] by \(H_s = \frac{1}{2} w (w\) ribbon width and \(t\) ribbon thickness, \(t << w\)).

Thus, the resulting energy in the case with the direct current is:

\[
W' = -K \cos^2(\theta - \alpha) - M_s H \cos \theta - M_s H_s \sin \theta
\]

(1)

where \(H_s\) is the transverse magnetic field due to the direct current. The contributions of all regions to the magnetization are found by minimizing the energy \(W'\) with respect to \(\theta\).

These contributions are added together in order to find the total magnetization. The process is repeated for various magnetic fields, and the model hysteresis loops are obtained.

The model hysteresis loops in figure 3 correspond to fixed torsion of 2 rad and three different values of the direct current (0, 10, 20). Like in figure 2, these model curves show an asymmetric behavior, and shift to the left direction with increasing the value of the current.

It was observed that the loops are reversible in the presence of the high current. Such a response to the flowing high current through the ribbon shows that the transverse magnetic field due to the current flow is more dominant than the external magnetic field.

**Conclusion**

It is to be concluded that the observed shift and the asymmetry are due to the direct current flowing along the ribbon length. As seen, the current affects the hysteresis loops of the amorphous ribbons via a magnetic field \(H_s\) produced by the direct current. This transverse
magnetic field $H_x$ generates the anisotropy axis perpendicular to the ribbon length. This transverse anisotropy axis causes the hysteresis loops of the amorphous ribbons to be asymmetric.

References

Abstract
The Al$_{1-x}$Fe$_x$ ($x = 0.08$) sputtering system, by simultaneous deposition, have been realised by CEMS, XR aluminides, which belong to Al rich and/or nanocrystalline structure as well as FeAl phases. The absence of TEM patterns, indicated the presence of treatment samples observed a nanocrystalline structure.

Introduction
The iron aluminides, which belong as protective coating layers to use in study and the use of these materials in the structure of stoichiometric compounds the whole concentration range. The Al-Fe compounds and alloys belong to bulk or thick film systems which may understand the physics of phenomena of Fe-Al alloys as thin films for practical applications with many possible applications to amorphous and/or nanocrystalline materials. In this paper, we intend to study the feasibility of protective layers by ion beam films at room temperature and high