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SHORT COMMUNICATION

INFLUENCE OF THE SAMPLE DIAMETER ON THE SWITCHING PROCESS OF MAGNETOSTRICTIVE AS-CAST FeSiB WIRES*

H. Chiriac, F. Borza, I. Murgulescu

National Institute of R&D for Technical Physics, 47 Mangeron Blvd., 6600 Iasi, Romania

Results of the research on the influence of the wire diameter on the switching process of as-cast amorphous wires are presented. We observed an increase in the switching field, H*, as the wire diameter increase. A decrease in the length of the wire, for which they still exhibit switching of the magnetization was also observed. We ascribe these dependencies to the demagnetizing effects.

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Magnetic amorphous wires prepared by rapid quenching from the melt have been extensively studied in the last years [1,2]. The interest in these materials, apart from the point of view of the basic research, is mainly due to their technological applicability. The magnetic amorphous wires are prospective materials for numerous types of sensors sensitive to magnetic field, current, torque, etc. Their applications are enabled by the wide range of possibilities to control their magnetic properties and behaviour.

Highly magnetostrictive wires ($\lambda \approx 35 \times 10^{-6}$) are characterized by single large Barkhausen jump which is characteristic for the total magnetization reversal at a switching field H*. Such a bistable magnetic state of the Fe-based amorphous wires is connected with the specific domain structure [1], that consists of an axially magnetized inner core and a radially magnetized outer shell, induced in the samples during the fabrication process. The application of reversal field, H*, in opposite direction with respect to the magnetization in the inner core results in total magnetization reversal and gives rise to a typical squared hysteresis loop.

The value of the switching field was found to depend on the sample length [3] and the effective diameter [4].

In this work we study the switching field, H*, and reduced magnetization, M*/Ms, of as-cast FeSiB amorphous wires as a function of diameter and length.

Amorphous wires of the nominal composition $Fe_{77.5}Si_{7.5}B_{15}$, with diameters of 70 to 210 μm, were prepared using the in rotating water quenching technique by varying the process' parameters. The amorphous state of the samples was checked by X-ray diffraction, DTA, DTMG, and thermomagnetic measurements. All samples were found to be amorphous.

Hysteresis loops of samples were measured by a fluxmetric method at 50 Hz in an alternating applied field of maximum 25 kA/m. The magnetizing and the pick-up coils were length 20 cm and 3 cm, respectively. The samples were set in the center of the magnetizing coil, symmetrically with respect to the ends of the pick-up coil, since the appearance of the B-H squared loop has been found to depend also on the position of the ends of the wires with respect to the coils edges [5]. The dependence of H* on the sample length was measured on the same sample, starting from 15 cm and reducing successively the length of the wire down to the value for which H* disappears.

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Fig. 1 illustrates the dependence of the switching field, H*, and reduced magnetization, M^*/M_s, on the diameter of the wire for samples having the same length of 12 cm.

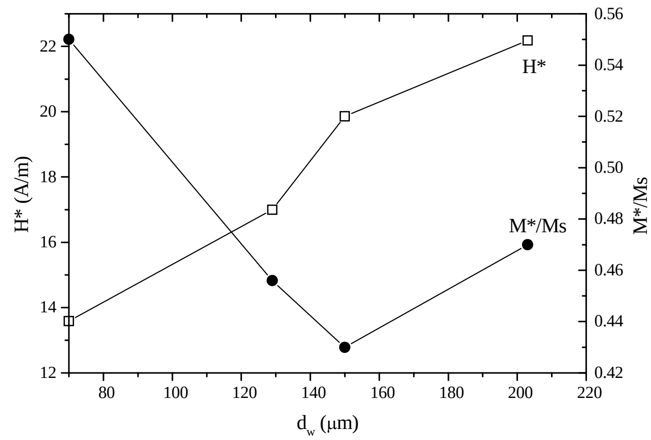

Fig. 1. Switching field, H*, and reduced magnetization, M^*/M_s, dependence on the wires diameter.

An increase in the value of the switching field of the wires as the diameter increases is observed. The difference between H* of the wires having 129 μm and 148 μm is not significant.

The magnetization at the switching field, M*, is about 0.5 M_s for the 12 cm long samples, decreasing to about 0.35 for the samples having the minimum length at which LBE still occurs. The higher value of M^*/M_s for the wires having 70 μm in diameter indicates a higher relative volume of the axially magnetized inner core (75% as compared to around 69% for wires having larger diameters). This estimation was made using the relation $\frac{M^*}{M_s} = \left(\frac{R_c}{R_w}\right)^2$, where R_c is the radius of the inner core and R_w is the total radius of the wire [3].

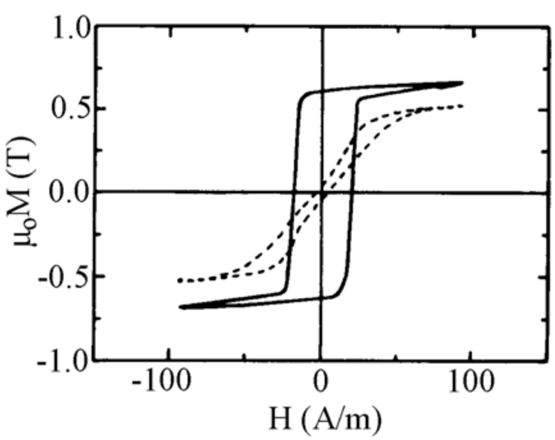

Fig. 2. Hysterezis loops for a 12 mm in length (squared loop) and for a 7 mm in length amorphous wire having 148 μm in diameter.

The differences in the values of H* in the wires with different R_w are attributed to the internal stresses induced during preparation.

Fig. 2 illustrates the hysteresis loops for the sample having 148 μm in diameter for two lengths: 12 cm and 7 cm (at latter value LBE disappeared). Down to 7 cm the sample present the typical bistable behavior characterized by squared hysteresis loop. A progressive decrease of H* was observed with decreasing the length of the wire. This behavior was in accord with the decreasing demagnetizing factor in longer wires. At the length of 7 cm the bistable behaviour changes, the hysteresis loop being characterized by two Barkhausen jumps. This behavior is similar for all samples.

The minimum length at which the wires still exhibited LBE decreases with the wire diameter: l_{min} = 9 cm, 8 cm, 7 cm and 5 cm for the wires having 208 μm, 148 μm, 129 μm and 70 μm in diameter respectively. We assign this behavior to the demagnetizing effects.

In this work the magnetic study of as-cast $Fe_{77.5}Si_{7.5}B_{15}$ amorphous wires is presented. We studied the switching field, H*, and the reduced magnetization, M^*/M_s, for as-cast wires as a function of diameter and length of the sample. The observed change in the switching field value was, in both cases, ascribed to the demagnetizing effect.

The results are important from the point of view of the experiments concerning the LBE, i.e. the exact values of H* for different diameters and lengths as well as from the point of view of the applications of these wires, i.e. of the practical aspects of LBE-based magnetic sensors.

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