Coercivity of melt-spun $Fe_{51}Ni_{49}$ alloy after different treatment of their structure

Mieszko Kołodziej[a,b], Jozef Marcin[c], Jozef Kovac[c], Zbigniew Śniadecki[a], Bogdan Idzikowski[a]

[a] *Institute of Molecular Physics, Polish Academy of Sciences, Poznań, Poland*
[b] *NanoBioMedical Centre of Adam Mickiewicz University, Poznań, Poland*
[c] *Institute of Experimental Physics, Slovak Academy of Sciences, Košice, Slovakia*

The alloy with $Fe_{51}Ni_{49}$ composition was synthesized by melt spinning from the meteoritic matter and nickel and subjected to high-pressure torsion (HPT) processing. Then such obtained series of alloys was annealed without an external magnetic field and in 14 T. We investigated the structural and magnetic properties using a combination of X-ray diffraction and vibrating sample magnetometry. The results show that HPT processing increased the potential of the alloys for the diffusion of Fe and Ni after further annealing at 296°C, which is lower than the known $L1_0$ FeNi order-disorder transition point. From magnetic measurements it could not be concluded that the hard magnetic $L1_0$ phase was formed during the experiment. All samples are magnetically soft with coercive field from 2 to maximum 13 Oe.

Keywords: Fe-based meteoritic matter; soft magnetic properties; coercive force

1. Introduction

We described the synthesis procedure and properties of quasi-equiatomic $Fe_{51}Ni_{49}$ alloys based on iron-rich meteoritic material of the Morasko Meteorite (MM). Morasko is a village name in Greater Poland, near Poznań, where the fall of the largest iron meteorite "shower" in Central Europe took place around 5 thousand years ago.

2. Results and discussion

Pieces of the MM were alloyed by an arc-melting method in an Ar atmosphere with pure Ni (3N) to obtain a quasi-equiatomic $Fe_{51}Ni_{49}$ composition. The obtained ingot was then quenched using the melt-spinning process in an Ar atmosphere with a copper wheel speed of 40 m/s. The obtained ribbons were then treated by high-pressure torsion (HPT) at a pressure of 6 GPa with a rotation velocity of 1 revolution per minute for 10, 30, and 50 times. In the next step, these samples underwent isothermal annealing at 296ºC for 120 hours, without an external magnetic field and in the presence of a 14 T external magnetic field.

X-ray diffraction confirms the presence of fcc-FeNi phase with the *Fm*-3*m* space group in each sample. These results are typical of FeNi alloys of equiatomic composition [1]. The magnetic hysteresis loops are shown in Fig. 1. For the as-quenched samples, the coercive field was in the range of 3-4 Oe (Fig. 1 A). Severe plastic deformation increased the coercive field to 8.5–12.2 Oe after 10 revolutions (Fig. 1 B). The coercivity was decreased to 7.0–8.1 Oe and 7.9–8.0 Oe after 30 and 50 rotations, respectively (Fig. 1 C, D). The coercivity varies within an error bar ±0.5 Oe. The tiny changes could be explained by pinning at the grain boundaries and grain refinement after the HPT process. Annealing for 120 h at a temperature of 296°C without an external magnetic field did not affect the coercive field in the as-quenched sample (3.8 Oe, Fig. 1 A). However, in the HPT-processed materials, the coercivity, at first, decreased to 6.3, then to 1.3 Oe, and even down to 1.2 Oe for 10, 30, and 50 revolutions, respectively (Fig. 1 B-D). This is most likely due to the evolution of the microstructure after severe plastic deformation but can also be attributed to the different shape anisotropy of the sample in disc form after HPT.

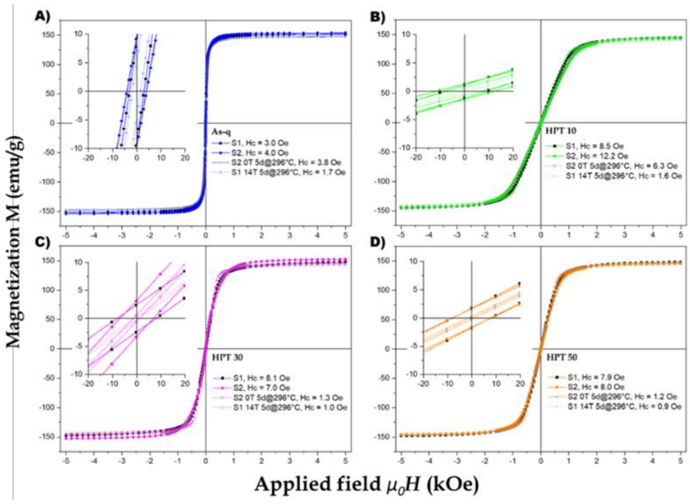

Figure 1: Magnetic field dependence of magnetization for $Fe_{51}Ni_{49}$ in (A) the as-quenched state, further annealed without and with the external magnetic field of 14 T; and for the initial HPT-treated samples after (B) 10, (C) 30, and (D) 50 revolutions, and further annealing without and with an external magnetic field of 14 T. S1 and S2 means samples pre- and post-annealed with and without an external magnetic field, respectively.

HPT processing was additionally followed by annealing in an external magnetic field of 14 T for 120 h, resulting in a further reduction in the coercive field to 1.7 Oe for the as-quenched sample (Fig. 1 A), and to 1.6, 1.0, and even 0.9 Oe for the annealed samples after 10, 30 and 50 rotations, respectively (Fig. 1 B-D). This further decrease is most likely explained by the grain-size dependence of coercivity, which can be caused by the averaging of random magnetocrystalline anisotropies in small grains or can also be the result of the presence of a low anisotropy network effect on the magnetization.

Reference

[1] Cacciamani, G. *et al.*, Critical evaluation of the Fe–Ni, Fe–Ti and Fe–Ni–Ti alloy systems, Intermetallics **14** (2006) 1312.

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