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Magnetic properties of bilayered $Fe_{67}Co_{18}Si_1B_{14}/Co_{66}Fe_4Ni_1Si_{15}B_{14}$ amorphous alloy core

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Abstract— In this paper, we present the investigation of magnetic characteristics of bilayered Fe-Co amorphous alloy ring-shaped core. They were measured on the specially designed measurement stand, called the hysteresisgraph. Highly nonlinear behavior, such as double hysteresis, was observed. The obtained B(H) and μ(H) characteristics are distinctly different from the typical, single-phase ferromagnetic materials.

Index Terms— amorphous alloys, metglas, magnetic hysteresis, hysteresisgraph

1 INTRODUCTION

THE amorphous alloys are heavily investigated for their unique properties [1], including magnetic ones, which make them the material of choice for special applications. Some of the amorphous and annealed, or nanocrystalline alloys exhibit ultra-high magnetic permeability [2], or highly linear, narrow hysteresis loop with low coercivity [3]. They are used also for the inverse magnetostrictive force transducers [4,5]. The available technologies allow for casting of ribbons, wires and small bars of amorphous alloys [6,7]. In this paper, we investigate the magnetic properties of the ring shaped magnetic core composed of two different ribbons, wound in the bilayer pattern. There are not many readily available results of similar measurements in the current scientific literature [8], despite the very unusual properties and relatively simple construction of such a core.

2 MEASUREMENT STAND

The hysteresis loops measurements are done on the hysteresisgraph, which is the specially developed test stand for magnetic hysteresis loop B(H) measurements (Figure 1). The whole test stand is controlled by the PC equipped with NI USB 6525 data acquisition card (DAQ). The DAQ is controlled by NI LabView software, for real-time control, as well as for the data processing. Voltage signal generated by the data acquisition card drives the Kepco BOP 36 voltage/current converter. The output of Kepco BOP 36 is connected to the magnetizing winding of the investigated ring sample. Measuring winding is connected to the Lakeshore 480 fluxmeter, which measures changes of the flux density B in the sample. Voltage output of the fluxmeter is connected to the data acquisition card. As a result, the hysteresisgraph presents B(H) hysteresis loops under digitally controlled values of amplitude of magnetizing field H, as well as for different frequencies and shapes of magnetizing signals. The developed software allows for automated series of measurements under varying amplitude of the magnetizing field H, which allow for obtaining the u(H) magnetic permeability characteristic of the sample.

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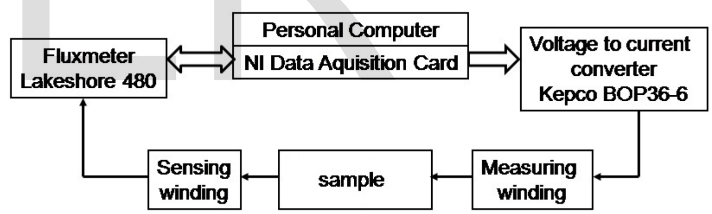

Fig. 1. Schematic diagram of the developed measurement test stand – hysteresisgraph

The magnetic sample tested was the ring-shaped core with the following characteristics (Table 1). The materials used have very high magnetic permeability and low (but different for each material) coercivity.

TABLE 1
SAMPLE PHYSICAL PROPERTIES

Property	Description/Value
Material	Bilayered amorphous ribbon $Fe_{67}Co_{18}Si_1B_{14}/Co_{66}Fe_4Ni_1Si_{15}B_{14}$
Shape	Ring
Number of magnetizing windings	4

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Number of measuring windings	200
Cross section	15 mm^2
Magnetic path length	84.7 mm

3 Measurement results

The results of the investigation are presented below. In the Figures 2-9 the magnetic B(H) characteristics can be seen. The change of the hysteresis loop shape under the increasing magnetizing field H are evident. The magnetizing field H was increased from 1 to 10 A/m in 1 A/m steps. Most interesting area is visible in Fig 6, under 4.5 A/m. It is the intermediate area between the single-phase behavior visible in Fig 5 and double-phase constricted hysteresis loop visible in Fig 7. At this field value, the coercive force of the second phase is reached.

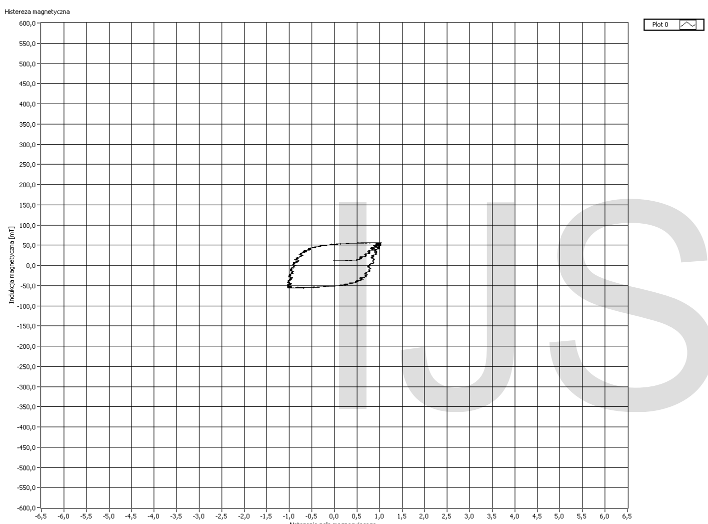

Fig. 2. B(H) loop measurement results, value of magnetizing field H = 1 A/m

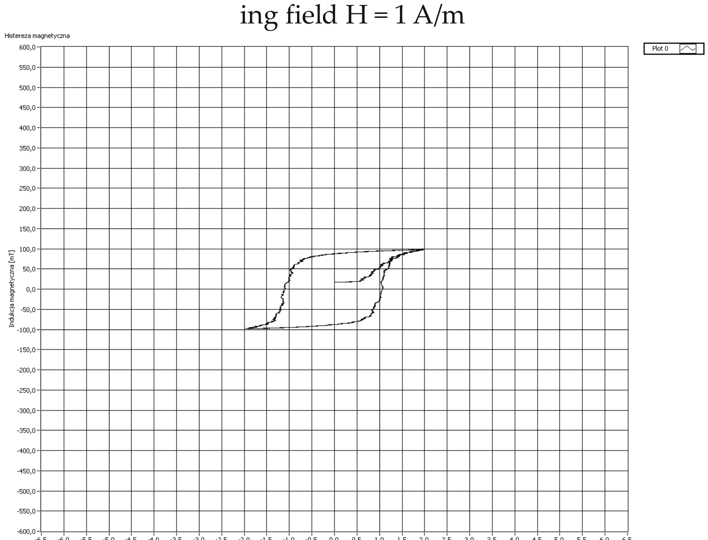

Fig. 3. B(H) loop measurement results, value of magnetizing field H = 2 A/m

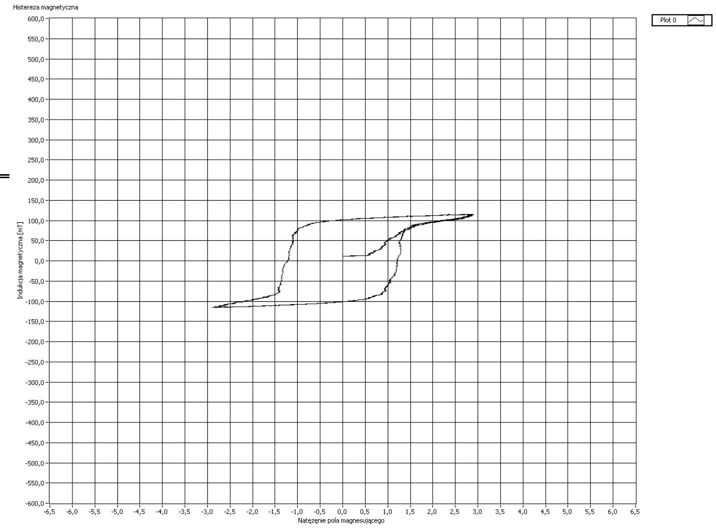

Fig. 4. B(H) loop measurement results, value of magnetizing field H = 3 A/m

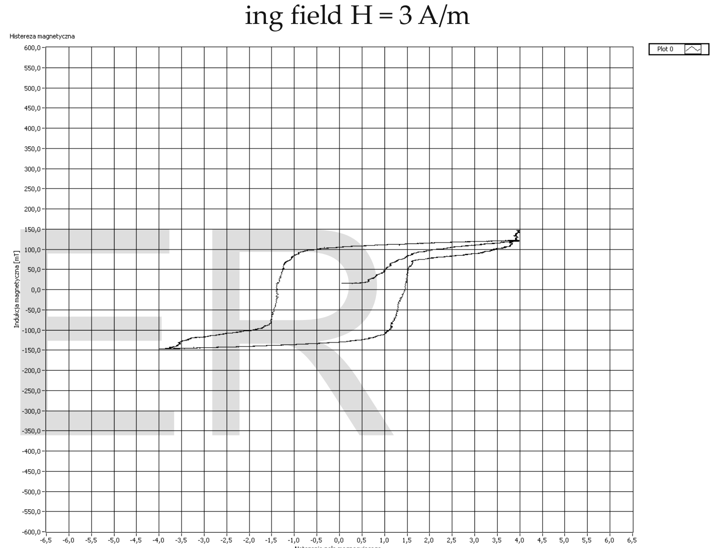

Fig. 5. B(H) loop measurement results, value of magnetizing field H = 4 A/m

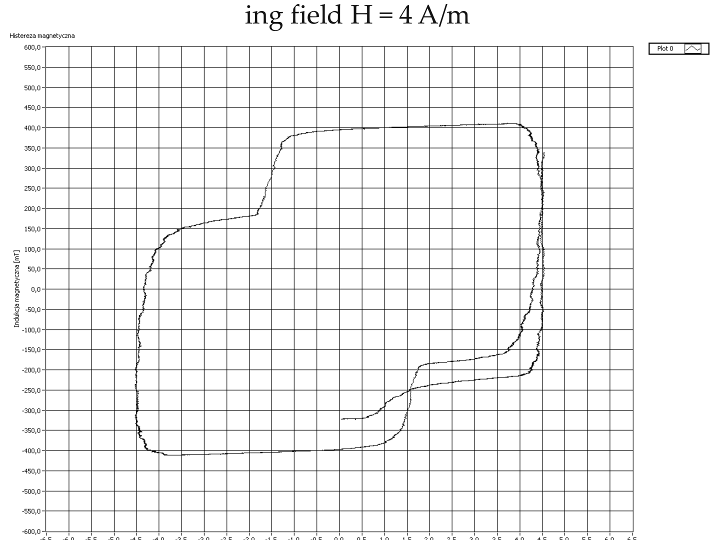

Fig. 6. B(H) loop measurement results, value of magnetizing field H = 4.5 A/m

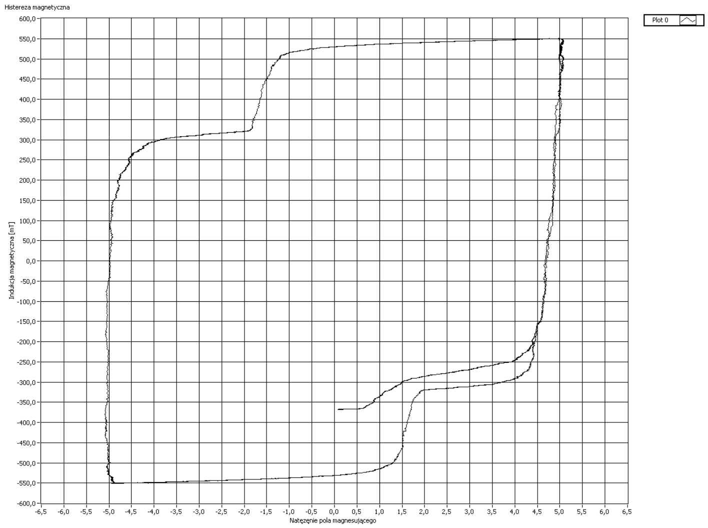

Fig. 7. B(H) loop measurement results, value of magnetizing field H = 5 A/m

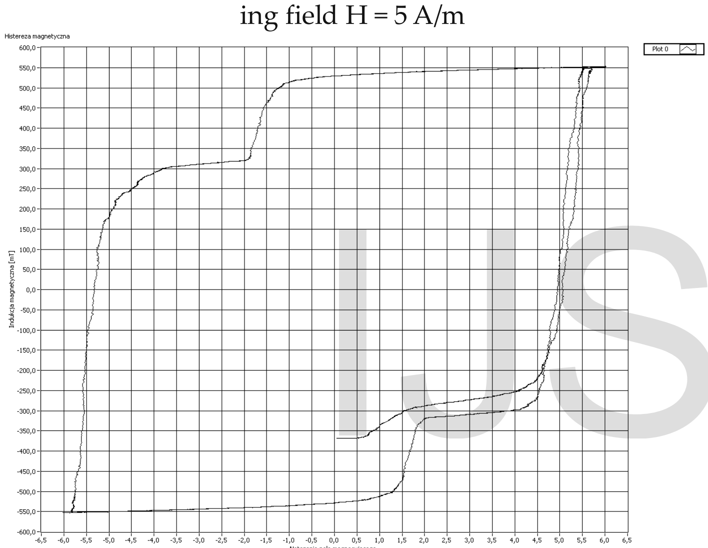

Fig. 8. B(H) loop measurement results, value of magnetizing field H = 6 A/m

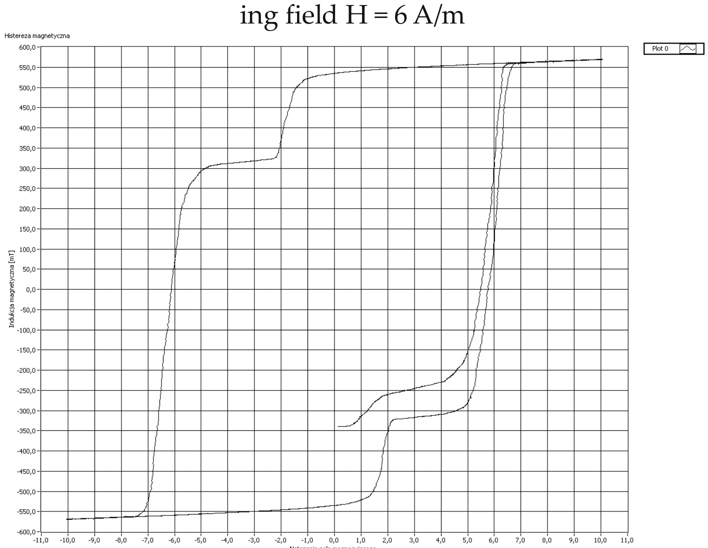

Fig. 9. B(H) loop measurement results, value of magnetizing field H = 10 A/m

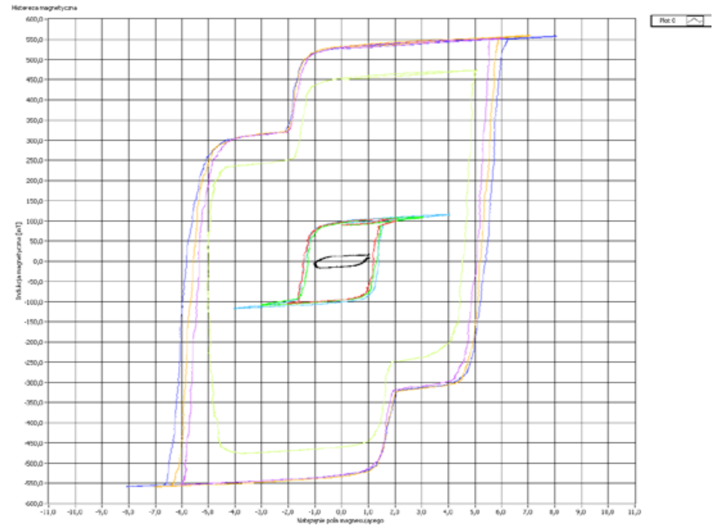

Fig. 10. B(H) loops measurement results, value of magnetizing field H from 1 to 10 A/m

In Figure 10 the comparison of the obtained series of hysteresis loops is presented.

In Figure 11 one can see the highly unusual μ(H) magnetic permeability characteristic of the bilayered magnetic core.

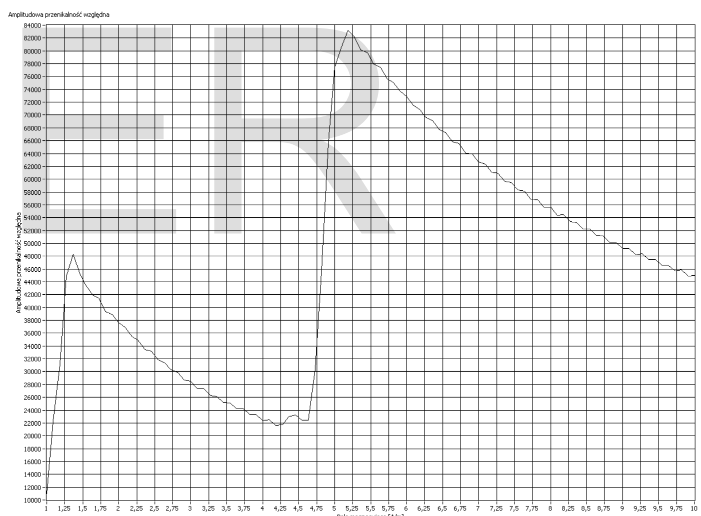

Fig. 11. μ(H) characteristic, value of magnetizing field H from 1 to 10 A/m

4 CONCLUSIONS

The hysteresis loops measurements were performed on the specially developed test stand for magnetic hysteresis loop measurements (hysteresisgraph). The whole test stand is controlled by the PC equipped with DAQ and NI LabView software, for real-time control as well as for the data processing. The obtained B(H) and μ(H) characteristics of the tested bilayered core exhibit high nonlinearity, more complex than in the typical ferromagnetic systems. Most interesting is the transition between single-phase and double-phase behavior, which can be potentially utilized in signal

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amplitude sensitive devices.

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