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INVESTIGATION OF THE ANNEALED METALLIC GLASS $Fe_{28}Co_{50}Si_9B_{13}$ BY THE X-RAY AND ELECTRICAL RESISTANCE METHODS

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In this paper results of investigations of the X-ray diffraction and the electrical resistance of the metallic glass $Fe_{28}Co_{50}Si_9B_{13}$ are presented. These investigations were performed for isothermally annealed samples during 4 hours in the temperature range from 573 to 823 K. As a result of annealing, the samples were obtained in a crystalline state. The second series of the investigations was performed for samples annealed at a constant temperature of 673 K but in different time intervals.

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1. Introduction

Metallic glass does not preserve its atomic structure received in the process of production. Annealing of an amorphous sample below the temperature of crystallization modifies the short range ordering. Majority of the changes are irreversible and are related to the topological short range ordering (TSRO). The changes in TSRO result from a gradual decrease in free volumes created in the production process. On the other hand, reversible structural changes leading to reversible changes of physical properties are related to the chemical short range ordering (CSRO), which results from changes in the region nearest to the atom [1–3]. The physical properties which are particularly sensitive to structural ones are: elasticity (the Young modulus), volume, coercivity, electrical resistance, the Curie temperature and specific heat [4].

2. Experiment

The metallic glass $Fe_{28}Co_{50}Si_9B_{13}$ studied in this work was produced by the roller quenching method in the Institute of Materials Engineering of Warsaw Technical University. For as-received and annealed samples of the alloy the electrical resistance and the X-ray diffraction measurements were performed.

Annealing of the samples was performed isothermally in an argon atmosphere for 4 hours at the temperatures 573, 673, 723, 773 and 873 K, and also at the constant temperature of 673 K in different time intervals 10^2, 10^3, 10^4, 1.44×10^4, 2×10^4 s. Each time the annealing was made for a sample as-received.

The X-ray studies were performed by DRON-20 diffractometer equipped with a horizontal goniometer GUR-5. An X-ray tube with a molybdenium target ($\lambda = 0.71069 \times 10^{-10}$ m) and a graphite monochromator in the primary beam were applied.

3. Results and discussion

The obtained results of the relative change in electrical resistance $\Delta\rho/\rho_0 = f(T)$ and the X-ray studies $I = f(2\Theta)$ for series of samples $Fe_{28}Co_{50}Si_9B_{13}$ annealed at different temperatures for 4 hours are presented in Figs. 1 and 2.

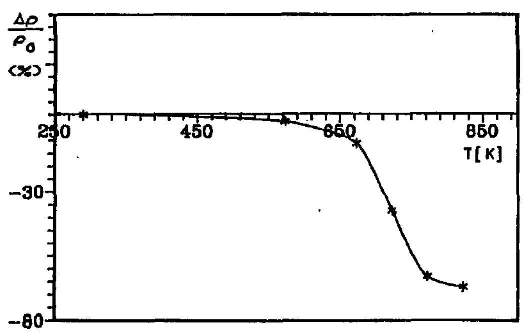

Fig. 1. The relative electrical resistivity $\Delta\rho/\rho_0$ as a function of annealing temperature T for the $Fe_{28}Co_{50}Si_9B_{13}$ alloy.

The changes of the electrical resistance caused by annealing at different temperatures (presented in Fig. 1 as the relative changes in electrical resistance related to the electrical resistance of the sample as-received) correspond to changes in the X-ray diffraction patterns of the investigated samples (Fig. 2). In comparison to as-received samples, annealing at 573 K does not produce significant change in the value of $\Delta\rho/\rho_0$ and in the diffraction pattern. It can be explained by a lack of significant change in topological ordering (TSRO). At 673 K a change is visible and may be explained by a displacement of atoms towards the existing free volumes where they take new positions [4]. At 723 K a crystallization takes place and a solid solution of iron and cobalt of α-Fe (bcc) structure is formed.

Annealing at higher temperatures results in appearance of new crystal phases of tetragonal structure Co_2B and Fe_2B [5, 6].

From the results one can see that this way of annealing leads to crystallization (Fig. 2), and it is related to the significant change of the electrical resistance (Fig. 1) with respect to the amorphous phase.

The second series of studies of the same properties ($\Delta\rho/\rho_0 = f(t)$, $I = f(2\Theta)$) concern the annealing at the temperature 673 K in different times and the results are given in Figs. 3 and 4.

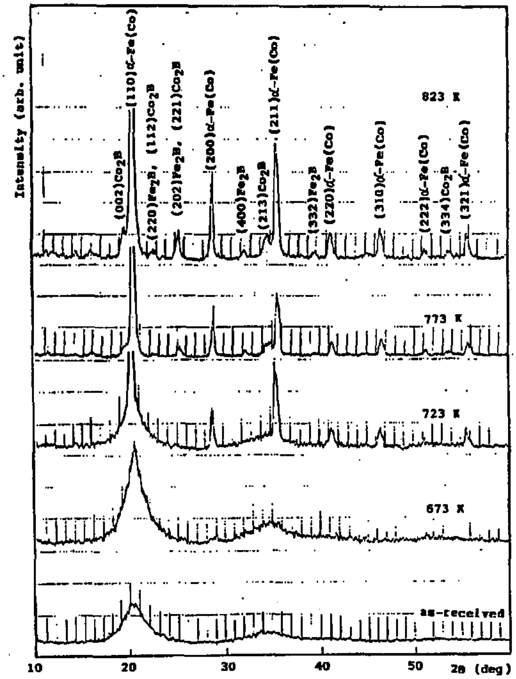

Fig. 2. X-ray diffraction patterns for samples of the $Fe_{28}Co_{50}Si_9B_{13}$ alloy annealed at different temperatures.

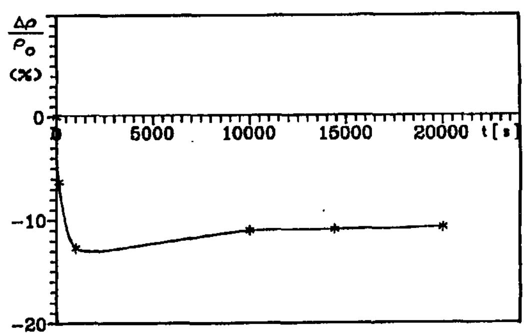

Fig. 3. Relative electrical resistivity $\Delta\rho/\rho_0$ as a function of annealing time at the temperature of 673 K.

Changes in atom positions are observed here as the more sharp diffusive "halo" and an appearance of a weak reflex at $2\Theta = 29°$. They are an evidence of growing atom clusters of range greater than normal short range ordering. Those changes in atom positions do not influence much the electrical resistance (Fig. 3). That is a proof of a certain stability in an amorphous phase.

However, at this temperature for longer times of annealing a trend to a phase transition (crystallization) is observed. In view of this fact we may consider the

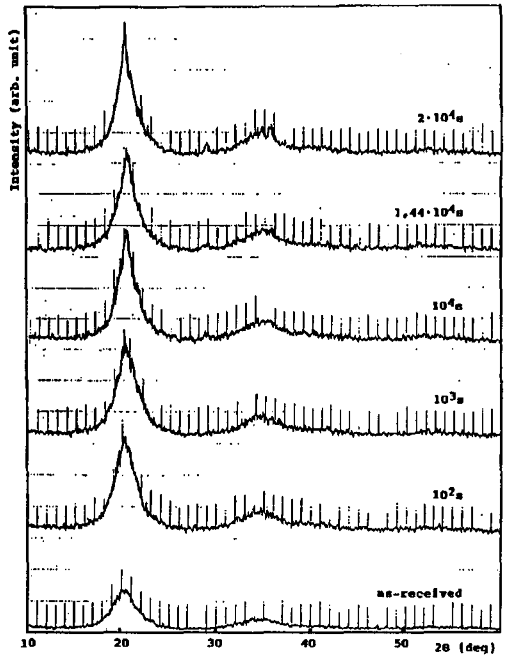

Fig. 4. X-ray diffraction patterns for samples of the $Fe_{28}Co_{50}Si_9B_{13}$ alloy annealed at the temperature of 673 K at different times.

temperature 673 K as a certain critical point for that composition.

References

[1] A. Van den Beukel, S. Radelaar, *Acta Metall.* **31**, 419 (1983).

[2] G. Riontino, M. Baricco, *Philos. Mag. B* **61**, 715 (1990).

[3] A. Van den Beukel, *Key Eng. Mater.* **81-83**, 3 (1993).

[4] T. Komatsu, *Res. Mech.* **31**, 263 (1990).

[5] W. Minor, B. Schönfeld, B. Lebeck, B. Buras, W. Dmowski, *J. Mater. Sci.* **22**, 4144 (1987).

[6] Y. Takahamara, K. Hatade, H. Matsuda, *J. Jpn. Inst. Met.* **51**, 95 (1987).