High energy diffraction measurements of FINEMET type alloys during isothermal annealing

V. Kolesar[1], J. Bednarci[2], P. Sovak[1] and H. Franz[2]

[1] Institute of Physics, P.J. Safarik University, Park Angelinum 9, Kosice 04001, Slovakia

[2]FS-DO at DESY, Notkestr. 85, 22607 Hamburg, Germany

FINEMET ($Fe_{73.5}Cu_1Nb_3Si_{13.5}B_9$) is nanocrystalline alloy which has been extensively studied due to excellent magnetic properties and low cost [1], [2] and [3]. Manufacturing of this alloy consists of two basic steps i.e. amorphous alloy preparation by melt-spinning method and one hour annealing at the temperature 550 °C. Annealing is energetically difficult process and production of nanocrystalline alloy directly by melt-spinning technique would be much advantageous. In this way, Lee et al. [4] developed so called TAGMET ($Fe_{75.4}Si_{15.5}B_7Ta_2Ag_{0.1}$) nanocrystalline alloy with the saturation magnetization 1.45 T and coercivity 8 Am^{-1}. ($Fe_{73.5-x}$ Zn_x) Cu_1 Nb_3 $Si_{13.5}$ B_9 (x=1, 3, 5) samples were prepared by melt spinning technique. Structure of as-quenched samples was investigated by X-ray powder diffraction method in Hasylab (DESY) at the BW5 beamline. The x=1 sample was in amorphous state and small crystalline fraction was found in x=3 sample. The presence of nanocrystalls with the grain size about 25 nm was confirmed in the x=5 sample. It means, there is possibility to reach nanocrystalline state of as-quenched alloy only by Zn addition without further annealing on the other hand the value of coercivity was surprisingly the highest for nanocrystalline sample ($Hc_{(x=5)}$=12.5 $A.m^{-1}$) and the smallest for amorphous sample ($Hc_{(x=1)}$=4.7 $A.m^{-1}$) [5]. For better description of structure evolution and thermal properties of prepared samples in-situ diffraction experiments were realized during heating of x=1 sample up to the temperature 500 °C (Fig. 1 a) and during isothermal annealing at this temperature (Fig. 1 b). Increasing Bragg peaks appeared during isothermal annealing belongs to Fe_3Si structure. The same measurements were realized during the same temperature program but the x=1 sample was heated only up to 470 °C and at this temperature was annealed. In this case was confirmed crystallization of Fe_3Si phase as well, but the increase of Bragg peaks is not so strong. In-situ diffraction measurements of x=3 and x=5 crystalline samples were realized from room temperature up to 600 °C at the same heating rate. From the data will be determined the grain size, lattice parameter and lattice strain evolution during heating and the results will be soon published.

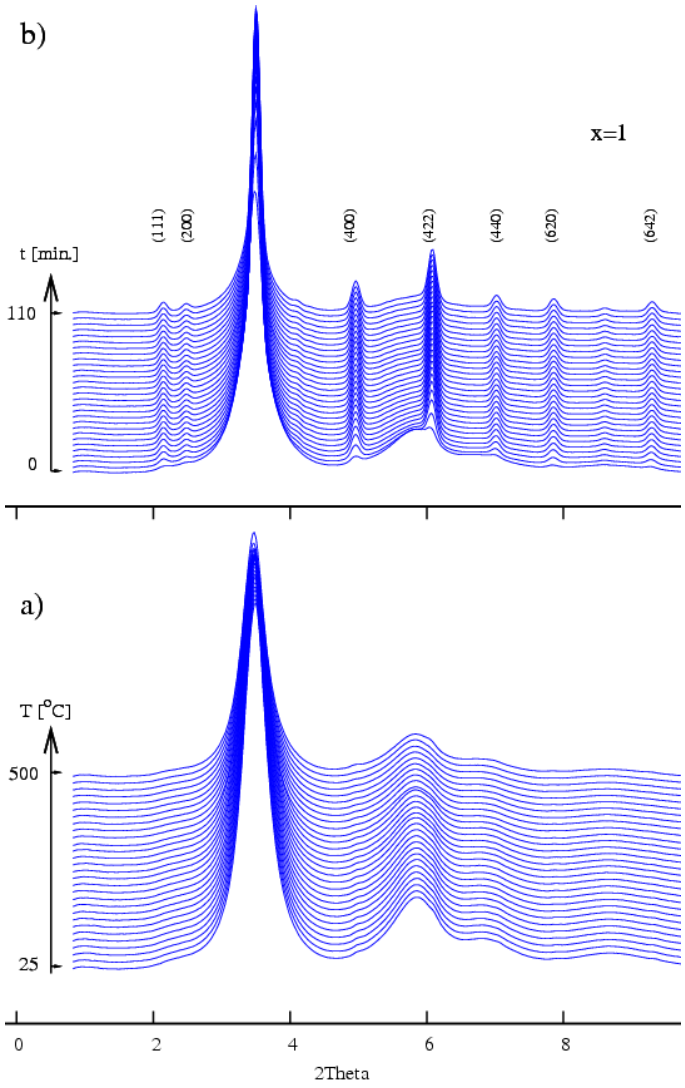

Figure 1: a) Diffraction patterns of $(Fe_{73.5-x}\ Zn_x)\ Cu_1\ Nb_3\ Si_{13.5}\ B_9$ (x=1) sample heated from room temperature up to 500 °C with the heating rate 10 °C.min^{-1}, b) Diffraction patterns of the same sample during annealing at the temperature 500 °C with the miller indexing of Fe_3Si phase.

References

[1] Y. Yoshizawa, S. Oguma and K. Yamauchi, *J. Appl. Phys.* **64**, 6044 (1998).

[2] K. Suzuki, A. Makino, A. Inoue and T. Masumoto, *J. Appl. Phys.* **70**, 6232 (1991).

[3] M.A. Willard, D.E. Laughlin, M.E. McHenry, D. Thoma, K. Sickafus, J.O. Cross and V.G. Harris, *J. Appl. Phys.* **84,** 6773 (1998).

[4] M. C. Lee, C. Y. Lin, T. S. Chin, *Intermetallics*, **15,** 1564-1567 (2007).

[5] V. Kolesar, s. Michalik, J. Kovac, V. Girman, P. Sovak, P. Kollar, Acta Phys. Polonica A, **118**, (2010)