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INVESTIGATION OF MAGNETIC SUSCEPTIBILITY IN AMORPHOUS AND RELAXED BINARY ZrNi SYSTEMS

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ABSTRACT
In this paper the investigation of magnetic susceptibility in binary amorphous and relaxed Zr35Ni65, Zr40Ni60, Zr62Ni38 systems was reported. Amorphous systems were relaxed at temperature 573K for 5 hours. That was the test of the theoretical results of the quantum theory paramagnetism of the amorphous and the crystal system.
The tests were conducted in temperature range from 80K to 250K by investigation the temperature dependence of the magnetic susceptibility. For this investigation was used a special sensitive method for measuring ac magnetic susceptibility which enabled a simultaneous measurement of the real and the imaginary component of the susceptibility.
A microstructure of samples was observed by Olympus light microscope, 1000x magnification. The research is fundamental, i.e. belongs to physics of the solid state.
The obtained results are presented graphically.
Keywords: Amorphous Metallic Alloys, ac Susceptibility, Paramagnetism, Phase Transition

1. INTRODUCTION
The quantum theory of paramagnetism amorphous metallic (Pauli paramagnetism) was showed the effect of disorder of metallic structure on the paramagnetic susceptibility, [3]. The following formula was obtained

$$\aleph_a = 4\pi\left(\frac{2m}{h^2}\right)^{3/2}\mu_B^2 E_F^{1/2}\left\{\left[1-\frac{1}{8}\left(\frac{\eta}{E_F}\right)^2\right]-\frac{\pi^2}{24}\left(\frac{kT}{E_F}\right)^2\left[1+\frac{15}{8}\left(\frac{\eta}{E_F}\right)^2\right]\right\}. \tag{1}$$

The relation for paramagnetic susceptibility of crystalline metals is

$$\aleph_{cr} = 4\pi\left(\frac{2m}{h^2}\right)^{3/2}\mu_B^2 E_F^{cr^{1/2}}\left[1-\frac{\pi^2}{24}\left(\frac{kT}{E_F^{cr}}\right)^2\right], \tag{2}$$

where are
m- mass electron
h- Planck's constant
μ_B - Bohr's magneton
E_F – Fermi's level
K - Boltzman's constant
T – absolutely temperature
η - coefficient of dispersion.

The relation (1) is generalized formula for paramagnetic susceptibility of amorphous metals. The transition from amorphous state to the crystalline results in the increase of the paramagnetic susceptibility. It follows from the comparasion of the relation (1) and (2).

2. EXPERIMENTAL INVESTIGATIONS

In the Laboratory for Pyisics of Metals at Faculty of Sciences, Dept. Physics, Sarajevo were produced alloys for the production amorphous systems. In order to obtain an amorphous magnetic metal system, it is necessary to prepare an alloy first. For this purpose, modifications were made to a vacuum electrical-arc furnace in atmospheric argon. In the furnace yielded required alloys of the following composition: Zr35Ni65 (Zr: 35 at.%; Ni: 65 at.%), Zr40Ni60 (Zr: 40 at.%; Ni: 60 at.%), Zr62Ni38 (Zr: 62 at.%; Ni: 38 at.%).

In the Laboratory for Physics of Metals (Faculty of Sciences, Dept. Physics, Sarajevo), so-called melt-spining method has been used to obtain amorphous metal systems in the form of metal ribbons.

The test of the theory was conducted in temperature range from 80K to 250K by investigation the temperature dependence of the magnetic susceptibility amorphous and relaxed system.

Amorphous systems were relaxed at temperature 573K for 5 hours.

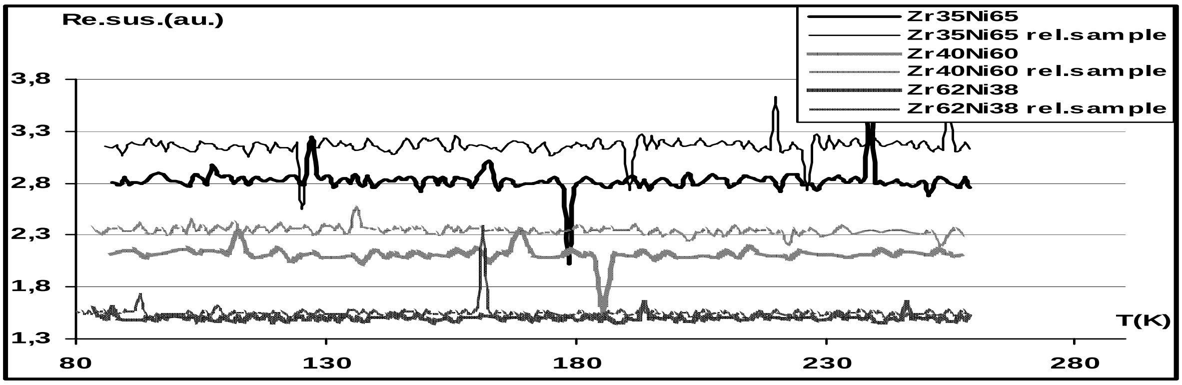
In the Laboratory for Metallography at Faculty of Metalurgy and Materials Science, a microstructure of samples was observed by Olympus light microscope, 1000x magnification.

The samples are impressed in resin by the cold pressing. The amorphous ribons are carefuly prepared by grinding and polishing because they are very thin. During the preparing of samples, it was not possible prepare complete surface. Some parts of ribon were very thin and took out during grinding or polishing. Only individual parts of ribon were prepared properly.

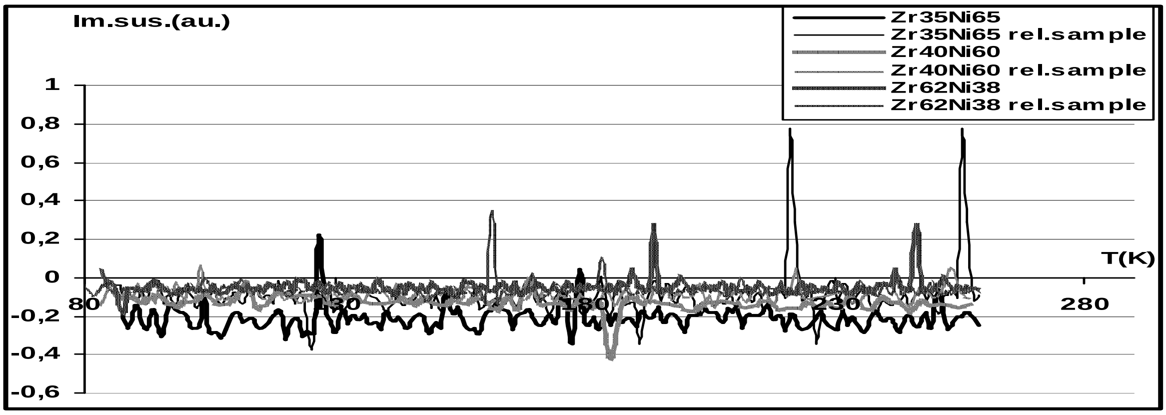
From the rest of ribons, the other samples were taken end heating in the furnace without a protective atmosphere at 573 K/ 5 hours. After that, they were cooling in the furnace. The samples were prepared for metallographyc observation on the same way as above mentioned. The samples were etching by solution of 10ml HCl i 100ml H_2O.

3. RESULTS AND CONCLUSIONS

Based on the analysis of the obtained results for the dependence of the magnetic susceptibility on the temperature of samples Zr35Ni65, Zr40Ni60, Zr62Ni38 the following conclusions can be drawn:

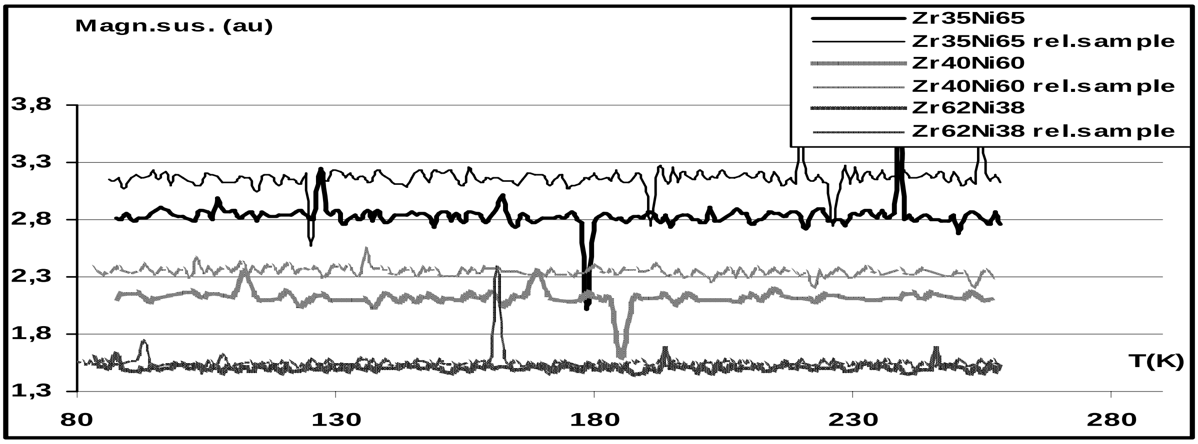


a)



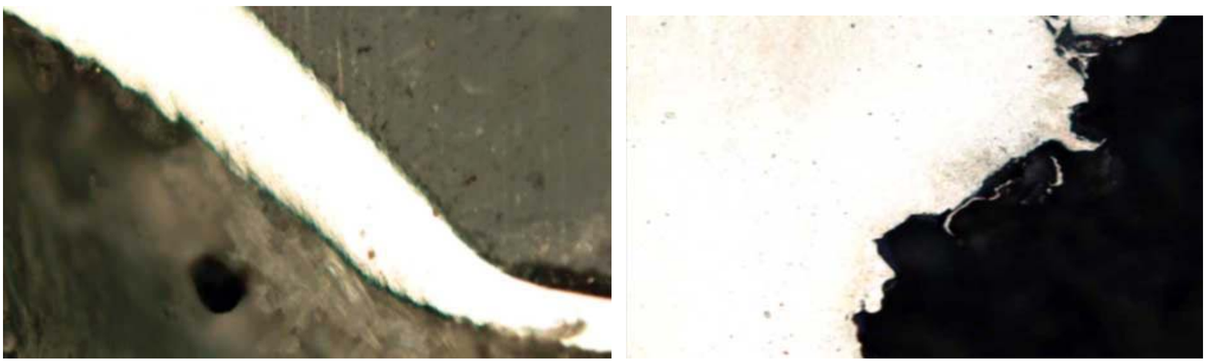
b)

Figure 1. Real and imaginary component of magnetic susceptibility of the amorphous and relaxed metal systems as a function of temperature (Re.- Real component, Im.-Imaginary component , (rel.-relaxed, au.-arbitrary units).



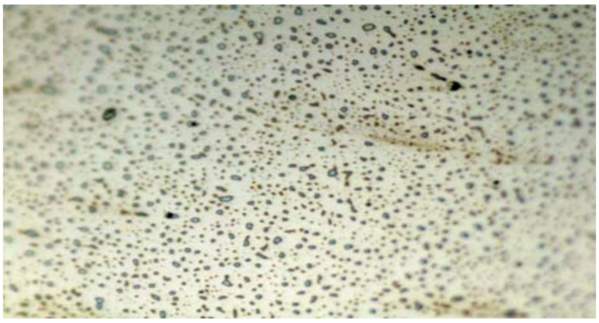
c)

Figure 2. Ac magnetic susceptibility of the amorphous and relaxed metal system as a function of temperature (rel.-relaxed au.-arbitrary units), Magn.sus.= $\sqrt{(\mathrm{Re}.sus.)^2 + (\mathrm{Im}.sus.)^2}$.



a) *b)*

Figure 3. Microstructure of amorphous and relaxed system Zr35Ni65
a) the amorphous sample, polished, 200x
b) the relaxed sample, etched, 200x



a) *b)*

c)

Figure 4. Microstructure of amorphous and relaxed system Zr40Ni60

a) the amorphous sample, polished, 200x

b) the amorphous sample, polished, 500x

c) the relaxed sample, etched, 200x

1. Efects of the dispersion for amorphous Zr35Ni65, Zr40Ni60, Zr62Ni38 systems were bigger then relaxed systems (higher value of „picks“ intensity of the magnetic susceptibility real component were for amorphous systems then relaxed systems, Fig. 1. a)).
2. Lower value of the imaginary component of the magnetic susceptibility of the relaxed samples compared to that of the amorphous samples indicates the stabilization of energy of the relaxed amorphous sample. The value of the imaginary component of the magnetic susceptibility is on average lower for the relaxed samples than for the non-relaxed ones (Fig. 1. b)).
3. The value of the ac magnetic susceptibility is on average higher for relaxed samples than for amorphous ones, Fig. 2. The relation (1) for paramagnetic susceptibility was confirmed.
4. The mikrostructure of samples confirm that Zr35Ni65 and Zr40Ni60 systems have the amorphous structure before and after relaxation process. Fig. 3 and 4.

4. REFERENCES

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