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Change of magnetic saturation polarisation, as a function of temperature, in bulk Fe-based amorphous alloys

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Abstract

This paper presents the results of research on the magnetic saturation polarisation, as a function of temperature, for rapidly-cooled iron alloys with an amorphous structure. The rapidly-cooled Fe-based amorphous alloys are characterised by good magnetic properties. The Curie temperature is one of the main parameters that determine the stability of the ferromagnetic properties of such alloys. The tested materials met the assumptions of Heisenberg's theory; therefore, the critical factor, β = 0.36, was used to determine the Curie temperature. It was found that both of the tested alloys have one Curie temperature pertaining to the amorphous matrix - which proves their effective homogenisation.

Introduction - essence

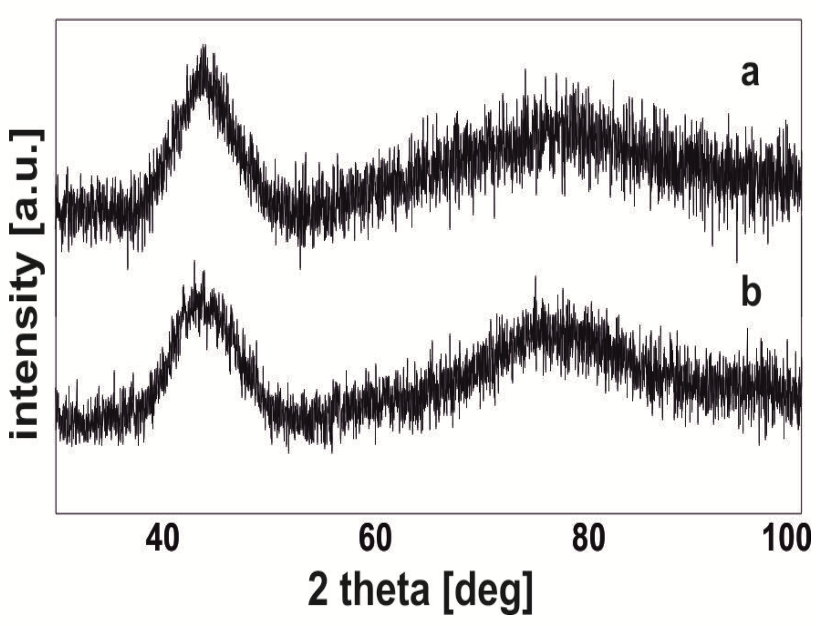
Constantly developing market of electrotechnical materials and their growing use have forced scientists to develop new materials with the desired properties [1,2]. Commonly used devices operate up to a critical temperature of about 100 °C. Above this temperature, electrical systems lose their properties. This temperature is also in many cases insufficient due to the nature of the device. Therefore, it is important to develop materials for which Curie temperature is stable to a range in excess of 100 °C and the material properties do not deteriorate. Curie temperature is main parameter that determines stability of ferromagnetic state, above it the material becomes paramagnetic [3-5]. In terms of use, it loses its properties and device no longer meets setting standards. In the nineties of last century, new group of materials called bulk amorphous materials was developed [6-8]. These materials are amorphous alloys, thickness of which is greater than 100 µm [xx]. Amorphous tapes, which had been commonly produced since the 1970s, did not meet many application requirements and it was necessary to develop new volumetric amorphous materials. Difficulty was to lower the critical cooling speed to 10^5-10^6 K/s [xx].

Experimental procedure - highligts

Post-solidified samples were subjected to structure measurements using BRUKER ADVANCE 8 X-ray diffractogram. Measuring apparatus was equipped with a cobalt lamp and worked in Bragg Brentano geometry. Prepared preparation in the form of obtained low-energy powder was irradied by Roentgen rays at room temperature in the range of angle 2 theta from 30 to 120 with an exposure time of 7 s per measuring step of 0.02°. Test samples were crushed in an agate mortar within toluene. Measurements of magnetic saturation polarization as a function of temperature were made using Faraday's magnetic balance. About 25 mg of the sample was placed in a platinum basket axially coupled to a 1 meter quartz holder. Measurements were made in a vacuum in the temperature range of up to 800 K with a build-up time of 10 K/min.

Results

Fig. 1. X-ray diffraction patterns for the alloy samples: a) $Fe_{70}Y_5Nb_5B_{20}$, b) $Fe_{70}Y_5Nb_5Mo_1B_{20}$	Fig. 2. Static magnetic hysteresis loops for tested alloys in solidified state: a) $Fe_{70}Y_5Nb_5B_{20}$, b) $Fe_{70}Y_5Nb_5Mo_1B_{20}$ 82 A/m 0.83T, b) 68A/m 0.87T



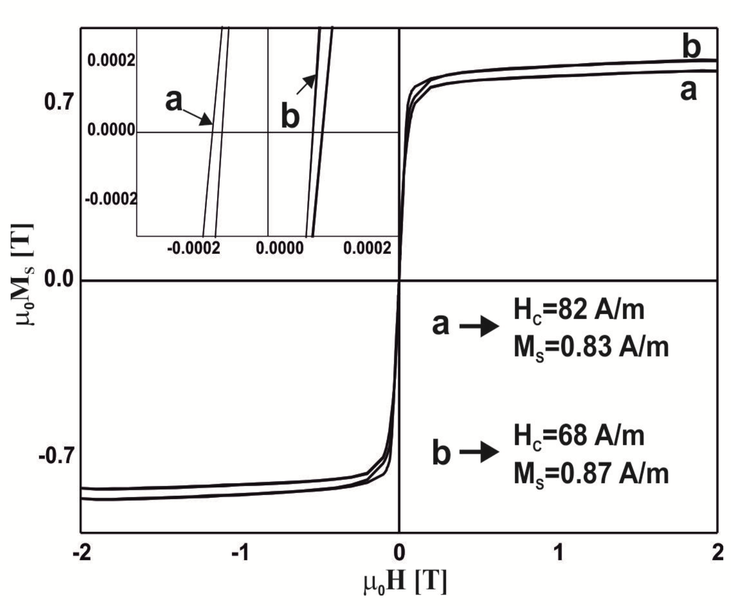
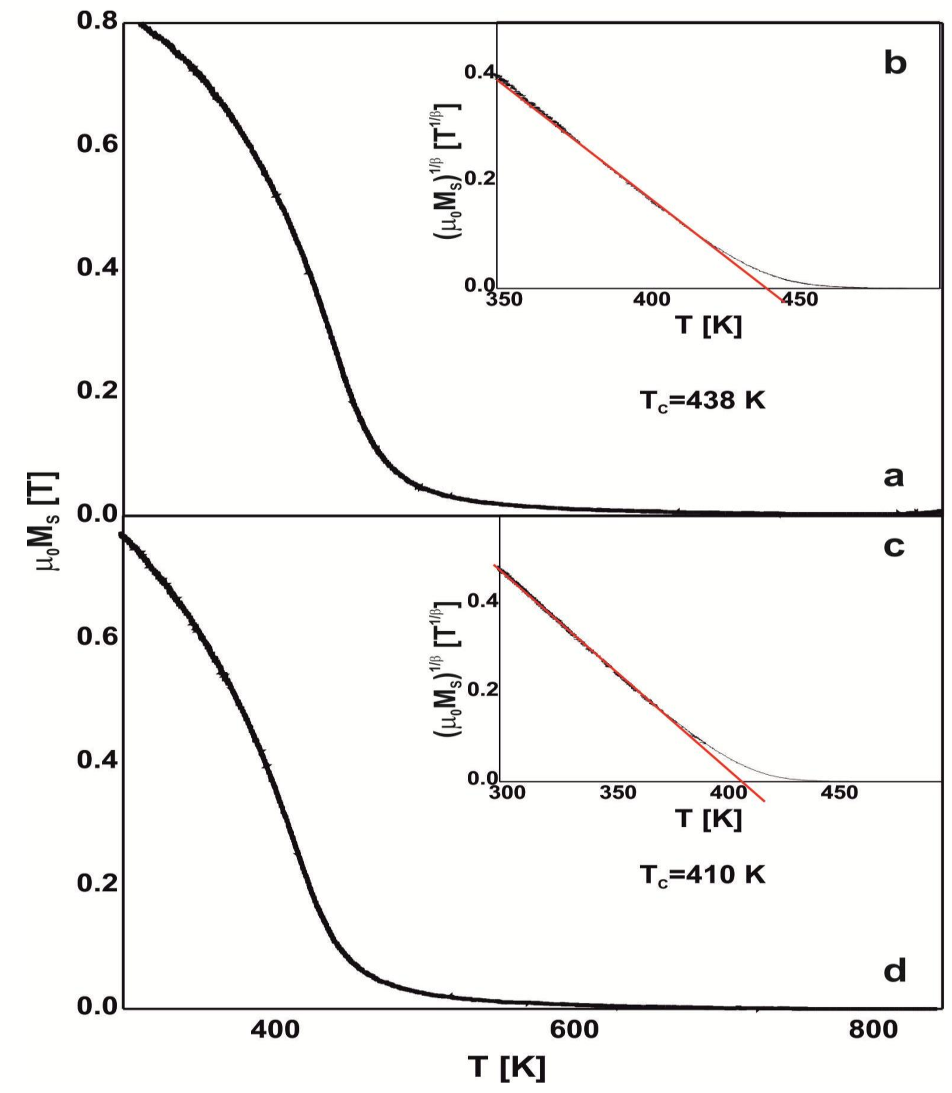


Fig. 3. Curves $m_0M_S(T)$ and $m_0M_S^{1/b}(T)$ for alloys $Fe_{70}Y_5Nb_5B_{20}$ a), b) and $Fe_{70}Y_5Nb_5Mo_1B_{20}$ c), d)



Conclusions

Tested samples show a fairly high Curie temperature. This means that they can be successfully used in devices that operate at temperatures up to 400 K. In addition, it can be concluded that the suction method gives possibility to produce amorphous samples with good magnetically soft properties.

References

M. E.Mchenry, M. A. Willard, D.E. Laughlin, Progress in Materials Science 44, 291-433 (1999). DOI: 10.1016/S0079-6425(99)00002-X

[2] C Suryanarayana, A Inoue Iron-based bulk metallic glasses, International Materials Reviews 58(3), 131-166 (2013). DOI:10.1179/1743280412Y.0000000007

[3] J. Gondro, J. Świerczek, J. Olszewski, J. Zbroszczyk, K. Sobczyk, W. Ciurzyńska, J. Rzącki, M. Nabiałek, Journal of Magnetism and Magnetic Materials 324(7) 1360-1364 (2012). DOI: 10.1016/j.jmmm.2011.11.038

[4] S. Lesz, P. Kwapuliński, M. Nabiałek, P. Zackiewicz, L. Hawelek, Journal of Thermal Analysis and Calorimetry 125(3), 1143-1149 (2016). DOI: 10.1007/s10973-016-5430-x

[5] K. Błoch, M. Nabiałek, P. Postawa, A.V. Sandu, A. ´ Sliwa, B. Jez, Materials 13, 846 (2020). DOI:10.3390/ma13040846

[6] A. Inoue, T. Zhang, T. Masumoto, Materials Transactions JIM 31, 177-183 (1990). DOI: 10.2320/matertrans1989.31.177

[7] S.G. Kim, A. Inoue, T. Masumoto, Materials Transactions JIM 31(11), 929-934 (1990). DOI:10.2320/matertrans1989.32.609

[8] A. Inoue, A. Kato, T. Zhang, S.G. Kim, T. Masumoto, Materials Transactions JIM 32, 609-616 (1991). DOI: 10.2320/matertrans1989.32.609

[9] P. Pietrusiewicz, K. Błoch, M. Nabiałek, S. Walters, Acta Physica Polonica A 127(2) 397-399 (2015). DOI: 10.12693/APhysPolA.127.397

[10] Z. Jaafari, A. Seifoddini, S. Hasani, Metallurgical and Materials Transactions A 50A, 2875 – 2885 (2019). DOI: 10.1007/s11661-019-05195-z

[11] M. Nabiałek, Archives of Metallurgy and Materials 61, 439-444 (2016). DOI: 10.1515/amm-2016-0079

[12] J. Olszewski, J. Zbroszczyk, M. Hasiak, J. Kaleta, M. Nabiałek, P. Bragiel, K. Sobczyk, W. Ciurzyńska, J. Świerczek, A. Łukiewska, Journal of Rare Earths 27(4), 680-683 (2009). DOI: 10.1016/S1002-0721(08)60315-4

[13] S. Hasani, P. Rezaei-Shahreza, A. Seifoddini, Metallurgical and Materials Transactions A 50, 63 – 71 (2019). DOI: 10.1007/s11661-018-4976-6

[14] J. Gondro, K.Błoch, M.Nabiałek, S. Garus, Materiali in Tehnologije 50(4) 559-564 (2016). DOI: 10.17222/mit.2015.148

[15] P. Vizureanu, M. Nabiałek, A. V. Sandu, B. Jeż, Materials 13, 835 (2020). DOI: 10.3390/ma13040835

[16] P. Pietrusiewicz, M. Nabiałek, B. Jeż, Revista de Chimie 69(8), 2097-2101 (2018). DOI: 10.37358/RC.18.8.6481

[17] M. Nabiałek, B. Jeż, K. Jeż, S. Walters, K. Błoch, ACTA PHYSICA POLONICA A 137(3), 350-354 (2020). DOI: 10.12693/APhysPolA.137.350

[18] M. Nabiałek, B. Jeż, K. Błoch, P. Pietrusiewicz, J. Gondro, Journal of Magnetism and Magnetic Materials 477, 214–219 (2019). DOI: 10.1016/j.jmmm.2019.01.073

[19] B. Jeż, Revista de Chimie 68(8), 1903-1907 (2017). DOI:10.37358/RC.17.8.5788

[20] D.C. Achitei, P. Vizureanu, M.G. Minciuna, A.V. Sandu, A. Buzaianu, D.I. Dana, Materiale Plastice 52, 165-167 (2015).

[21] B. Płoszaj, European Journal of Materials Science and Engineering 05, 69-73 (2020). DOI: 10.36868/ejmse.2020.05.02.069

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