Influence of Nd substitution on the phase constitution in (Zr,Ce)$Fe_{10}Si_2$ alloys with the $ThMn_{12}$ structure

Mieszko Kołodziej,[1,2] Jean-Marc Grenéche,[3] Sandy Auguste,[3] Bogdan Idzikowski,[1] Maciej Zubko,[4,5] Lofti Bessais,[6] and Zbigniew Śniadecki[1]

[1] *Institute of Molecular Physics, Polish Academy of Sciences, Smoluchowskiego 17, 60-179 Poznań, Poland*

[2] *NanoBioMedical Centre UAM, Wszechnicy Piastowskiej 3, 61-614 Poznań, Poland*

[3] *Le Mans Université, Institut des Molécules et Matériaux du Mans IMMM, UMR CNRS 6283, Avenue Olivier Messiaen, 72085 Le Mans, Cedex 09, France*

[4] *Institute of Materials Engineering, Faculty of Science and Technology, University of Silesia, 75 Pułku Piechoty 1a, 41-500 Chorzów, Poland*

[5] *Department of Physics, Faculty of Science, University of Hradec Králové, Rokitanského 62, 500 03, Hradec Králové, Czech Republic*

[6] *Université Paris Est Créteil, ICMPE, UMR CNRS 7182, 2 rue Henri Dunant, 94320 Thiais, France*

Iron-based alloys with a tetragonal $ThMn_{12}$-type structure have the potential to bridge the performance gap between ferrite and 2:14:1-type magnetic materials. Calcualtions based on the semi-empirical Miedema's model were performed for the (Zr, Nd, Ce)-Fe-Si system with emphasis on Fe-rich compositions. The stability range and stabilization routes of the amorphous phase, solid solutions and intermetallic compounds were compared and discussed. Afterwards, $Zr_{0.4-x}Nd_xCe_{0.6}Fe_{10}Si_2$ alloys were synthesized. It was already known that in $Zr_{0.4}Ce_{0.6}Fe_{10}Si_2$ $ThMn_{12}$-type structure could be stabilized in almost 100% of the volume fraction [1]. The substitution of Zr by Nd was thought to improve the hard magnetic properties of these alloys. To confirm the phase constitution in the obtained alloys, X-ray diffraction experiments were performed and followed by ^{57}Fe Mössbauer spectrometry. The presence of a $ThMn_{12}$-type structure in the arc-melted samples was confirmed over almost the whole composition range. The substitution Nd by Zr led to the destabilization of the $ThMn_{12}$-type structure and facilitated the formation of a bcc-Fe type structure. It is related to the expansion of the lattice parameter and the destabilization of $ThMn_{12}$-type structure. Additionally, it was confirmed that isothermal annealing at 1373 K led to the stabilization of the $ThMn_{12}$-type structure in an even wider compositional range.

References:

[1] A. Gabay, G. Hadjipanayis, J. Alloys Compd. 657 (2016) 133-137

[2] K. Kobayashi et al., Mater. Trans. 59 (2018) 1845-1853