STRUCTURAL AND PHASE TRANSFORMATIONS IN ALLOYS OF Mg – Y – Ni – H SYSTEM

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Magnesium – based alloys have attracted increasing interest as structural metallic materials due to their high specific strength. Nevertheless, corrosion resistance is an important attribute of a number of magnesium – based alloy systems and the mechanisms that control their behavior in hostile environments must be understood for design of novel alloys. In this paper we aim to carry out comparative analysis of structural and phase transformations in $Mg_{80}Y_5Ni_{15}$ as - cast alloy, liquid quenched as well as their hydrogenated states.

The microstructure of a ribbon received by a TEM is presented on Fig. 1.It is seen that it manifests crystalline domains (from 25 up to 500 nanometers in size) in amount not exceeding 5 - 8 % in a single amorphous phase. This statement is evidaced by analysis of the electron-diffraction pattern and dark - field images which have been carried out in ring reflections of point and diffusive character.

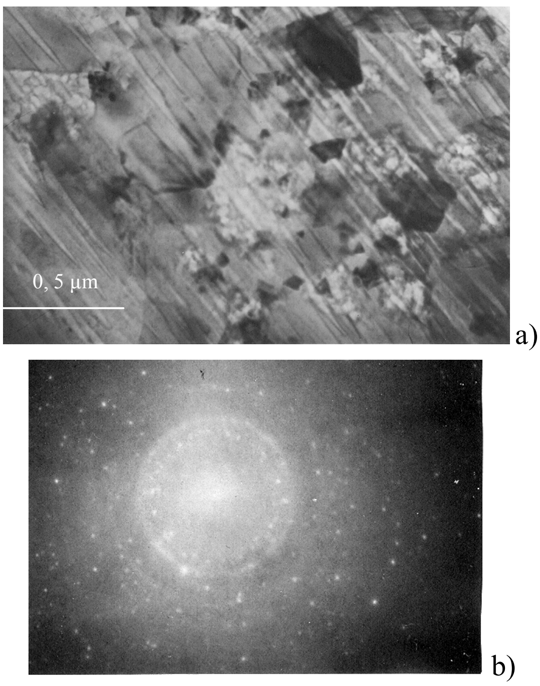

Fig. 1. A bright field electron micrograph showing ribbon microstructure of the $Mg_{80}Y_5Ni_{15}$ alloy produced by single roller melt spinning (a) and electron-diffraction pattern from this region (b).

X - ray researches carried out on diffractometer DRON-UM1 in monochromatic CuK $_{\alpha}$ - radiation. Graphite single crystal as monochromator was established on diffracted beam. For high-temperature X - ray researches the add-on device UVD - 2000 was installed to operate in a helium atmosphere. Processing diffractometer data was carried out with use of PowderCell 2.4 programs for analysis of x-ray spectra from a mix of polycrystalline phase components.

Amorphous halo and weak maximum peaks of some crystal phases, in particular magnesium oxide MgO (Fig. 2.) are fixed on initial material difractograms. Saturation by hydrogen results in shift of the amorphous halo aside small corners of diffraction. At X-ray 'in-situ' researches the changes in diffraction pictures of amorphous and hydrogenated specimens are not found out up to temperature 150°C.

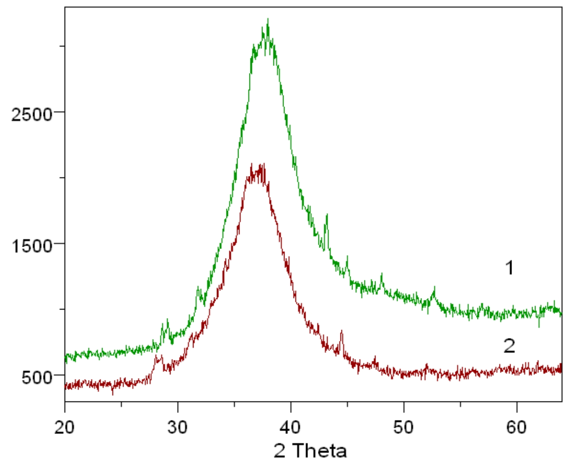

Fig. 2. X-ray difractograms for initial $Mg_{80}Y_5Ni_{15}$ after liquid quenching (1) and after its hydrogenating (2).

The first maximums of crystal phases are registered at temperature increase up to 200 °C. The analysis of difractograms shows, that they belong to phases Mg_2Ni and Mg. There are strongly broad peak of yttrium hydride YH_2 with the period of a cubic lattice a=0,5178 (2) nm in a hydrogenated alloy. The temperature increasing up to 300 – 400 °C results in increasing of intensity and narrowing of peaks from crystalline phases (Fig. 3).

It should be noted, that in both samples up to temperature 300 °C a number of weak additional peaks that do not belong to any of known crystal phases are fixed. As a first approximation these peaks can be described within the framework of a tetragonal cell with the periods a=0,7103 nm, c=1,0050 nm.

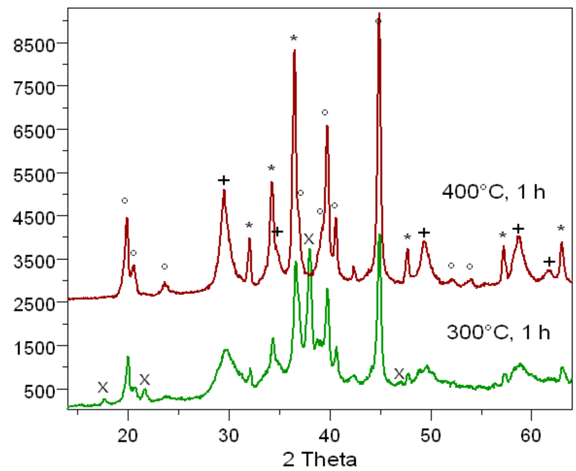

Fig.3. X-ray 'in-situ' difractograms of $Mg_{90}Y_5Ni_{15}$ alloy after hydrogenating and annealing. Designations of maximums: * - Mg, ^{o} – Mg_2NiH, + - YH_2, x – additional peaks.

Investigations of temperature dependence of electroresistance (ER) of as - cast and hydrogenated alloy states are confirmed by results the X -ray analysis (Fig. 3). Occurrence of a maximum at ~300 ^{0}C on a curve 3 is accounted for by decay of hydric phases, probably Mg_2NiH or a unknown phase reflexes of which on difractograms also disappear after annealing (2 hours) at this temperature. Jump value of ER at 510 ^{0}C is connected to decay of conducting phase Mg_2Ni and observed in both cases.

The electrochemical behavior of alloy $Mg_{80}Y_5Ni_{15}$ in as - cast and amorphous states was investigated in alkaline and neutral chlorine-containing electrolytes. Anodic and cathodic voltage-current curves ($\partial E/\partial\tau$=1 mV/c) are take off in a standard 3-electrode cell. As electrodes of comparison we used mercury - oxide in alkaline medium, and in neutral medium - sated chlorine - silver, an auxiliary electrode - a platinum plate.

The received dependences testify to full identity of cathodic behaviour of cast and amorphous alloys in alkaline electrolytes of both concentration. Cathodic emission of hydrogen proceeds with a high overvoltage, the slope of a linear section lg i - E is equal 0.13 - 0.16 V. Activation of amorphous alloy surface by cathodic reduction at 5 multiple cycling potential in region E -1.2 V do not result in change of cathodic process parameters. The cathodic curves received on electrodes after activation of a surface in a solution 0.5M H_2SO_4 (15 c), are characterized by essential decrease in an overvoltage of hydrogen emission (on 0,3 B) and an slope of linear section 0,12 V.

Analyzing the received data it is possible to draw a conclusion, that the cast alloy owing to higher structural heterogeneity and presence of grain boundaries possesses lower corrosion resistance in chloride solutions, and is declined to formation less perfect passive film in alkaline electrolytes.

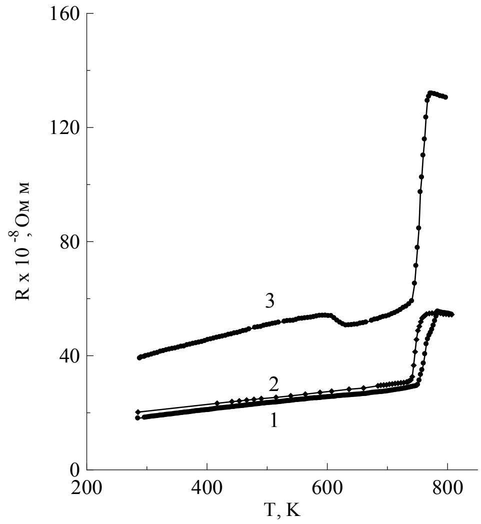

Fig. 4. Temperature dependences of electroresistance of as - cast alloy $Mg_{80}Y_5Ni_{15}$ at heating (1), cooling (2) and after saturation by hydrogen (3).

Thus, according to ER temperature dependence and X - ray researches the effect of influence of hydrogen on structure amorphous alloy is established. The analysis of phase transformations has shown presence of unknown phase, it is probably hydric phases which delays at 300 ^{0}C. The results strongly suggest the conclusion [1], that amorphous magnesium – based alloys exhibit higher corrosion resistance than those for crystalline ones. The alloys of Mg-Y-Ni system could be used in various application fields where high strength with light weight and corrosion resistance are required.

References

1. Inoue A. and Masumoto T. Production and properties of light - metal - based amorphous alloys. Mat. Sci. and Eng. 1991; A133: 6-9.