RADIATION INFLUENCE ON PROPERTIES OF NANOCRYSTALLINE ALLOYS

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1. Introduction

Nanocrystalline materials have a wide range of application. They are the materials with very interesting composition, for example ultra-fine structure, different chemical composition and in multiphase state. Nanocrystalline structure also allows to create materials with a plastic core and solid surface, which is essential for advancing technology [1].

The one of important alloys are FINEMET, NANOPERM and HITPERM-type because they exhibit excellent soft magnetic properties. From the many studied externals factors of influence at these alloys is influence of different kind radiation at the structural and magnetic properties [2]. It has been demonstrated that certain physical properties of nanocrystalline materials may be more or less influenced by the neutron irradiation. In the case of nanocrystalline alloys, consisting of nanocrystal grains dispersed in an amorphous rest, the process of irradiation with neutrons will result in distortion of the periodic atomic arrangement of the crystal lattice and exchange of atoms between the amorphous and crystalline component [2].

After neutron irradiation many changes of parameters were observed e.g. changes in the orientation of the magnetic moment, intensity of mean internal magnetic field and the structural changes of amorphous and nanocrystalline components were found.

The effect of radiation of different particles and different doses and for different has a also influence and the structural changes of amorphous and nanocrystalline alloy.

Our work is focused on the studied of structural changes amorphous and nanocrystalline alloys after irradiation with electrons [3]. For the analysis of these alloy we use two spectroscopic methods: Mösbauer spectroscopy and XRD.

2. Experimental technique

Samples were prepared in the form of ribbon by planar flow casting of the melt at the Physical Institute SAS. Thickness of the samples was a 25 microns with composition of $(Fe_3Ni)_{81}Nb_7B_{12}$. Electron irradiation was performed at SMU Trenčín using a linear accelerator with a dose up to 4MGy with energy 5 MeV. Mössbauer spectra were measured by transmission geometry on a standard constant acceleration spectrometer with a source of ^{57}Co (Rh). All spectra were recorded at room temperature and evaluated using the CONFIT program [4], allowing simultaneous treatment of crystalline components and residual amorphous phases using individual lines and distributions of hyperfine parameters. XRD spectra were recorded at the diffractometer D8 Advance Brucker with Co lamp.

3. Results and discussion

Mössbauer spectra all samples were evaluated using fitting model comprising too component groups e.g. the first one consist of narrow lines attributed to the Fe-atoms situated in the bulk nanocrystalline grains and the second groups describes amorphous rest. The decomposition of Mössbauer spectra is demonstrated in Fig.1. In this figure Mössbauer spectrum $(Fe_3Ni_1)_{81}Nb_7B_{12}$ of the non-irradiation sample represents amorphous and crystalline part spectra. In Fig. 2. non-irradiated and irradiated spectra are shown. According

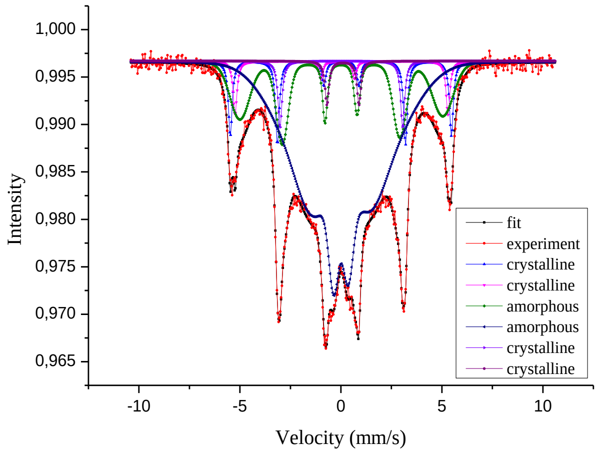

Fig.1: *Spectrum of nanocrystalline alloy $(Fe_3Ni_1)_{81}Nb_7B_{12}$, with all components*

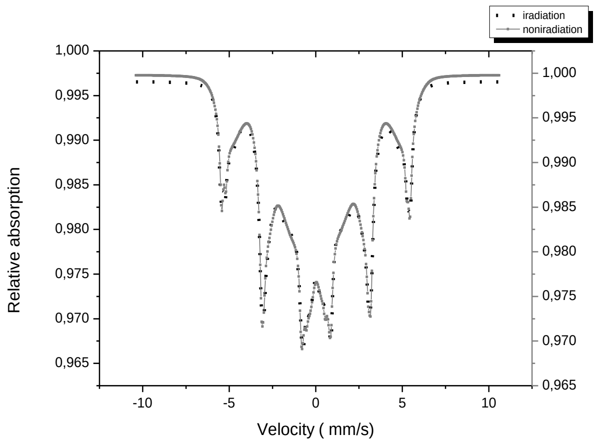

Fig. 2: *fitted spectra of irradiated and non-irradiated samples*

to the previous measurement [6] after irradiation changes in the orientation of the net magnetic moment, in the value average hyperfine magnetic field of the amorphous and crystalline components and their volumetric fraction took place. Orientation of the net magnetic moment is reflect in the ratio of the second and fifth line intensities of Mössbauer spectrum (A_{23}) [5]. This parameters achieves maximum value if the direction of the net magnetic moment lay in sample surface and its minimum value, when is oriented perpendicular to the sample. Parameters of non-irradiated and irradiated samples are give in Tab. 1

Tab. 1. *Parameters of Mössbauer spectra of non-irradiated and irradiated nanocrystalline $(Fe_3Ni_1)_{81}Nb_7B_{12}$ alloy. A_{23} – intensity of second and fift line, B- induction of internal magnetic filed, A_a- amount of amorphous part, A_c- amount of crystalline part*

sample	*amorphous component*						*crystalline component*		
	A_{23}	*B_1[T]*	*B_2[T]*	*A_1[%]*	*A_2[%]*	*A_a[%]*	*A_{23}*	*B[T]*	*A_c[%]*
non-irrad	2.27	*31.23*		*22*		*89*	*3.34*	*33.38*	*11*
	2.06		13.65		67				
irrad	3.07	31.30		26		86	3.44	33.13	14
	3,16		12.83		60				

Changes in the volumetric fraction in the constituent phase were found. After irradiation the volumetric fraction of crystalline components increased about 3% and amorphous component the decreased in the same value. Volumetric fraction we determined also from XRD spectra measurement given in Fig. 2. After evaluation of the XRD spectra we found changes between irradiated and non-irradiated spectra in a frame 4 %. Experimental error in both methods is about 3%, therefore we suppose that volumetric fraction changes with irradiation but in this case in the frame of error [5, 6]. From parameters of Mösbauer spectra the most sensitive parameter is (A_{23}) what represents the direction of the net magnetic moment. Its value is listed in Tab. 1. Our measurement shows that after irradiation direction of net magnetic moment changes and turn on ribbon plane in both components. We observed also small changes in internal magnetic film but also in a frame of error [6].

Simulation of electron interaction with our sample is give on fig.4. As a input parameter we use electrons of 5 MeV energy and absorption material we supposed iron as a main constituent elements. This simulation shows that electrons are fully absorbed in our sample of the thickness 25 μm.

According to our result this kind of alloy is resistive up to 4 MGy dose of electrons because we do not observed structural changes by both spectroscopic method. Previous measurements at the samples irradiated by neutrons show structural changes by high fluency of neutrons. After low fluency of neutrons we did not observe structural changes but we indicated changes in magnetic structure reflected in changes of direction of net magnetic moment [6, 7]. From this point of you we supposed that the same phenomena take place by irradiation of electrons. This is a reason that in our samples we did not find structural changes but we found some changes in magnetic structure during the net magnetic moment. This indicate that after 4 MGy started the radiation damage process by irradiation of electrons. We can confirm that amorphous part of the alloy is more sensitive at electron radiation than crystalline part. The same phenomena we observed in the samples after irradiation with neutrons.

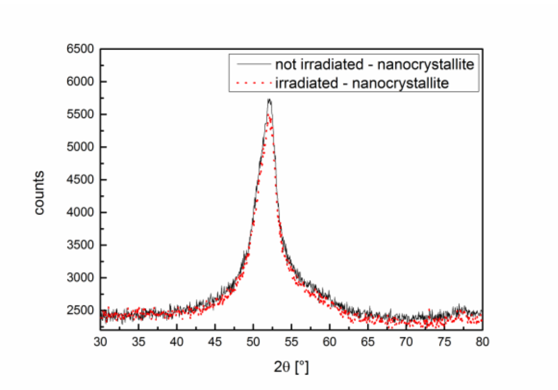

Fig.3: *XRD spectra of both samples.*

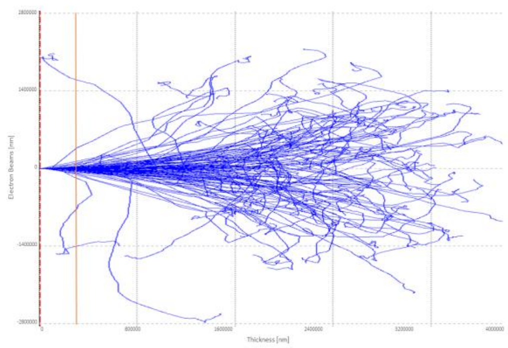

Fig.4: *Simulation of electrons penetration into alloy: the vertical line sign thickness of our samples*

4. Conclusion

Measurements of nanocrystalline $(Fe_3Ni_1)_{81}Nb_7B_{12}$ samples before and after electrons irradiation by means of Mössbauer spectroscopy and XRD showed that the electrons causes changes in magnetic structure which is reflected changes of direction of net magnetic moment. Structural changes occurs in the frame of error indicated by both spectroscopic methods. We can confirm that this kind alloys a resistive again electrons irradiation up to doses of 4 MGy. We observed in this frame only beginning of the radiation damage.

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